WELDING FORMULAS AND TABLES

for STRUCTURAL and MECHANICAL ENGINEERS and PIPE SUPPORT DESIGNERS

I.V.I. Structural Design Service
Portland Oregon

WELDING FORMULAS and TABLES for Structural and Mechanical Engineers and Pipe Support Designers

by T.S. Hobert

The Manual contains formulas and time saving tables for the design of welded structures and recommended for structural and mechanical engineers, pipe support designers and students familiar with the basics of structural design.

Notice:
Although this manual is based on the best available knowledge, it must not be used without independent examination and verification of its suitability by a licensed structural engineer. The use of these formulas and tables can only be made with understanding that "I.V.I. Structural Design Service" makes no warranty of any kind respecting such use and the user assumes all liability arising therefrom.

Published by I.V.I. Structural Design Service.
7943 S.W. 56th Portland Oregon 97219

Watch for the following I.V.I. publications scheduled to come out:
Formulas and tables for the design and calculation of:

- beams
- frames
- deflections
- torsion
- and the math formula booklet.

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SHARAD C. PATEL

CONTENTS

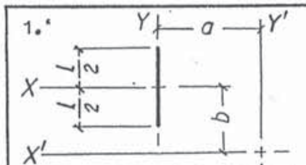
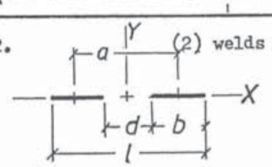
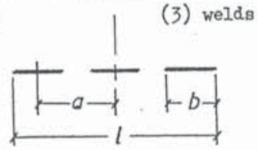
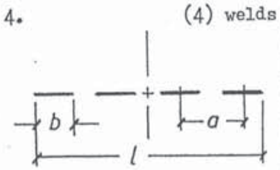
PROPERTIES OF WELD TREATED AS A LINE

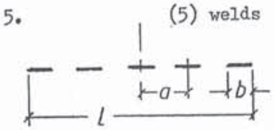
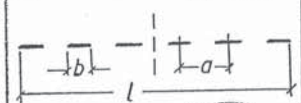
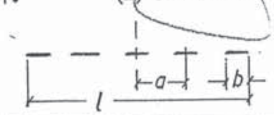
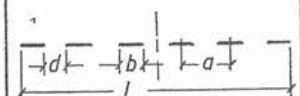
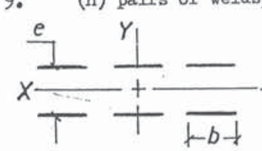
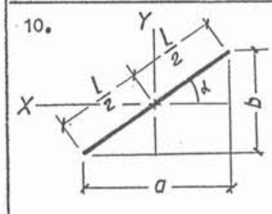
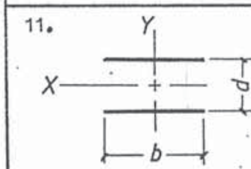
Notation:

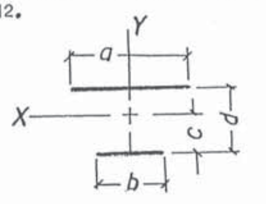
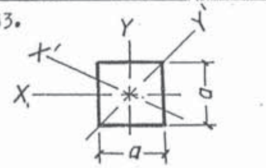
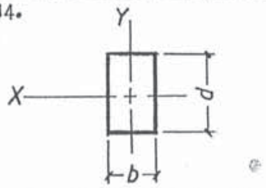
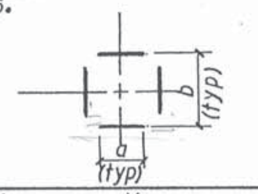
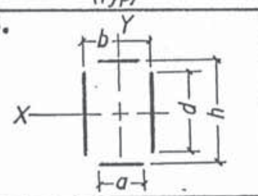
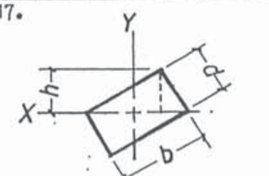
a,b,d etc. – linear dimensions as shown (in)(cm)
L – area (length) of weld (in)(cm)
c,g – distances to center of gravity (in)(cm)
Ix, Iy – moments of inertia $(in^3)(cm^3)$
Sx, Sy – section modulus $(in^2)(cm^2)$
J – polar moment of inertia $(in^3)(cm^3)$
α – angle (degree)
$\theta = \frac{\pi \cdot \alpha}{180}$ angle (radian) (1 radian $= \frac{\pi}{180} \simeq .0174533$)

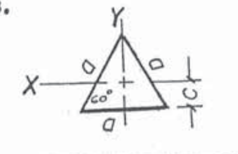
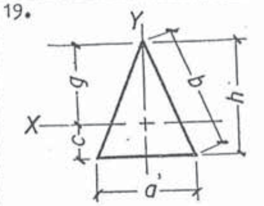
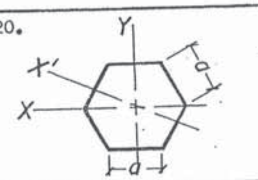
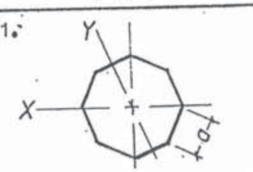
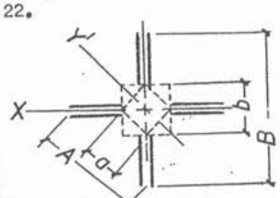
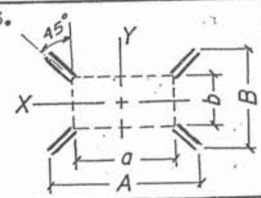
Where J or S are not shown they can be found as $J = I_x + I_y$;

$S = \frac{I}{c_1}$; c – distance from c.g. to the extreme fiber

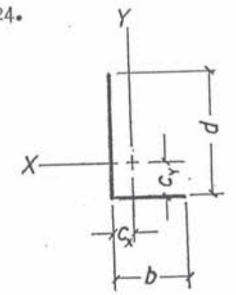
1. 	$L = l$; $I_x = \frac{l^3}{12}$; $I_y = 0$; $J = I_x + I_y = \frac{l^3}{12}$; $S_x = \frac{l^2}{6}$; $S_y = 0$; $I_x' = \frac{l^3}{12} + lb^2$; $I_y' = la^2$
2. (2) welds 	$L = l - d = 2b$; $l = a + b$; $I_x = 0$; $I_y = \frac{l^3 - d^3}{12} = \frac{b^3}{6} + \frac{a^2 b}{2}$; $S_y = \frac{l^3 - d^3}{6l}$
3. (3) welds 	$L = 3b$; $l = 2a + b$; $I = \frac{b^3}{4} + 2a^2 b$
4. (4) welds 	$L = 4b$; $l = 3a + b$; $I = \frac{b^3}{3} + 5a^2 b$

5. (5) welds 	$L = 5b$; $l = 4a + b$; $I = 5b\left(\frac{b^2}{12} + 2a^2\right)$
6. (6) welds 	$L = 6b$; $l = 5a + b$; $I = \frac{b}{2}(b^2 + 35a^2)$
7. (n) odd welds 	$L = nb$; $l = a(n - 1) + b$; $I = \frac{bn}{12}\left[b^2 + a^2(n^2 - 1)\right]$
8. (n) even welds 	$L = nb$; $l = a(n - 1) + b$; $d = a - b$; $I = \frac{l^3}{12} - \frac{d(n - 1)}{12}\left[d^2 + a^2 n(n - 2)\right]$
9. (n) pairs of welds 	$L = 2nb$; $I_y = 2I$; (Where I from formulas 7,8) $I_x = \frac{be^2}{2}n$; $S_x = ben$;
10. 	$L = l$; $I_x = \frac{l^3 \sin^2\alpha}{12} = \frac{b^2 l}{12}$; $I_y = \frac{l^3 \cos^2\alpha}{12} = \frac{a^2 l}{12}$; $J = \frac{l^3}{12}$; $S_x = \frac{l^2 \sin\alpha}{6} = \frac{bl}{6}$; $S_y = \frac{l^2 \cos\alpha}{6} = \frac{al}{6}$;
11. 	$L = 2b$; $I_x = \frac{bd^2}{2}$; $I_y = \frac{b^3}{6}$; $J = \frac{b}{6}(b^2 + 3d^2)$; $S_x = bd$; $S_y = \frac{b^2}{3}$;

12. 	$L = a + b$; $c = \frac{ad}{a + b}$; $I_x = a(d - c)^2 + bc^2$; $I_y = \frac{a^3 + b^3}{12}$; $S_{xt} = a(d-c) + \frac{bc^2}{(d - c)}$; $S_y = \frac{1}{6}(a^2 + \frac{b^3}{a})$; $S_{xb} = \frac{a(d - c)^2}{c} + bc$;
13. 	$L = 4a$; $I_x = I_y = I_{x'} = I_{y'} = I = \frac{2}{3}a^3$; $J = 2I$; $S_x = S_y = \frac{4}{3}a^2$; $S_{y'} = \frac{2\sqrt{2}a^2}{3}$;
14. 	$L = 2(b + d)$; $I_x = \frac{d^2}{6}(3b + d)$; $I_y = \frac{b^2}{6}(b + 3d)$; $J = \frac{(b + d)^3}{6}$; $S_x = d(b + \frac{d}{3})$; $S_y = b(d + \frac{b}{3})$;
15. 	$L = 4a$; $I = \frac{a}{2}(\frac{a^2}{3} + b^2)$; $J = a(\frac{a^2}{3} + b^2)$; $S = \frac{a}{b}(\frac{a^2}{3} + b^2)$;
16. 	$L = 2(a + d)$; $I_x = \frac{d^3}{6} + \frac{ah^2}{2}$; $I_y = \frac{a^3}{6} + \frac{db^2}{2}$; $J = \frac{a^3 + d^3}{6} + \frac{ah^2 + db^2}{2}$; $S_x = \frac{d^3}{3h} + ah$; $S_y = \frac{a^3}{3b} + bd$;
17. 	$L = 2(b + d)$ $I_x = \frac{2}{3}h^2(b + d) = \frac{2b^2d^2(b + d)}{3(b^2 + d^2)}$ $S_x = \frac{2}{3}h(b + d) = \frac{2bd(b + d)}{3\sqrt{b^2 + d^2}}$

18. 	$L = 3a$; $c = \frac{a}{2\sqrt{3}}$; $I_x = I_y = \frac{a^3}{4}$; $J = \frac{a^3}{2}$; $S_{xt} = \frac{a^2\sqrt{3}}{4}$; $S_{xb} = \frac{a^2\sqrt{3}}{2}$; $S_y = \frac{a^2}{2}$;
19. 	$L = a + 2b$; $c = \frac{bh}{a + 2b}$; $g = \frac{(a + b)h}{a + 2b}$; $I_x = \frac{b(2b - a)(b + 2a)}{12}$; $I_y = \frac{a^2}{6}(\frac{a}{2} + b)$; $S_{xt} = \frac{I_x}{g}$; $S_{xb} = \frac{I_x}{c}$; $S_y = \frac{a}{3}(\frac{a}{2} + b)$;
20. 	$L = 6a$; $I_x = I_y = I_{x'} = 2.5a^3$; $J = 5a^3$; $S_x = \frac{5a^2}{\sqrt{3}}$; $S_y = 2.5a^2$;
21. 	$L = 8a$; $I_x = I_{y'} \simeq 6.16a^3$; $J \simeq 12.32\,a^3$; $S_x \simeq 4.71a^2$; $S_y \simeq 5.1a^2$;
22. 	$L = 4(B - b)$; $I_x = I_{y'} = \frac{\sqrt{2}}{3}(A^3 - a^3) = \frac{B^3 - b^3}{6}$ $S_x = \frac{B^3 - b^3}{3B}$; $S_{y'} = \frac{2\sqrt{2}(A^3 - a^3)}{3A}$;
23. 	$I_x = \frac{\sqrt{2}}{3}(B^3 - b^3)$; $I_y = \frac{\sqrt{2}}{3}(A^3 - a^3)$

24.



$L = b + d;$

$c_x = \frac{b^2}{2(b + d)}; \quad c_y = \frac{d^2}{2(b + d)};$

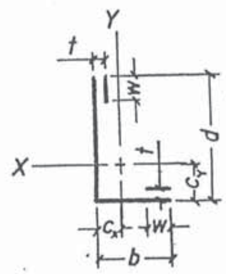
$Ix = \frac{d^3}{12}(\frac{4b + d}{b + d}); \quad Iy = \frac{b^3}{12}(\frac{b + 4d}{b + d});$

$J = \frac{b^3 + d^3}{12} + \frac{bd(b^2 + d^2)}{4(b + d)};$

$Sxb = \frac{d}{6}(4b + d); \quad Sxt = \frac{d^2}{6}(\frac{4b + d}{2b + d});$

$Syl = \frac{b}{6}(b + 4d); \quad Syr = \frac{b^2}{6}(\frac{b + 4d}{b + 2d});$

25.



$L = b + d + 2w;$

$c_x = \frac{b^2 + w(2b + 2t - w)}{2L};$

$c_y = \frac{d^2 + w(2d + 2t - w)}{2L};$

$Ix = \frac{d^3 + w^3}{12} + c_y^2(b + d) + d^2(\frac{d}{4} - c_y) +$
$+ w[(c_y - t)^2 + (d - c_y - \frac{w}{2})^2];$

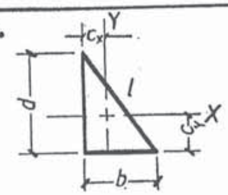
$Iy = \frac{b^3 + w^3}{12} + c_x^2(b + d) + b^2(\frac{b}{4} - c_x) +$
$+ w[(c_x - t)^2 + (b - c_x - \frac{w}{2})^2];$

$J = Ix + Iy;$

$Sxb = \frac{Ix}{c_y}; \quad Sxt = \frac{Ix}{d - c_y};$

$Syl = \frac{Iy}{c_x}; \quad Syr = \frac{Iy}{b - c_x};$

26.



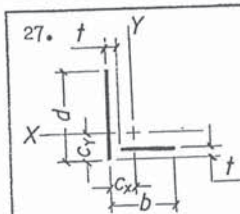
$L = b + d + l; \quad l = \sqrt{b^2 + d^2};$

$c_y = \frac{d}{2L}(d + l); \quad c_x = \frac{b}{2L}(b + l);$

$I_x = (d + l)(\frac{d^2}{3} - dc_y + c_y^2) + bc_y^2;$

$I_y = (b + l)(\frac{b^2}{3} - bc_x + c_x^2) + dc_x^2;$

27.



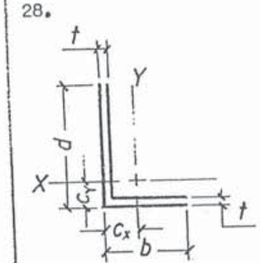
$L = b + d - t; \quad a = b - t;$

$c_x = \frac{a(\frac{a}{2} + t)}{L}; \quad c_y = \frac{\frac{d^2}{2} + at}{L};$

$Ix = \frac{d^3}{3} - dc_y(d - c_y) + a(c_y - t)^2;$

$Iy = \frac{a^3}{12} + dc_x^2 + a(\frac{b + t}{2} - c_x)^2$

28.



$L = 2(b + d - t); \quad a = b - t; \quad e = d - t;$

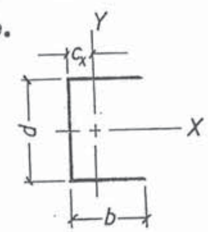
$c_x = \frac{a^2 + b^2 + 2t(a + e)}{2L};$

$c_y = \frac{d^2 + e^2 + 2t(a + e)}{2L};$

$Ix = \frac{d^3 + e^3}{12} + c_y^2(b + d) + d^2(\frac{d}{4} - c_y) +$
$+ a(c_y - t)^2 + e(\frac{d + t}{2} - c_y)^2$

$Iy = \frac{b^3 + a^3}{12} + c_x^2(b + d) + b^2(\frac{b}{4} - c_x) +$
$+ e(c_x - t)^2 + a(\frac{b + t}{2} - c_x)^2$

29.



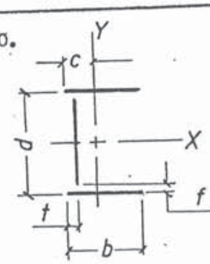
$L = 2b + d; \quad c_x = \frac{b^2}{2b + d};$

$Ix = \frac{d^2}{12}(6b + d); \quad Iy = \frac{b^3}{3}(\frac{b + 2d}{2b + d});$

$Sx = d(b + \frac{d}{6})$

$Syl = \frac{b}{3}(b + 2d); \quad Syr = \frac{b^2}{3}(\frac{b + 2d}{b + d});$

30.

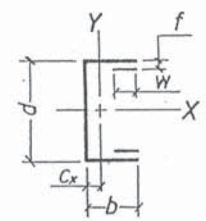


$L = 2b + e; \quad e = d - 2f; \quad c = \frac{b^2 + et}{L};$

$Ix = \frac{e^3}{12} + \frac{bd^2}{2};$

$Iy = \frac{2}{3}b^3 + 2bc(c - b) + e(c - t)^2$

31.



$L = d + 2(b + w);$

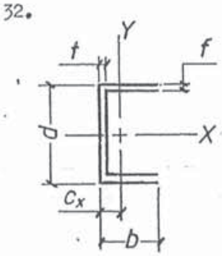
$c_x = \frac{(b + w)^2 - 2w^2}{L};$

$Ix = \frac{d^2}{2}(\frac{d}{6} + b) + 2w(\frac{d}{2} - f)^2;$

$Iy = \frac{b^3 + w^3}{6} + dc_x^2 + 2b(\frac{b}{2} - c_x)^2 +$

$+ 2w(b - c_x - \frac{w}{2})^2;$

32.



$L = 2(a + b) + d + e; \quad a = b - t; \quad e = d - 2f;$

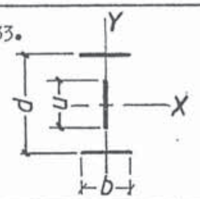
$c_x = \frac{2b^2 - t(t - e)}{L};$

$Ix = \frac{1}{2}(\frac{d^3 + e^3}{6} + bd^2 + ae^2);$

$Iy = \frac{a^3 + b^3}{6} + dc_x^2 + e(c_x - t)^2 +$

$+ 2b(\frac{b}{2} - c_x)^2 + \frac{a}{2}(b + t - 2c_x)^2;$

33.

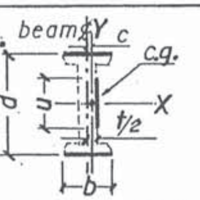


$L = 2b + u; \quad Ix = \frac{1}{2}(bd^2 + \frac{u^3}{6}); \quad Iy = \frac{b^3}{6};$

$J = \frac{1}{2}\left[b(\frac{b^2}{3} + d^2) + \frac{u^3}{6}\right];$

$Sx = bd + \frac{u^3}{6d}; \quad Sy = \frac{b^2}{3};$

34.

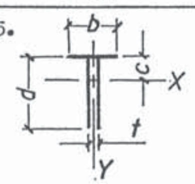


$L = 2b + u; \quad c = \frac{ut}{2L}; \quad Ix = \frac{1}{2}(bd^2 + \frac{u^3}{6});$

$Iy = b(\frac{b^2}{6} + 2c^2) + u(\frac{t}{2} - c)^2;$

$Sx = bd + \frac{u^3}{6d}$

35.

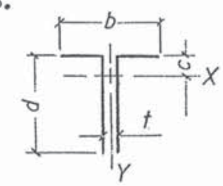


$L = b + 2d; \quad c = \frac{d^2}{L};$

$Ix = \frac{d^3(2b + d)}{3(b + 2d)}; \quad Iy = \frac{b^3}{12}; \quad Sy = \frac{b^2}{6};$

$Sxt = \frac{d(2b + d)}{3}; \quad Sxb = \frac{d^2(2b + d)}{3(b + d)};$

36.



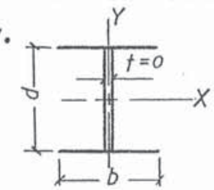
$L = 2d + b - t; \quad c = \frac{d^2}{L}; \quad a = \frac{b - t}{2};$

$Ix = \frac{d^3}{6}(\frac{4a + d}{a + d}); \quad Iy = \frac{b^3 - t^3}{12} + \frac{dt^2}{2};$

$Sxt = \frac{d}{3}(4a + d); \quad Sxb = \frac{d^2}{3}(\frac{4a + d}{L - d});$

$Sy = \frac{b^3 - t^3 + 6dt^2}{6b};$

37.

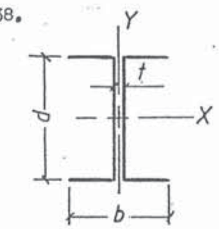


$L = 2(b + d); \quad Ix = \frac{d^2}{2}(b + \frac{d}{3});$

$Iy = \frac{b^3}{6}; \quad J = \frac{b^3 + d^2(3b + d)}{6};$

$Sx = d(b + \frac{d}{3}); \quad Sy = \frac{b^2}{3};$

38.



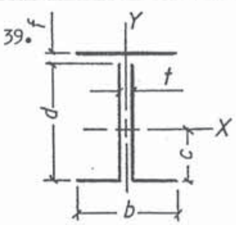
$L = 2(b + d - t);$

$Ix = \frac{d^2}{2}(\frac{d}{3} + b - t); \quad Iy = \frac{b^3 + t^2(3d - t)}{6}$

$J = \frac{b^3 + d^3 - t^3}{6} + \frac{d}{2}(bd - dt + t^2);$

$Sx = d(\frac{d}{3} + b - t); \quad Sy = \frac{b^2}{3} + \frac{t^2}{b}(d - \frac{t}{3});$

39.



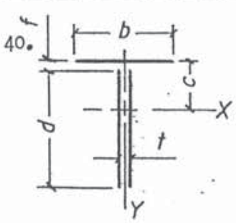
$L = 2(b + d) - t; \quad c = \frac{d^2 + b(d + f)}{L};$

$Ix = \frac{2d^3}{3} - 2dc(d - c) + (b - t)c^2 +$

$+ b(d + f - c)^2; \quad Iy = \frac{b^3}{6} + \frac{t^2}{2}(d - \frac{t}{6});$

$Sy = \frac{b^2}{3} + \frac{t^2}{b}(d - \frac{t}{6});$

40.

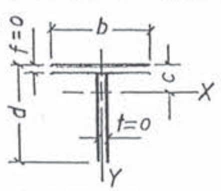


$L = b + 2d; \quad c = \frac{d(d + 2f)}{L};$

$Ix = \frac{d^3}{6} + bc^2 + 2d(\frac{d}{2} + f - c)^2$

$Iy = \frac{1}{2}(\frac{b^3}{6} + dt^2);$

41.

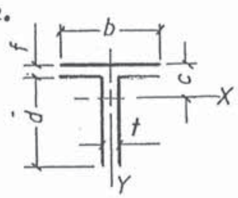


$$L = 2(b + d); \quad c = \frac{d^2}{L};$$

$$Ix = \frac{d^3(4b + d)}{3L}; \quad Iy = \frac{b^3}{6}; \quad Sy = \frac{b^2}{3};$$

$$Sxt = \frac{d(4b + d)}{3}; \quad Sxb = \frac{d^2(4b + d)}{3(2b + d)};$$

42.



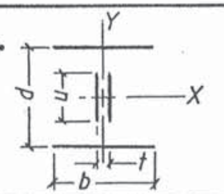
$$L = 2(b + d) - t; \quad c = \frac{f(b + 2d - t) + d^2}{L};$$

$$Ix = \frac{d^3}{6} + bc^2 + (b - t)(c - f)^2 +$$

$$+ 2d(\frac{d}{2} + f - c)^2;$$

$$Iy = \frac{b^3}{6} + \frac{t^2}{2}(d - \frac{t}{6});$$

43.

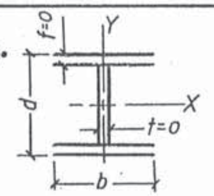


$$L = 2(b + u); \quad Ix = \frac{bd^2}{2} + \frac{u^3}{6};$$

$$Iy = \frac{ut^2}{2} + \frac{b^3}{6}; \quad J = \frac{b^3 + u^3}{6} + \frac{bd^2 + ut^2}{2};$$

$$Sx = bd + \frac{u^3}{3d}; \quad Sy = \frac{b^2}{3} + \frac{ut^2}{b};$$

44.

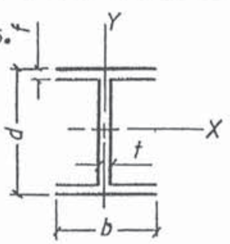


$$L = 4b + 2d; \quad Ix = \frac{d^3}{6} + bd^2;$$

$$Iy = \frac{b^3}{3}; \quad J = \frac{d^3 + 2b^3}{6} + bd^2$$

$$Sx = \frac{d^2}{3} + 2bd; \quad Sy = \frac{2}{3}b^2;$$

45.



$$L = 2(b + e + a); \quad Ix = \frac{a^2}{2}(\frac{a}{3} + e) + \frac{bd^2}{2};$$

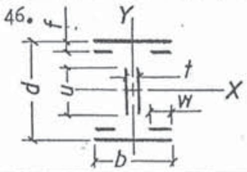
$$Iy = \frac{b^3}{6} + \frac{e^3}{24} + \frac{at^2}{2} + \frac{e(b + t)^2}{8};$$

$$Sx = \frac{a^2}{d}(\frac{a}{3} + e) + bd;$$

$$Sy = \frac{b^2}{3} + \frac{1}{b}\left[\frac{e^3}{12} + at^2 + \frac{e(b + t)^2}{4}\right];$$

$$a = d - 2f; \quad e = b - t;$$

46.

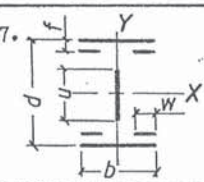


$$L = 2(b + u + 2w);$$

$$Ix = \frac{bd^2}{2} + wa^2 + \frac{u^3}{6}; \quad Iy = \frac{b^3}{3} - \frac{e^3}{6} + \frac{ut^2}{2};$$

$$a = d - 2f; \quad e = b - 2w;$$

47.

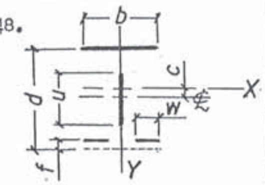


$$L = 2b + 4w + u;$$

$$Ix = \frac{bd^2}{2} + wa^2 + \frac{u^3}{12}; \quad Iy = \frac{b^3}{3} - \frac{e^3}{6};$$

$$a = d - 2f; \quad e = b - 2w;$$

48.

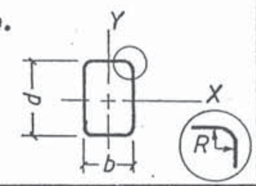


$$L = b + u + 2w; \quad c = \frac{bd - 4wa}{2L};$$

$$Ix = \frac{u^3}{12} + b(\frac{d}{2} - c)^2 + 2w(a + c)^2 + uc^2;$$

$$Iy = \frac{b^3}{6} - \frac{(b - 2w)^3}{12}; \quad a = \frac{d}{2} - f;$$

49.

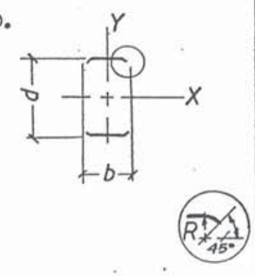


$$L = 2(b + d - .86R); \quad a = b - 2R; \quad h = d - 2R;$$

$$Ix = \frac{h^3}{6} + \frac{ad^2}{2} + R\left[\frac{\pi h^2}{2} + R(4h + \pi R)\right];$$

$$Iy = \frac{a^3}{6} + \frac{hb^2}{2} + R\left[\frac{\pi a^2}{2} + R(4a + \pi R)\right];$$

50.

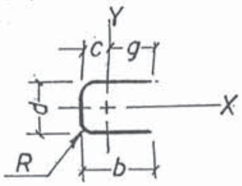
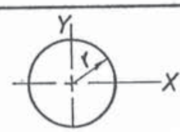
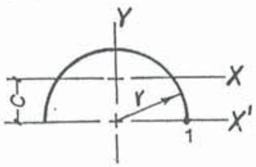
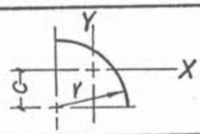
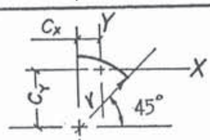
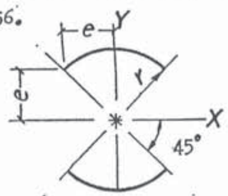


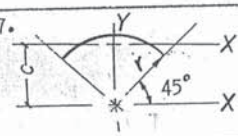
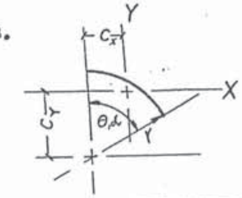
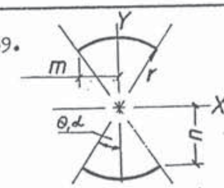
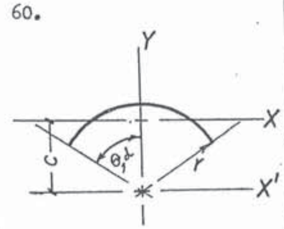
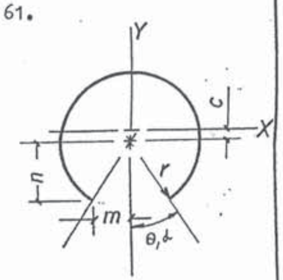
$$L = 2b - .86R; \quad a = b - 2R;$$

$$Ix = \frac{ad^2}{2} + \pi R(\frac{d}{2} - .1R)^2 + .024R^3;$$

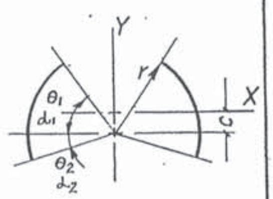
$$Iy = \frac{a^3}{6} + \pi R(\frac{b}{2} - .627R)^2 + .137R^3;$$

$$Sx = \frac{2Ix}{d}; \quad Sy = \frac{2Iy}{b - .586R};$$

51.		$L = 2b + d - .86R$; $a = b - R$; $h = d - 2R$; $I_x = \frac{h^3}{12} + \frac{ad^2}{2} + \frac{R}{2}\left[\frac{\pi h^2}{2} + R(4h + \pi R)\right]$; $I_y = \frac{2a^3}{3} + hc^2 - 2ag(a - g) + .298R^3 + \pi R(c - .363R)^2$; $c = \frac{a(b + R) + 1.14R^2}{L}$; $g = b - c$;
52.		$L = 2\pi r$; $I = \pi r^3$; $S = \pi r^2$; $J = 2\pi r^3$;
53.		$L = \pi r$; $I_x = r^3(\frac{\pi}{2} - \frac{4}{\pi}) \simeq .3r^3$; $I_{x'} = \frac{\pi r^3}{2}$; $I_y = \frac{\pi r^3}{2}$; $J = r^3(\pi - \frac{4}{\pi})$; $c = \frac{2r}{\pi}$; At point "1": $S_x = \frac{r^2}{4}(\pi^2 - 8)$; $S_y = \frac{\pi r^2}{2}$;
54.		$L = \frac{\pi r}{2} \simeq 1.57r$; $I \simeq .149r^3$ $c = \frac{2r}{\pi} \simeq .637r$;
55.		$L = \frac{\pi r}{4}$; $I_x \simeq .006r^3$; $I_y \simeq .0335r^3$; $c_x \simeq .373r$; $c_y \simeq .9r$;
56.		$L = \pi r$; $I_x \simeq 2.57r^3$; $I_y \simeq .57r^3$; $J = \pi r^3$; $e = \frac{r}{\sqrt{2}}$; $S_x \simeq 2.57r^2$; $S_y \simeq .8r^2$;

57.		$L = \frac{\pi r}{2}$; $I_x \approx .012r^3$; $I_y \simeq .285r^3$; $I_{x'} \simeq 1.285r^3$; $c \simeq .9r$;
58.		$L = \theta r$; $I_x = (\frac{\theta + \sin\alpha\cos\alpha}{2} - \frac{\sin^2\alpha}{\theta})r^3$; $I_y = (\frac{\theta - \sin\alpha\cos\alpha}{2} - \frac{(1 - \cos\alpha)^2}{\theta})r^3$; $c_x = \frac{r(1 - \cos\alpha)}{\theta}$; $c_y = \frac{r\sin\alpha}{\theta}$;
59.		$L = 4r\theta$; $m = r\sin\alpha$; $n = r\cos\alpha$; $I_x = r^3(2\theta + \sin 2\alpha)$; $I_y = r^3(2\theta - \sin 2\alpha)$; $J = 4r^3\theta$;
60.		$L = 2r\theta$; $c = \frac{r\sin\alpha}{\theta}$; $I_x = r^3(\theta + \sin\alpha\cos\alpha - \frac{2\sin^2\alpha}{\theta})$; $I_y = r^3(\theta - \sin\alpha\cos\alpha)$; $J = 2r^3(\theta - \frac{\sin^2\alpha}{\theta})$; $I_{x'} = r^3(\theta + \sin\alpha\cos\alpha)$;
61.		$L = 2r(\pi - \theta)$; $m = r\sin\alpha$; $n = r\cos\alpha$; $I_x = r^3(\pi - \theta - \frac{\sin 2\alpha}{2} - \frac{2\sin^2\alpha}{\pi - \theta})$; $I_y = r^3(\pi - \theta + \frac{\sin 2\alpha}{2})$; $J = 2r^3(\pi - \theta - \frac{\sin^2\alpha}{\pi - \theta})$; $c = \frac{r\sin\alpha}{\pi - \theta}$;

62.



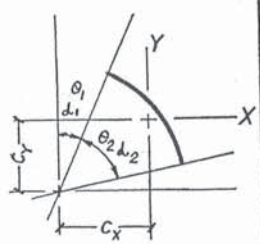
$L = 2r\theta$; $c = \frac{\cos\alpha_2 - \cos\alpha_1}{\theta} \cdot r$; $\theta = \theta_1 + \theta_2$;

$I_x = r^3\left[\theta - \frac{\sin 2\alpha_1 + \sin 2\alpha_2}{2} - \frac{2(\cos\alpha_1 - \cos\alpha_2)^2}{\theta}\right]$;

$I_y = r^3\left(\theta + \frac{\sin 2\alpha_1 + \sin 2\alpha_2}{2}\right)$;

$J = 2r^3\left[\theta - \frac{(\cos\alpha_1 - \cos\alpha_2)^2}{\theta}\right]$;

63.



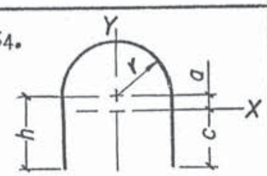
$L = \theta_2 r$; $\alpha = \alpha_1 + \alpha_2$; $\theta = \theta_1 + \theta_2$;

$c_x = \frac{\cos\alpha_1 - \cos\alpha}{\theta_2} \cdot r$; $c_y = \frac{\sin\alpha - \sin\alpha_1}{\theta_2} \cdot r$;

$I_x = r^3\left[\frac{\theta_2 + \sin\alpha\cos\alpha - \sin\alpha_1\cos\alpha_1}{2} - \frac{(\sin\alpha - \sin\alpha_1)^2}{\theta_2}\right]$;

$I_y = r^3\left[\frac{\theta_2 - \sin\alpha\cos\alpha + \sin\alpha_1\cos\alpha_1}{2} - \frac{(\cos\alpha_1 - \cos\alpha)^2}{\theta_2}\right]$;

64.

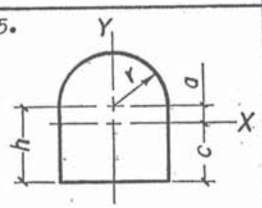


$L = \pi r + 2h$; $a = h - c$;

$I_x = \frac{2}{3}h^3 + \frac{\pi}{2}r^3 - 2hac + ra(4r + \pi a)$;

$I_y = \frac{r^2}{2}(\pi r + 4h)$; $c = \frac{2r^2 + \pi rh + h^2}{\pi r + 2h}$;

65.

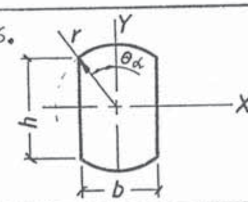


$L = r(\pi + 2) + 2h$; $a = h - c$;

$I_x = \frac{2}{3}h^3 + \frac{\pi}{2}r^3 - 2hac + ra(4r + \pi a) + 2rc^2$; $I_y = r^2\left(2h + \frac{\pi r}{2} + \frac{2r}{3}\right)$;

$c = \frac{2r^2 + \pi rh + h^2}{r(\pi + 2) + 2h}$;

66.

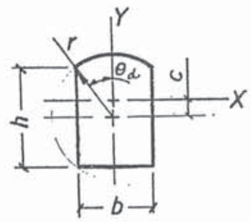


$L = 4r(\cos\alpha + \theta)$; $b = 2r\sin\alpha$; $h = 2r\cos\alpha$;

$I_x = r^3\left(\frac{4}{3}\cos^3\alpha + \sin 2\alpha + 2\theta\right)$;

$I_y = r^3(2\sin 2\alpha\sin\alpha - \sin 2\alpha + 2\theta)$;

67.



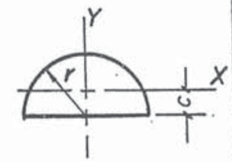
$L = 2r(\sin\alpha + 2\cos\alpha + \theta)$; $b = 2r\sin\alpha$;

$c = \frac{2r^2\sin\alpha(1 - \cos\alpha)}{L}$; $h = 2r\cos\alpha$;

$I_x = r^3\left[2\cos^2\alpha\left(\sin\alpha + \frac{2}{3}\cos\alpha\right) + \sin\alpha\cos\alpha + \theta\right] - Lc^2$;

$I_y = r^3\left[\frac{2}{3}\sin^2\alpha(\sin\alpha + 6\cos\alpha) - \sin\alpha\cos\alpha + \theta\right]$;

68.

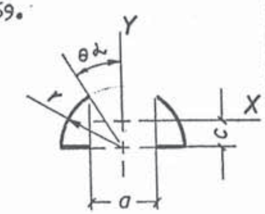


$L = r(\pi + 2)$; $c = \frac{2r}{\pi + 2} \simeq .389r$;

$I_x = \frac{r^3(\pi + 4)(\pi - 2)}{2(\pi + 2)} \simeq .793r^3$

$I_y = r^3\left(\frac{2}{3} + \frac{\pi}{2}\right) \simeq 2.237r^3$

69.



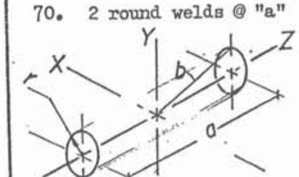
$L = rk$; $k = \pi + 2(1 - \sin\alpha - \theta)$;

$c = \frac{2r(1 - \sin\alpha)}{k}$;

$I_x = r^3\left(\frac{\pi}{2} - \theta - \sin\alpha\cos\alpha - \frac{4(1 - \sin\alpha)^2}{k}\right)$;

$I_y = r^3\left[\frac{\pi}{2} - \theta + \sin\alpha\cos\alpha + \frac{2}{3}(1 - \sin^3\alpha)\right]$;

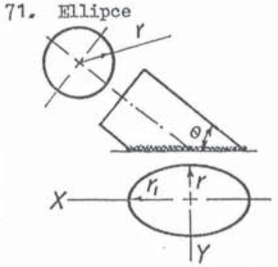
70. 2 round welds @ "a"



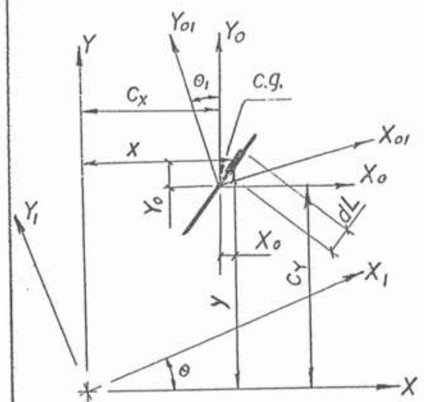
$L = 4\pi r$; $b = \frac{\sqrt{4r^2 + a^2}}{2}$;

$I_x = I_y = \pi r(2r^2 + a^2)$; $I_z = J = 4\pi r^3$;

$S_x = S_y = \frac{2\pi r(2r^2 + a^2)}{\sqrt{4r^2 + a^2}}$; $S_z = 4\pi r^2$;

71. Ellipce 	$L = \pi(r + r_1)$; $r_1 = \frac{r}{\sin\theta}$; $Ix = \frac{\pi r^2}{4}(r + 3r_1)$; $Iy = \frac{\pi r_1^2}{4}(3r + r_1)$; $J = \frac{\pi}{4}\left[r^3 + r_1^3 + 3rr_1(r + r_1)\right]$; $Sx = \frac{\pi r}{4}(r + 3r_1)$; $Sy = \frac{\pi r_1}{4}(3r + r_1)$;

WELD PROPERTIES OF ANY PLANE PATTERN



1. Area of weld – L(in)

$L = \int_L dL$

dL – infinitesimal length

2. Moment of area – $\overline{M}(in^2)$

(x,y coordinates)

$\overline{Mx} = \int_L dL \cdot y$; $\overline{My} = \int_L dL \cdot x$;

3. Center of gravity – c(in)

$c_x = \frac{\overline{My}}{L}$; $c_y = \frac{\overline{Mx}}{L}$;

4. Moment of inertia – $I(in^3)$

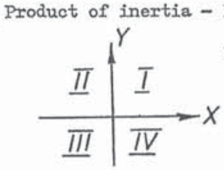
(x_o, y_o coordinates)

$Ix_o = \int_L Y_o^2 \cdot dL$; $Iy_o = \int_L X_o^2 \cdot dL$;

5. Polar moment of inertia – $J(in^3)$

$$J_o = \int_L (X_o^2 + Y_o^2)dL = Ix_o + Iy_o$$

6. Product of inertia – $Ixy(in^3)$



$$Ix_oy_o = \int_L X_oY_o \cdot dL$$

Positive in the 1st and 3rd quadrant, and negative in the 2nd and 4th quadrant.

7. Moment of inertia about parallel axis (x,y)

$$Ix = Ix_o + c_yL; \quad Iy = Iy_o + c_xL;$$

$$Ixy = Ix_oy_o + c_xc_yL;$$

8. Moment of inertia about any axis $(x_1 y_1)$

$$Ix_1 = Ix\cos^2\theta + Iy\sin^2\theta - Ixy\sin2\theta$$

$$Iy_1 = Ix\sin^2\theta + Iy\cos^2\theta + Ixy\sin2\theta$$

$$J = Ix + Iy = Ix_1 + Iy_1$$

$$Ix_1y_1 = Ixy\cos2\theta - \frac{1}{2}(Iy - Ix)\sin2\theta$$

If weld properties have at least one axis of symmetry, $I_{xoyo} = 0$

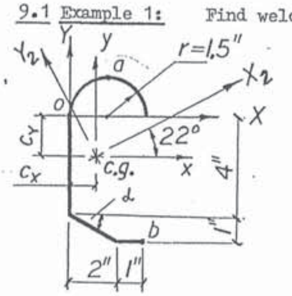
and $I_{xo_1} = I_{xo} \cos^2\theta_1 + I_{yo} \sin^2\theta_1$

$I_{yo_1} = I_{xo} \sin^2\theta_1 + I_{yo} \cos^2\theta_1$

If also $I_{xo} = I_{yo}$ then $I_{xo} = I_{yo} = I_{xo_1} = I_{yo_1} = I$

9. Practical way to find weld properties treating as a line

9.1 Example 1: Find weld properties as shown. (Ref. formulas 1,10,53)



1. Divide weld on four elements and locate base lines X & Y with original at point "O".

2. Area of weld. $L = \sum l$;

$\tan\alpha = 1/2$; $\alpha = 26.565°$

$L = 1 + 2/\cos\alpha + 4 + 1.5\pi =$

$= 1 + 2.236 + 4 + 4.712 = 11.95$ in

3. Moments of area. $\overline{M}_x = \sum l \cdot y$;

$\overline{M}_y = \sum l \cdot x$;

$$\overline{M}_x = 1(-5) + 2.236(-4.5) + 4(-2) + 4.712\left(\frac{2 \times 1.5}{\pi}\right) = -18.56 \text{ in}^2$$

$$\overline{M}_y = 1(2.5) + 2.236(1) + 4.712(1.5) = 11.8 \text{ in}^2$$

4. Center of gravity. $c_x = \frac{\overline{M}_y}{L}$; $c_y = \frac{\overline{M}_x}{L}$;

$$c_x = \frac{11.8}{11.95} = 1 \text{ in} \qquad c_y = \frac{-18.56}{11.95} = -1.55 \text{ in}$$

5. Moments of inertia about c.g. $I_x = \sum I_{xo} + \sum l \cdot y^2$;

$I_y = \sum I_{yo} + \sum l \cdot x^2$;

Where I_{xo}, I_{yo} – moments of inertia of each element about its own c.g.

x, y – distances from c.g. of weld pattern to c.g. of an element

$$I_x = \frac{1^2 \times 2.236}{12} + \frac{4^3}{12} + .3 \times 1.5^3 + 1(5 - 1.55)^2 +$$

$$+ 2.236(4.5 - 1.55)^2 + 4(2 - 1.55)^2 + 4.712(1.55 + .95)^2 =$$

$$= 68.15 \text{ in}^3$$

$$I_y = \frac{1^3}{12} + \frac{2.236 \times 2^2}{12} + \frac{1.5^3\pi}{2} + 1(2.5 - 1)^2 + 2.236(1 - 1)^2 +$$

$$+ 4(1)^2 + 4.712(1.5 - 1)^2 = 13.56 \text{ in}^3$$

6. Polar moment of inertia. $J = I_x + I_y =$

$= 68.15 + 13.56 = 81.7$ in^3

7. Sections modulus. $S_x = \frac{I_x}{y}$; $S_y = \frac{I_y}{x}$;

Where x, y – distances from c.g. of weld pattern to desired points of weld.

For point "a" $S_{xa} = \frac{68.15}{1.55 + 1.5} = 22.3$ in^2

For point "b" $S_{xb} = \frac{68.15}{5 - 1.55} = 19.75$ in^2 $S_{yb} = \frac{13.56}{3 - 1} = 6.78$ in^2

9.2 Find weld properties about X_2 & Y_2 coordinates which are rotated 22° from original position.

1. Product of inertia. $I_{xy} = \sum l \cdot x \cdot y$;

Cont. example 1. $I_{xy} = 1(1.5)(-3.45) + 2.236(0)(-2.95) +$

$+ 4(-1)(-.45) + 4.712(1.55 + .95)(.5) = 2.5$ in^3

2. Moments of inertia.

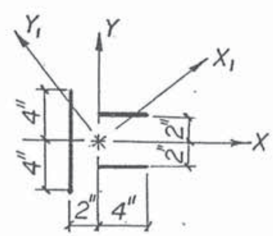
$I_{x2} = 68.15\cos^2 22 + 13.56\sin^2 22 - 2.5\sin 44 = 58.7$ in^3

$I_{y2} = 68.15\sin^2 22 + 13.56\cos^2 22 + 2.5\sin 44 = 23$ in^3

3. Check polar moment of inertia.

$J = 58.7 + 23 = 81.7$ in^3

9.3 Example 2:



$L = 4 \times 2 + 8 = 16$ in

$c_x = \frac{4 \times 2 \times 2 - 8 \times 2}{16} = 0$

$c_y = 0$

$I_x = \frac{8^3}{12} + 2 \times 4 \times 2^2 = 74.67$ in^3

$I_y = 2\frac{4^3}{12} + 8 \times 2^2 + 2 \times 4 \times 2^2 =$

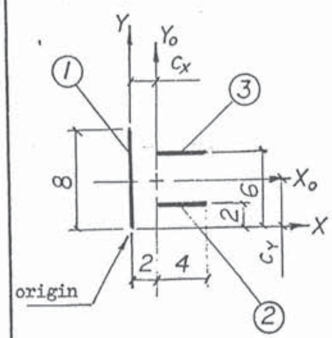
$= 74.67$ in^3

$Ixy = 8 \times (-2) \times (0) + 4 \times 2 \times 2 + 4 \times 2 \times (-2) = 0$

$Ix_1 y_1 = 0$

$Ix = Iy = Ix_1 = Iy_1$, but section modulus is different due to different distances to extreme points.

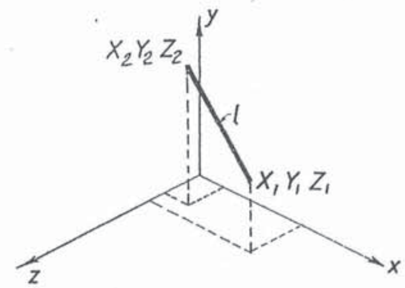
10. Sample of calculation with using programmable calculator TI - 59



WP-1

input	①	0.	Y
		0.	X
		8.	L
	②	2.	X
		2.	Y
		4.	L
	③	2.	X
		6.	Y
		4.	L
		16.00	ΣL
		2.00	CX
		4.00	CY
output		74.67	IX
		74.67	IY
		149.33	IZ
		18.67	SXB
		18.67	SXT
		37.33	SYL
		18.67	SYR

PROPERTIES OF THREE-DIMENSIONAL WELD (Straight lines)



Notation:

$X_1Y_1Z_1X_2Y_2Z_2$ - coordinates of each weld (l_i)

$l_1 l_2 l_3 \dots l_i$ - length of each weld

$c_x\ c_y\ c_z$ - coordinates of c.g. of weld pattern

L - total length (area) of weld

Ix Iy Iz - moments of inertia of weld pattern with respect to c.g of weld

$$l_i = \sqrt{(X_1 - X_2)^2 + (Y_1 - Y_2)^2 + (Z_1 - Z_2)^2}; \quad L = \sum_1^n l_i$$

$$c_x = \frac{\sum[l_i(X_1 + X_2)]}{2L}; \quad c_y = \frac{\sum[l_i(Y_1 + Y_2)]}{2L}; \quad c_z = \frac{\sum[l_i(Z_1 + Z_2)]}{2L};$$

Let: $A_i = (X_1^2 + X_2^2 + X_1X_2)$; $B_i = (Y_1^2 + Y_2^2 + Y_1Y_2)$;

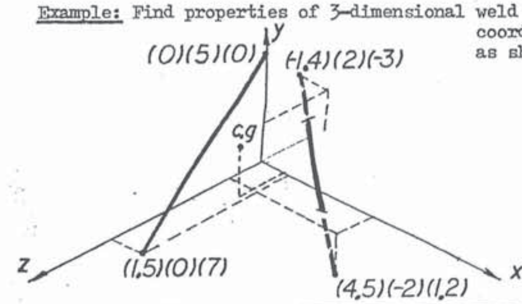
$C_i = (Z_1^2 + Z_2^2 + Z_1Z_2)$;

Then: $$Ix = \frac{1}{3}\sum[l_i(B_i + C_i)] - L(c_y^2 + c_z^2);$$

$$Iy = \frac{1}{3}\sum[l_i(A_i + C_i)] - L(c_x^2 + c_z^2);$$

$$Iz = \frac{1}{3}\sum[l_i(A_i + B_i)] - L(c_x^2 + c_y^2);$$

Example: Find properties of 3-dimensional weld pattern with coordinates X,Y,Z as shown



$$L = \sqrt{(1.5 - 0)^2 + (0 - 5)^2 + (7 - 0)^2} + \sqrt{[4.5 - (-1.4)]^2 + [(-2) - 2]^2 + [1.2 - (-3)]^2} = 8.73 + 8.27 = 17.0$$

$$c_x = \frac{8.73(1.5 + 0) + 8.27[4.5 + (-1.4)]}{2 \times 17} = 1.14$$

$$c_y = \frac{8.73(0 + 5) + 8.27[(-2) + 2]}{34} = 1.28$$

$$c_z = \frac{8.73(7 + 0) + 8.27[1.2 + (-3)]}{34} = 1.36$$

$A_1 = 1.5^2 + 0^2 + 1.5 \times 0 = 2.25$; $A_2 = 4.5^2 + 1.4^2 + 4.5(-1.4) = 15.91$

$B_1 = 0^2 + 5^2 + 0 \times 5 = 25$ $\qquad$ $B_2 = 2^2 + 2^2 + (-2)(2) = 4$

$C_1 = 7^2 + 0^2 + 7 \times 0 = 49$ $\qquad$ $C_2 = 1.2^2 + 3^2 + 1.2(-3) = 6.84$

$$Ix = \frac{1}{3}[8.73(25 + 49) + 8.27(4 + 6.84)] - 17(1.28^2 + 1.36^2) = 185.9$$

$$Iy = \frac{1}{3}[8.73(2.25 + 49) + 8.27(15.91 + 6.84)] - 17(1.14^2 + 1.36^2) = 158.3$$

$$Iz = \frac{1}{3}[8.73(2.25 + 25) + 8.27(15.91 + 4)] - 17(1.14^2 + 1.28^2) = 84.2$$

Same problem can be solved by using TI - 59 programmable calculator:

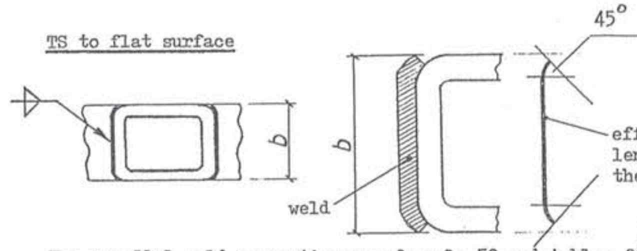
(Discrepancy in the results is due to more accurate calculation by computer)

WP-31

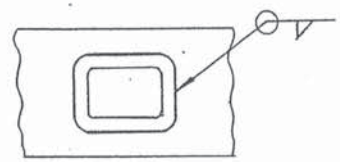
input	1.5	X1
	0.	X2
	0.	Y1
	5.	Y2
	7.	Z1
	0.	Z2
	-1.4	X1
	4.5	X2
	2.	Y1
	-2.	Y2
	-3.	Z1
	1.2	Z2
output	17.01	L
	1.14	CX
	1.28	CY
	1.36	CZ
	185.84	IX
	158.42	IY
	84.13	IZ

WELDING OF STRUCTUTAL TUBING (TS)

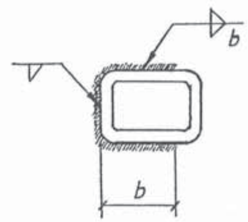
TS to flat surface



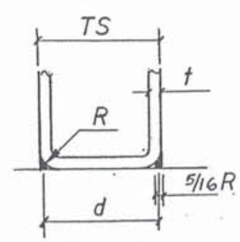
For parallel weld properties see formula 50 and tables 21, 22.



For weld all around properties see formula 49 and tables 19,20.



For C-weld properties see formula 51.

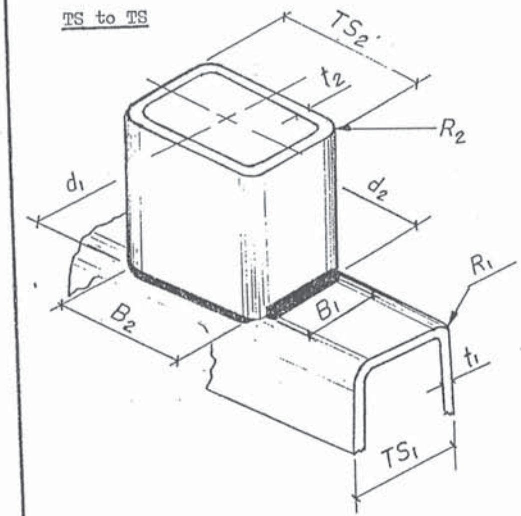


Distance between flare-bevel welds can be assumed as:

$d = TS - \frac{1}{4}R$ or

for $R = 2t$ $\quad d = TS - \frac{t}{2}$

TS to TS



Weld length can be assumed as:

$B_1 = TS_1 - R$

$R = R_1$ or $R = R_2$ whichever is grater.

For $R = 2t$

$B_1 = TS_1 - 2t_{(1 \text{ or } 2)}$

Distance between welds:

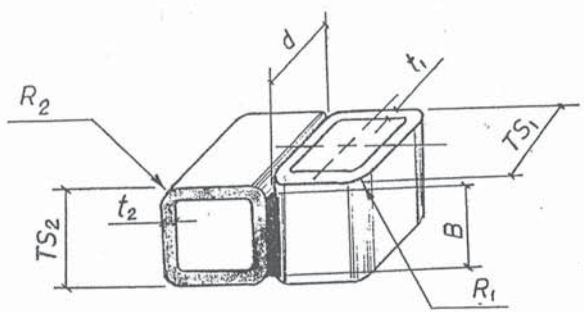
$d_2 = TS_2$

$B_2 = TS_2 - R_2$ or

$B_2 = TS_2 - 2t_2$

$d_1 = TS_1 - \frac{R_1}{4}$ or

$d_1 = TS_1 - \frac{t_1}{2}$



$B = TS_2 - R_2$ or for $R = 2t$ $B = TS_2 - 2t_2$

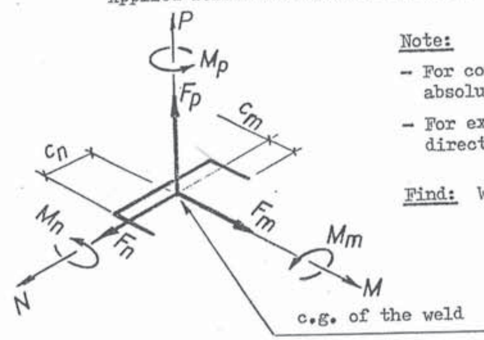
$d = TS_1 - \frac{R_1}{4}$ or $d = TS_1 - \frac{t_1}{2}$

WELD STRESS FOR VARIOUS WELD PATTERNS

1. Find properties of weld pattern
2. Determine applied forces and moments with respect to the center of gravity of the weld
3. Weld stress formulas

Data: Weld properties (L, Sm, Sn, J, c_m, c_n)

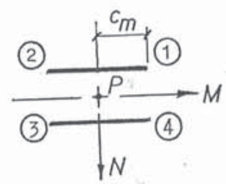
Applied forces and moments (Fm, Fn, Fp, Mm, Mn, Mp)



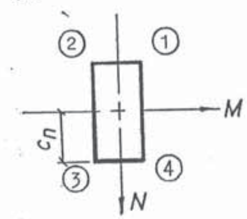
Note:

- For conservative formulas use absolute values for F and M
- For exact solutions consider direction of F and M

Find: Weld stress



or:



Conservative formula:

$$f_w = \left[\left(\frac{Fp}{L} + \frac{Mm}{Sm} + \frac{Mn}{Sn}\right)^2 + \left(\frac{Fm}{L} + \frac{Mp}{J}Cn\right)^2 + \left(\frac{Fn}{L} + \frac{Mp}{J}Cm\right)^2\right]^{1/2}$$

Exact solution @ points 1,2,3,4:

$f_p = \frac{Fp}{L}$; $f_m = \frac{Fm}{L}$; $f_n = \frac{Fn}{L}$;

$f_{pm} = \frac{Mm}{Sm}$; $f_{pn} = \frac{Mn}{Sn}$;

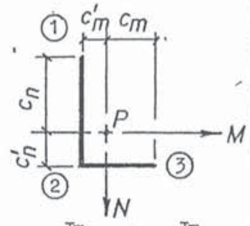
$f_{mp} = \frac{Mp}{J}Cn$; $f_{np} = \frac{Mp}{J}Cm$;

$$f_1 = \left[(f_p + f_{pm} + f_{pn})^2 + (f_m - f'_{mp})^2 + (f_n - f_{np})^2\right]^{1/2}$$

$$f_2 = \left[(f_p + f_{pm} - f_{pn})^2 + (f_m - f_{mp})^2 + (f_n + f_{np})^2\right]^{1/2}$$

$$f_3 = \left[(f_p - f_{pm} - f_{pn})^2 + (f_m + f_{mp})^2 + (f_n + f_{np})^2\right]^{1/2}$$

$$f_4 = \left[(f_p - f_{pm} + f_{pn})^2 + (f_m + f_{mp})^2 + (f_n - f_{np})^2\right]^{1/2}$$

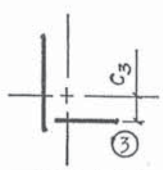


$S_m = \frac{I_m}{C_n}$; $S'_m = \frac{I_m}{C'_n}$;

$S_n = \frac{I_n}{C_m}$; $S'_n = \frac{I_n}{C'_m}$;

or:

or:



Here, for point 3

$S'_m = \frac{I_m}{C_3}$

<u>Conservative formula:</u>

$$f_w = \left[\left(\frac{F_p}{L} + \frac{M_m}{S_m} + \frac{M_n}{S_n}\right)^2 + \left(\frac{F_m}{L} + \frac{M_p}{J} C_n\right)^2 + \left(\frac{F_n}{L} + \frac{M_p}{J} C_m\right)^2\right]^{1/2}$$

<u>Exact solution @ points 1,2,3:</u>

$f_p = \frac{F_p}{L}$; $f_m = \frac{F_m}{L}$; $f_n = \frac{F_n}{L}$;

$f_{pm} = \frac{M_m}{S_m}$; $f'_{pm} = \frac{M_m}{S'_m}$; $f'_{pn} = \frac{M_n}{S'_n}$;

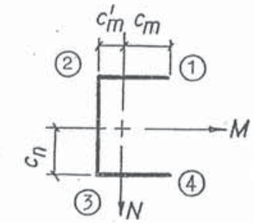
$f_{pn} = \frac{M_n}{S_n}$; $f_{mp} = \frac{M_p}{J} C_n$; $f'_{mp} = \frac{M_p}{J} C'_n$;

$f'_{np} = \frac{M_p}{J} C'_m$; $f_{np} = \frac{M_p}{J} C_m$

$$f_1 = \left[(f_p + f_{pm} - f'_{pn})^2 + (f_m - f_{mp})^2 + (f_n + f'_{np})^2\right]^{1/2}$$

$$f_2 = \left[(f_p - f'_{pm} - f'_{pn})^2 + (f_m + f'_{mp})^2 + (f_n + f'_{np})^2\right]^{1/2}$$

$$f_3 = \left[(f_p - f'_{pm} + f_{pn})^2 + (f_m + f'_{mp})^2 + (f_n - f_{np})^2\right]^{1/2}$$



$S_n = \frac{I_n}{C_m}$; $S'_n = \frac{I_n}{C'_m}$;

<u>Conservative formula:</u>

$$f_w = \left[\left(\frac{F_p}{L} + \frac{M_m}{S_m} + \frac{M_n}{S_n}\right)^2 + \left(\frac{F_m}{L} + \frac{M_p}{J} C_n\right)^2 + \left(\frac{F_n}{L} + \frac{M_p}{J} C_m\right)^2\right]^{1/2}$$

<u>Exact solution @ points 1,2,3,4:</u>

$f_p = \frac{F_p}{L}$; $f_m = \frac{F_m}{L}$; $f_n = \frac{F_n}{L}$;

$f_{pm} = \frac{M_m}{S_m}$; $f_{pn} = \frac{M_n}{S_n}$; $f'_{pn} = \frac{M_n}{S'_n}$;

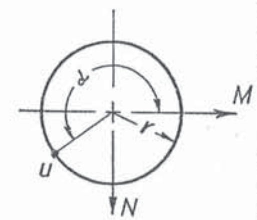
$f_{mp} = \frac{M_p}{J} C_n$; $f_{np} = \frac{M_p}{J} C_m$; $f'_{np} = \frac{M_p}{J} C'_m$

$$f_1 = \left[(f_p + f_{pm} + f_{pn})^2 + (f_m - f_{mp})^2 + (f_n - f_{np})^2\right]^{1/2}$$

$$f_2 = \left[(f_p + f_{pm} - f'_{pn})^2 + (f_m - f_{mp})^2 + (f_n + f'_{np})^2\right]^{1/2}$$

$$f_3 = \left[(f_p - f_{pm} - f'_{pn})^2 + (f_m + f_{mp})^2 + (f_n + f'_{np})^2\right]^{1/2}$$

$$f_4 = \left[(f_p - f_{pm} + f_{pn})^2 + (f_m + f_{mp})^2 + (f_n - f_{np})^2\right]^{1/2}$$



$f' = \frac{M_p}{J} r$

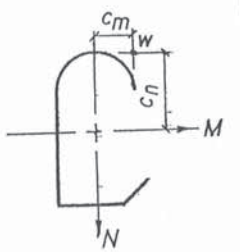
<u>Conservative formula:</u>

$$f_w = \left[\left(\frac{F_p}{L} + \frac{\sqrt{M_m^2 + M_n^2}}{S}\right)^2 + \left(\frac{\sqrt{F_m^2 + F_n^2}}{L} + f'\right)^2\right]^{1/2}$$

<u>Exact solution @ any point "u":</u>

$$f_u = \left[\left(\frac{F_p}{L} + \frac{M_m}{S}\sin\alpha + \frac{M_n}{S}\cos\alpha\right)^2 + \left(\frac{F_m}{L} - f'\cdot\sin\alpha\right)^2 + \left(\frac{F_n}{L} - f'\cdot\cos\alpha\right)^2\right]^{1/2}$$

Any weld pattern



Conservative formula:

We can select some imaginary (or real) point with maximum distances from c.g.

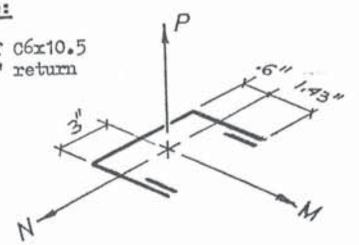
Then:

$$f_w = \left[\left(\frac{F_p}{L} + \frac{M_m}{I_m}C_n + \frac{M_n}{I_n}C_m\right)^2 + \left(\frac{F_m}{L} + \frac{M_p}{J}C_n\right)^2 + \left(\frac{F_n}{L} + \frac{M_p}{J}C_m\right)^2\right]^{1/2}$$

Exact solution @ any point should consider real direction of applied forces and moments and actual coordinates of the point.

Example:

Weld of C6x10.5 with 1" return



Data:

$F_m = -380$ lb

$F_n = 2000$ lb

$F_p = -1500$ lb

$M_m = 32000$ lb-in

$M_n = 5000$ lb-in

$M_p = -7200$ lb-in

From table 15 weld properties are:

$L = 12.1$ in

$C_m' = .6$ in; $C_m = 2.03 - .6 = 1.43$ in

$C_n = 3$ in

$S_m = 22.9$ in^2

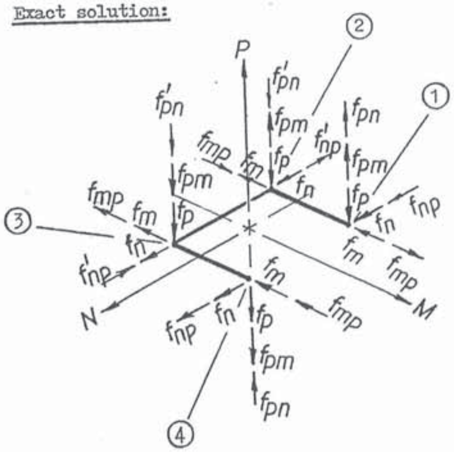
$S_n = 4.3$ in^2; $S_n' = 10.3$ in^2

$J = 74.9$ in^3

Conservative formula: (Use absolute values of |F| and |M|)

$$f_w = \left[\left(\frac{1500}{12.1} + \frac{32000}{22.9} + \frac{5000}{4.3}\right)^2 + \left(\frac{380}{12.1} + \frac{7200}{74.9}\cdot 3\right)^2 + \left(\frac{2000}{12.1} + \frac{7200}{74.9}1.43\right)^2\right]^{1/2} = 2720 \text{ lb/in}$$

Exact solution:



$f_p = \frac{-1500}{12.1} = -124$ lb

$f_m = \frac{-380}{12.1} = -31$ lb

$f_n = \frac{2000}{12.1} = 165$ lb

$f_{pm} = \frac{32000}{22.9} = 1397$ lb

$f'_{pn} = \frac{5000}{10.3} = 485$ lb

$f_{pn} = \frac{5000}{4.3} = 1163$ lb

$f_{mp} = \frac{-7200}{74.9}\,3 = -288$ lb

$f_{np} = (-96)(1.43) = -137$ lb

$f'_{np} = (-96)(.6) = -58$ lb

$$f_1 = \left[(-124 + 1397 + 1163)^2 + (-31 - (-288))^2 + (165 - (-137))^2\right]^{1/2} = 2468 \text{ lb/in}$$

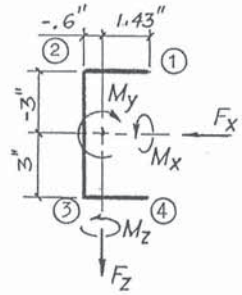
$$f_2 = \left[(-124 + 1397 - 485)^2 + (-31 - (-288))^2 + (165 + (-58))^2\right]^{1/2} = 836 \text{ lb/in}$$

$$f_3 = \left[(-124 - 1397 - 485)^2 + (-31 + (-288))^2 + (165 + (-58))^2\right]^{1/2} = 2034 \text{ lb/in}$$

$$f_4 = \left[(-124 - 1397 + 1163)^2 + (-31 + (-288))^2 + (165 - (-137))^2\right]^{1/2} = 567 \text{ lb/in}$$

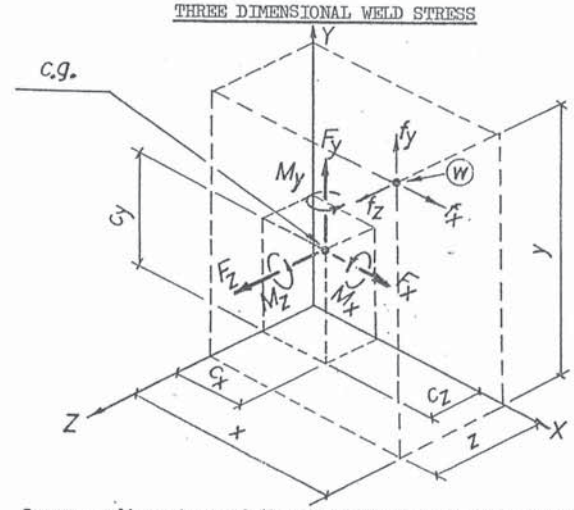
Same problem can be solved by using TI - 59 programmable calculator.

Discrepancy in the results is due to
more accurate calculation by computer.




```
WS-1
       0.      A
       0.      B
     12.1      L
     68.7      IX
     6.18      IZ
       0.      X
       0.      Y
       0.      Z
    -380.      FX
   -1500.      FY
    2000.      FZ
   32000.      MX
   -7200.      MY
    5000.      MZ

     -0.6      *A
       3.      *B
    2035.      *W

     -0.6      *A
      -3.      *B
     836.      *W

     1.43      *A
       3.      *B
     572.      *W

     1.43      *A
      -3.      *B
    2463.      *W
```


THREE DIMENSIONAL WELD STRESS

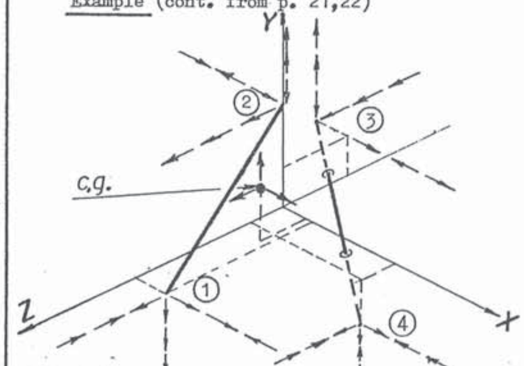


Corresponding signs of the applied forces,moments and coordinates automatically will give correct value of weld stress.

At point "w":

$$f_w = \Big[\Big(\frac{Fx}{L} + \frac{My}{Iy}(z - c_z) - \frac{Mz}{Iz}(y - c_y)\Big)^2 + \Big(\frac{Fy}{L} - \frac{Mx}{Ix}(z - c_z) + \frac{Mz}{Iz}(x - c_x)\Big)^2 + \Big(\frac{Fz}{L} + \frac{Mx}{Ix}(y - c_y) - \frac{My}{Iy}(x - c_x)\Big)^2\Big]^{1/2}$$

Example (cont. from p. 21,22)



Fx = 2700 lb

Fy = -1500 lb

Fz = 6400 lb

Mx = 17500 lb-in

My = 92000 lb-in

Mz = -9000 lb-in

For weld properties
see p. 21,22

At each point of weld:

$$f_x = \frac{2700}{17} = 159; \qquad f_y = \frac{-1500}{17} = -88; \qquad f_z = \frac{6400}{17} = 376;$$

$$\frac{Mx}{Ix} = \frac{17500}{185.9} = 94.1; \quad \frac{My}{Iy} = \frac{92000}{158.3} = 581.2 \quad \frac{Mz}{Iz} = \frac{-9000}{84.2} = -106.9$$

$$f_1 = \Big[(159 + 581.2(7 - 1.36) + 106.9(0 - 1.28))^2 +$$
$$+ (-88 - 94.1(5.64) - 106.9(1.5 - 1.14))^2 +$$
$$+ (376 + 94.1(-1.28) - 581.2(.36))^2\Big]^{1/2} = 3365 \text{ lb/in}$$

$$f_2 = \Big[(159 + 581.2(-1.36) + 106.9(5 - 1.28))^2 +$$
$$+ (-88 - 94.1(-1.36) - 106.9(0 - 1.14))^2 +$$
$$+ (376 + 94.1(3.72 - 581.2(-1.14))^2\Big]^{1/2} = 1417 \text{ lb/in}$$

$$f_3 = \Big[(159 + 581.2(-3 - 1.36) + 106.9(2 - 1.28))^2 +$$
$$+ (-88 - 94.1(-4.36) - 106.9(-1.4 - 1.14))^2 +$$
$$+ (376 + 94.1(.72) - 581.2(-2.54))^2\Big]^{1/2} = 3053 \text{ lb/in}$$

$$f_4 = \Big[(159 + 581.2(1.2 - 1.36) + 106.9(-2 - 1.28))^2 +$$
$$+ (-88 - 94.1(-.16) - 106.9(4.5 - 1.14))^2 +$$
$$+ (376 + 94.1(-3.28) - 581.2(3.36))^2\Big]^{1/2} = 1955 \text{ lb/in}$$

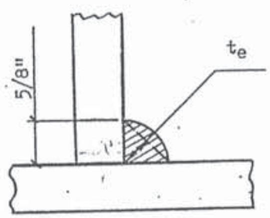
Same problem can be solved by using TI-59 programmable calculator:

```
WS-31
    17.      L
    1.14     CX
    1.28     CY
    1.36     CZ
   185.9     IX
   158.3     IY
    84.2     IZ
  2700.      FX
 -1500.      FY
  6400.      FZ
 17500.      MX
 92000.      MY
 -9000.      MZ

    1.5      X
    0.       Y
    7.       Z
  3365.      FW

    0.       X
    5.       Y
    0.       Z
  1418.      FW

   -1.4      X
    2.       Y
   -3.       Z
  3053.      FW

    4.5      X
   -2.       Y
    1.2      Z
  1955.      FW
```

TABLE 1

ALLOWABLE LOADS FOR VARIOUS SIZES OF FILLET WELDS (lb/in)

Leg Size	E60XX	E70XX	
		Base Metal Fy = 36 ksi	Base Metal Fy > 37.1 ksi
1"	12,728	14,400	14,849
7/8"	11,137	12,600	12,993
3/4"	9,546	10,800	11,137
5/8"	7,955	9,000	9,281
1/2"	6,364	7,200	7,425
7/16"	5,568	6,300	6,497
3/8"	4,773	5,400	5,568
5/16"	3,977	4,500	4,640
1/4"	3,182	3,600	3,712
3/16"	2,386	2,700	2,784
1/8"	1,591	1,800	1,856
1/16"	795	900	928



$$t_e = \frac{.625}{\sqrt{2}} = .442 \text{ in}$$

Example: (Ref. AISC, 8th Edition Spec. 1.5.3)

For E60 $F_{al} = 60(.3)(.442) = 7.96$ k/in

For E70 $F_{al} = 70(.3)(.442) = 9.28$ k/in

For A-36 steel $F_y = 36.0$ ksi

$F_{al} = 36(.4)(.625) = 9.0$ k/in

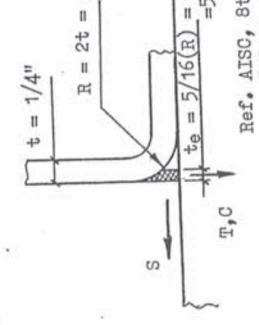
TABLE 2

ALLOWABLE LOADS FOR VARIOUS STRUCTURAL TUBING OF FLARE BEVEL WELDS (lb/in)* (For R = 2t)

Here: S - Allowable shear on effective area (lb/in)
T - Allowable tension normal to effective area (lb/in)
C - Allowable compression normal to effective area (lb/in)

Electrode		E 60 XX								E 70 XX				
Base Metal Fy(ksi)		36.0			42.0			≥45.0		50.0			≥52.5	
Allowable		S	T	C	S	T	C	S,T	C	S	T	C	S,T	C
Wall thickness (in)	3/16"	1,687	2,109	4,219	1,969	2,109	4,922	2,109	$C = F_y \cdot t_e$	2,344	2,461	5,859	2,461	$C = F_y \cdot t_e$
	1/4"	2,250	2,812	5,625	2,625	2,812	6,562	2,812		3,125	3,281	7,812	3,281	
	5/16"	2,812	3,516	7,031	3,281	3,516	8,203	3,516		3,906	4,101	9,766	4,101	
	3/8"	3,375	4,219	8,437	3,937	4,219	9,844	4,219		4,687	4,922	11,719	4,922	
	1/2"	4,500	5,625	11,250	5,250	5,625	13,125	5,625		6,250	6,562	15,625	6,562	
	5/8"	5,625	7,031	14,062	6,562	7,031	16,406	7,031		7,812	8,203	19,531	8,203	

Example:



Ref. AISC, 8th Edition,
* Spec. 1.5.3
** Spec. 1.14.6.1.3

Electrode E60 $F_y = 60.0$ ksi; $F_{al} = 60000(.3)(\frac{5}{32}) = 2812$ lb/in

Steel A-42 $F_y = 42.0$ ksi; Allowable:

t = 1/4"

Shear $S = 42000(.4)(\frac{5}{32}) = 2625$ lb/in

Tension $T = 42000(.6)(\frac{5}{32}) = 3937$ lb/in

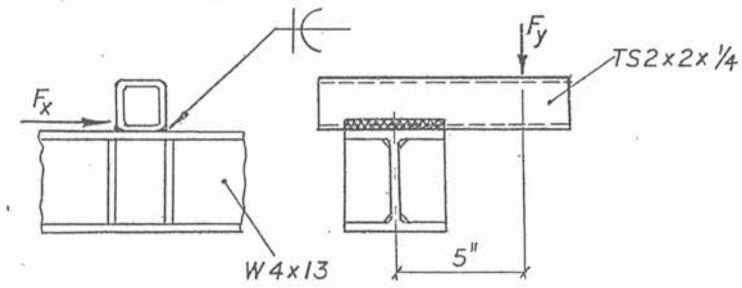
Compression $C = 42000(\frac{5}{32}) = 6562$ lb/in

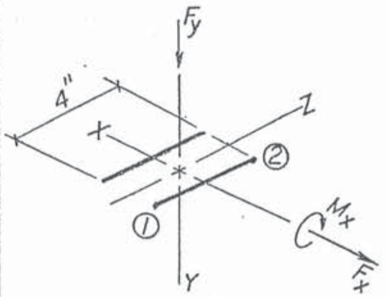
Therefore allowable:

S = 2,625 lb/in (Restricted by base metal)
T = 2,812 lb/in (Restricted by weld metal)
C = 6,562 lb/in (Restricted by base metal)

Example:

Check weld between TS 2x2x1/4 (F_y = 42.0 ksi) and W 4x13 (F_y = 36.0 ksi), Electrode E 60 XX





1. Weld properties:

   b = 4 in; L = 8 in;

   $S_x = \frac{4^2}{3} = 5.33\ in^2$

2. Applied forces and moments at c.g. of the weld:

   F_x = 5000 lb

   F_y = 3200 lb

   M_x = 3200 x 5 = 16000 lb-in

3. Weld stress

3.1 Conservative design:

$$f_{w_{1,2}} = \left[\left(\frac{3200}{8} + \frac{16000}{5.33}\right)^2 + \left(\frac{5000}{8}\right)^2\right]^{1/2} = 3459 \text{ lb/in}$$

Allowable loads (Table 2) for flare bevel weld (t = 1/4"; F_y = 36.0 ksi; E 60 XX)

F_s = 2250 < 3459 lb/in

F_t = 2812 < 3459 lb/in

F_c = 5625 > 3459 lb/in

More accurate design required to qualify the weld

3.2 Exact design:

3.2.1 Shear stress $f_s = \frac{5000}{8} = 625$ lb/in

3.2.2 Tensile stress (at point 1) $f_t = \frac{16000}{5.33} - \frac{3200}{8} = 2602$ lb/in

3.2.3 Compressive stress (at point 2)

$$f_c = \frac{16000}{5.33} + \frac{3200}{8} = 3402 \text{ lb/in}$$

3.2.4 Interaction formula can be used

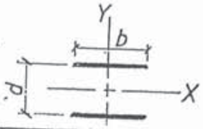
at point 1 $\left[\left(\frac{2602}{2812}\right)^2 + \left(\frac{625}{2250}\right)^2\right]^{1/2} = .966 < 1$

at point 2 $\left[\left(\frac{3402}{5625}\right)^2 + \left(\frac{625}{2250}\right)^2\right]^{1/2} = .666 < 1$

PARALLEL WELDS

(Formula 11)

TABLE 3

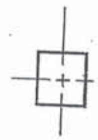


b	d	1	2	3	4	5	6	7	8	9
1	L	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	Sx	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
	Sy	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
	J	0.67	2.17	4.67	8.17	12.67	18.17	24.67	32.17	40.67
2	L	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	Sx	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0
	Sy	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33
	J	2.33	5.33	10.33	17.33	26.33	37.33	50.33	65.33	82.33
3	L	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
	Sx	3.0	6.0	9.0	12.0	15.0	18.0	21.0	24.0	27.0
	Sy	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	J	6.0	10.5	18.0	28.5	42.0	58.5	78.0	100.5	126.0
4	L	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
	Sx	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0
	Sy	5.33	5.33	5.33	5.33	5.33	5.33	5.33	5.33	5.33
	J	12.67	18.67	28.67	42.67	60.67	82.67	108.7	138.7	172.7
5	L	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	Sx	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0
	Sy	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33
	J	23.33	30.83	43.33	60.83	83.33	110.8	143.3	180.8	223.3
6	L	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
	Sx	6.0	12.0	18.0	24.0	30.0	36.0	42.0	48.0	54.0
	Sy	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
	J	39.0	48.0	63.0	84.0	111.0	144.0	183.0	228.0	279.0
7	L	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0,	14.0
	Sx	7.0	14.0	21.0	28.0	35.0	42.0	49.0	56.0	63.0
	Sy	16.33	16.33	16.33	16.33	16.33	16.33	16.33	16.33	16.33
	J	60.67	71.17	88.67	113.2	144.7	183.2	228.7	281.2	340.7
8	L	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
	Sx	8.0	16.0	24.0	32.0	40.0	48.0	56.0	64.0	72.0
	Sy	21.33	21.33	21.33	21.33	21.33	21.33	21.33	21.33	21.33
	J	89.33	101.3	121.3	149.3	185.3	229.3	281.3	341.3	409.3
9	L	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
	Sx	9.0	18.0	27.0	36.0	45.0	54.0	63.0	72.0	81.0
	Sy	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
	J	126.0	139.5	162.0	193.5	234.0	283.5	342.0	409.5	486.0
10	L	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
	Sx	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0
	Sy	33.33	33.33	33.33	33.33	33.33	33.33	33.33	33.33	33.33
	J	171.7	186.7	211.7	246.7	291.7	346.7	411.7	486.7	571.7

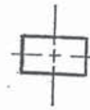
TABLE 4

SQUARE and RECTANGULAR WELDS

(Formulas 13,14)



	L	S	J
1x1	4.0	1.33	1.33
1.5x1.5	6.0	3.0	4.5
2x2	8.0	5.33	10.67
2.5x2.5	10.0	8.33	20.83
3x3	12.0	12.0	36.0
3.5x3.5	14.0	16.33	57.2
4x4	16.0	21.33	85.3
4.5x4.5	18.0	27.0	121.5
5x5	20.0	33.3	167.7
6x6	24.0	48.0	288.0
7x7	28.0	65.3	457.0
8x8	32.0	85.3	683.0
9x9	36.0	108.0	972.0
10x10	40.0	133.3	1333.0
11x11	44.0	163.3	1775.0
12x12	48.0	192.0	2304.0
14x14	56.0	261.0	3659.0
16x16	64.0	341.0	5461.0

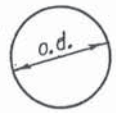


	L	Sx	Sy	J
2x1	6.0	3.33	2.33	4.5
3x1	8.0	6.0	3.33	10.67
3x2	10.0	9.0	7.33	20.83
4x2	12.0	13.33	9.33	36.0
4x3	14.0	17.33	15.0	57.2
5x2	14.0	18.33	11.33	57.2
5x3	16.0	23.33	18.0	85.3
5x4	18.0	28.33	25.33	121.5
6x2	16.0	24.0	13.33	85.3
6x3	18.0	30.0	21.0	121.5
6x4	20.0	36.0	29.33	166.7
7x3	20.0	37.3	24.0	166.7
8x2	20.0	37.3	17.33	166.7
8x3	22.0	45.3	27.0	222.0
8x4	24.0	53.3	37.3	288.0
8x6	28.0	69.3	60.0	457.0
9x3	24.0	54.0	30.0	288.0
9x6	30.0	66.0	81.0	562.0

TABLE 5

CIRCUMFERENTIAL WELD

(Formula 52)



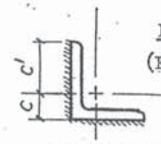
Nominal Diameter	Outside Diameter	L	S	J
1/2	0.840	2.64	0.55	0.47
3/4	1.050	3.30	0.87	0.91
1	1.315	4.13	1.36	1.79
1-1/4	1.660	5.22	2.16	3.59
1-1/2	1.900	5.97	2.84	5.39
2	2.375	7.46	4.43	10.5
2-1/2	2.875	9.03	6.49	18.7
3	3.500	11.0	9.62	33.7
3-1/2	4.000	12.6	12.6	50.3
4	4.500	14.1	15.9	71.6
5	5.563	17.5	24.3	135
6	6.625	20.8	34.5	228
8	8.625	27.1	58.4	504
10	10.750	33.8	90.8	976
12	12.750	40.1	128	1628
14	14.000	44.0	154	2155
16	16.000	50.3	201	3217
18	18.000	56.6	254	4580
20	20.000	62.8	314	6283
22	22.000	69.1	380	8363
24	24.000	75.4	452	10857
26	26.000	81.7	531	13804
28	28.000	88.0	616	17241
30	30.000	94.2	707	21206
32	32.000	101	804	25736
34	34.000	107	908	30869
36	36.000	113	1018	36643
42	42.000	132	1385	58189

TABLE 6

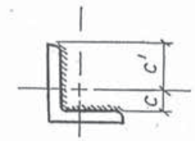
ANGLES

Equal legs

(Formula 24)



Exterior weld



Interior weld

	Angle	L	Sb	St	J	e	c'
E. W.	L8x8	16.0	53.3	17.8	213	2.00	6.00
Interior Weld	L8x8x1-1/8	13.7	39.4	13.1	135	1.72	5.16
	x 1	14.0	40.8	13.6	143	1.75	5.25
	x 7/8	14.2	42.3	14.1	151	1.78	5.35
	x 3/4	14.5	43.8	14.6	159	1.81	5.44
	x 5/8	14.7	45.3	15.1	167	1.84	5.34
	x 1/2	15.0	46.9	15.6	176	1.88	5.62
E. W.	L6x6	12.0	30.0	10.0	90.0	1.50	4.50
Interior Weld	L6x6x 1	10.0	20.8	6.94	52.1	1.25	3.75
	x 7/8	10.2	21.9	7.30	56.1	1.28	3.85
	x 3/4	10.5	23.0	7.66	60.3	1.31	3.94
	x 5/8	10.7	24.1	8.03	64.7	1.34	4.04
	x 1/2	11.0	25.2	8.40	69.3	1.38	4.12
	x 3/8	11.2	26.4	8.79	74.2	1.41	4.22
E. W.	L5x5	10.0	20.8	6.94	52.1	1.25	3.75
Interior Weld	L5x5x 7/8	8.25	14.2	4.73	29.2	1.03	3.10
	x 3/4	8.50	15.0	5.02	32.0	1.06	3.19
	x 1/2	9.00	16.9	5.63	38.0	1.13	3.37
	x 3/8	9.25	17.8	5.94	41.2	1.16	3.47
	x 5/16	9.38	18.3	6.10	42.9	1.17	3.52
E. W.	L4x4	8.00	13.3	4.44	26.7	1.00	3.00
Interior Weld	L4x4x 3/4	6.50	8.80	2.93	14.3	.81	2.44
	x 5/8	6.75	9.49	3.16	16.0	.84	2.54
	x 1/2	7.00	10.2	3.40	17.9	.88	2.62
	x 3/8	7.25	10.9	3.65	19.8	.91	2.72
	x 5/16	7.37	11.3	3.78	20.9	.92	2.77
	x 1/4	7.50	11.7	3.91	22.0	.94	2.81
E. W.	L3½x3½	7.00	10.2	3.40	17.9	.88	2.62
Int. Weld	L3½x3½x 3/8	6.25	8.14	2.71	12.7	.78	2.35
	x5/16	6.38	8.47	2.82	13.5	.80	2.39
	x 1/4	6.50	8.80	2.93	14.3	.81	2.44

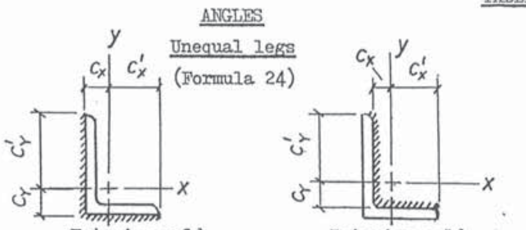
	Angle	L	Sb	St	J	c	c'
E. W.	L3x3	6.00	7.50	2.50	11.2	.75	2.25
Interior Weld	L3x3x 1/2	5.00	5.21	1.74	6.51	.63	1.87
	x 3/8	5.25	5.74	1.91	7.54	.66	1.97
	x 5/16	5.38	6.02	2.01	8.09	.67	2.02
	x 1/4	5.50	6.30	2.10	8.67	.69	2.06
	x 3/16	5.63	6.59	2.20	9.27	.70	2.11
E. W.	L2½x2½	5.00	5.21	1.74	6.51	.63	1.87
Int. Weld	L2½x2½x 3/8	4.25	3.76	1.25	4.00	.53	1.60
	x5/16	4.38	3.99	1.33	4.36	.55	1.64
	x 1/4	4.50	4.22	1.41	4.75	.56	1.69
	x3/16	4.63	4.46	1.49	5.15	.58	1.73
E. W.	L2x2	4.00	3.33	1.11	3.33	.50	1.50
Interior Weld	L2x2x 3/8	3.25	2.20	.73	1.79	.41	1.22
	x 5/16	3.38	2.37	.79	2.00	.42	1.27
	x 1/4	3.50	2.55	.85	2.23	.44	1.31
	x 3/16	3.62	2.74	.91	2.48	.45	1.36
	x 1/8	3.75	2.93	.98	2.75	.47	1.40
E. W.	L1¾x1¾	3.50	2.55	.85	2.23	.44	1.31
Int. Weld	L1¾x1¾x 1/4	3.00	1.87	.62	1.41	.37	1.13
	x3/16	3.12	2.03	.68	1.59	.39	1.17
	x 1/8	3.25	2.20	.73	1.79	.41	1.22
E. W.	L1½x1½	3.00	1.87	.62	1.41	.37	1.13
Int. Weld	L1½x1½x 1/4	2.50	1.30	.43	.81	.31	.94
	x3/16	2.62	1.43	.48	.94	.33	.98
	x 1/8	2.75	1.57	.52	1.08	.34	1.03
E. W.	L1¼x1¼	2.50	1.30	.43	.81	.31	.94
Int. Weld	L1¼x1¼x 1/4	2.00	.83	.28	.42	.25	.75
	x3/16	2.12	.94	.31	.50	.26	.80
	x 1/8	2.25	1.05	.35	.59	.28	.84
E. W.	L1x1	2.00	.83	.28	.42	.25	.75
Int. Weld	L1x1x 1/4	1.50	.47	.16	.17	.19	.56
	x 3/16	1.62	.55	.18	.22	.20	.61
	x 1/8	1.75	.64	.21	.28	.22	.66

TABLE 7

ANGLES

Unequal legs

(Formula 24)



Exterior weld   Interior weld

	Angle	L	Sxb	Sxt	Syl	Syr	J	c_x	c'_x	c_y	c'_y
E. W.	L8x6	14.0	42.7	17.1	38.0	10.4	146	1.29	4.71	2.29	5.71
Int. Weld	L8x6x1	12.0	31.5	13.0	27.5	7.24	93.0	1.04	3.96	2.04	4.96
	x3/4	12.5	34.1	13.9	30.0	7.97	105	1.10	4.15	2.10	5.15
	x1/2	13.0	36.9	14.9	32.5	8.73	118	1.16	4.34	2.16	5.34
E. W.	L8x4	12.0	32.0	16.0	24.0	4.80	101	.67	3.33	2.67	5.33
Int. Weld	L8x4x1	10.0	22.2	11.9	15.5	2.74	61.3	.45	2.55	2.45	4.55
	x3/4	10.5	24.5	12.9	17.5	3.20	70.0	.50	2.75	2.50	4.75
	x1/2	11.0	26.9	13.9	19.5	3.70	79.6	.56	2.94	2.56	4.94
E. W.	L7x4	11.0	26.8	12.5	21.3	4.74	75.3	.73	3.27	2.23	4.77
Int. Weld	L7x4x3/4	9.50	20.0	9.80	15.3	3.16	49.7	.56	2.69	2.06	4.19
	x1/2	10.0	22.2	10.7	17.2	3.65	57.5	.61	2.89	2.11	4.39
	x3/8	10.2	23.3	11.1	18.2	3.91	61.6	.64	2.99	2.14	4.49
E. W.	L6x4	10.0	22.0	9.43	18.7	4.67	54.5	.80	3.20	1.80	4.20
Inter. Weld	L6x4x3/4	8.50	16.0	7.13	13.1	3.10	34.0	.62	2.63	1.62	3.63
	x5/8	8.75	16.9	7.50	14.0	3.34	37.0	.65	2.73	1.65	3.73
	x1/2	9.00	17.9	7.87	14.9	3.59	40.2	.68	2.82	1.68	3.82
	x3/8	9.25	18.9	8.24	15.8	3.85	43.5	.71	2.92	1.71	3.92
E. W.	L6x3.5	9.50	20.0	9.23	16.0	3.62	48.2	.64	2.86	1.89	4.11
I. W.	L6x3.5x3/8	8.75	17.0	8.05	13.3	2.90	38.2	.56	2.57	1.81	3.82
	x5/16	8.88	17.5	8.24	13.8	3.02	39.7	.57	2.62	1.82	3.87
E. W.	L5x3.5	8.50	15.8	6.60	13.7	3.55	33.2	.72	2.78	1.47	3.53
Inter. Weld	L5x3.5x3/4	7.00	10.8	4.71	9.05	2.21	18.8	.54	2.21	1.29	2.96
	x1/2	7.50	12.4	5.30	10.5	2.63	23.0	.60	2.40	1.35	3.15
	x3/8	7.75	13.2	5.61	11.3	2.84	25.3	.63	2.50	1.38	3.25
	x5/16	7.88	13.6	5.77	11.6	2.96	26.5	.65	2.54	1.40	3.29
E. W.	L5x3	8.00	14.2	6.44	11.5	2.65	28.6	.56	2.44	1.56	3.44
Inter. Weld	L5x3x1/2	7.00	10.9	5.15	8.54	1.86	19.5	.45	2.05	1.45	3.05
	x3/8	7.25	11.7	5.46	9.24	2.04	21.6	.48	2.15	1.48	3.15
	x5/16	7.38	12.1	5.62	9.60	2.14	22.7	.49	2.20	1.49	3.20
	x1/4	7.50	12.5	5.78	9.97	2.24	23.8	.50	2.25	1.50	3.25

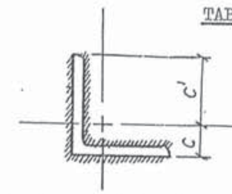
	Angle	L	Sxb	Sxt	Syl	Syr	J	c_x	c'_x	c_y	c'_y
E. W.	L4x3.5	7.50	12.0	4.36	11.4	3.46	22.1	.82	2.68	1.07	2.93
Inter. Weld	L4x3.5x1/2	6.50	9.04	3.33	8.50	2.55	14.4	.69	2.31	.94	2.56
	x3/8	6.75	9.74	3.58	9.18	2.76	16.1	.72	2.41	.97	2.66
	x5/16	6.88	10.1	3.70	9.53	2.88	17.0	.74	2.45	.99	2.70
	x1/4	7.00	10.5	3.83	9.89	2.99	18.0	.75	2.50	1.00	2.75
E. W.	L4x3	7.00	10.7	4.27	9.50	2.59	18.3	.64	2.36	1.14	2.86
Inter. Weld	L4x3x1/2	6.00	7.88	3.24	6.88	1.81	11.6	.52	1.98	1.02	2.48
	x3/8	6.25	8.53	3.49	7.49	1.99	13.1	.55	2.08	1.05	2.58
	x5/16	6.38	8.87	3.61	7.81	2.09	13.9	.57	2.12	1.07	2.62
	x1/4	6.50	9.22	3.74	8.14	2.18	14.7	.58	2.17	1.08	2.67
E. W.	L3.5x3	6.50	9.04	3.33	8.50	2.55	14.4	.69	2.31	.94	2.56
Int. Weld	L3.5x3x3/8	5.75	7.10	2.65	6.62	1.96	10.0	.60	2.03	.85	2.28
	x5/16	5.88	7.40	2.76	6.91	2.05	10.6	.61	2.08	.86	2.33
	x1/4	6.00	7.72	2.87	7.22	2.15	11.3	.63	2.12	.88	2.37
E. W.	L3.5x2.5	6.00	7.88	3.24	6.88	1.81	11.6	.52	1.98	1.02	2.48
Int. Weld	L3.5x2.5x3/8	5.25	6.05	2.57	5.18	1.31	7.86	.43	1.70	.93	2.20
	x5/16	5.38	6.34	2.67	5.45	1.39	8.42	.45	1.74	.95	2.24
	x1/4	5.50	6.64	2.78	5.72	1.47	9.00	.46	1.79	.96	2.29
E. W.	L3x2.5	5.50	6.50	2.44	6.04	1.78	8.75	.57	1.93	.82	2.18
Int. Weld	L3x2.5x3/8	4.75	4.87	1.86	4.47	1.29	5.66	.48	1.65	.73	1.90
	x1/4	5.00	5.39	2.04	4.97	1.44	6.59	.51	1.74	.76	1.99
	x3/16	5.13	5.65	2.14	5.23	1.52	7.09	.52	1.79	.77	2.04
E. W.	L3x2	5.00	5.50	2.36	4.67	1.17	6.82	.40	1.60	.90	2.10
Inter. Weld	L3x2x3/8	4.25	3.99	1.78	3.28	.78	4.26	.31	1.32	.81	1.82
	x5/16	4.38	4.23	1.87	3.50	.84	4.63	.33	1.36	.83	1.86
	x1/4	4.50	4.47	1.97	3.72	.90	5.02	.34	1.41	.84	1.91
	x3/16	4.63	4.72	2.06	3.95	.96	5.43	.36	1.45	.86	1.95
E. W.	L2.5x2	4.50	4.38	1.68	4.00	1.14	4.82	.44	1.56	.69	1.81
Inter. Weld	L2.5x2x3/8	3.75	3.05	1.21	2.74	.76	2.80	.35	1.28	.60	1.53
	x5/16	3.88	3.26	1.28	2.94	.82	3.09	.37	1.32	.62	1.57
	x1/4	4.00	3.47	1.36	3.14	.88	3.40	.38	1.37	.63	1.62
	x3/16	4.13	3.69	1.44	3.34	.94	3.72	.40	1.41	.65	1.66

ANGLES

Equal legs

(Formula 28)

TABLE 8



Angle	L	St	Sb	J	c	c'
L8x8x1-1/8	29.7	32.0	75.2	359	2.39	5.61
x1	30.0	32.3	77.6	365	2.35	5.65
x7/8	30.2	32.6	80.2	370	2.31	5.69
x3/4	30.5	32.9	83.1	377	2.27	5.73
x5/8	30.7	33.2	86.3	384	2.22	5.78
x1/2	31.0	33.6	89.7	391	2.18	5.82
L6x6x1	22.0	17.8	40.3	148	1.84	4.16
x7/8	22.2	18.0	41.8	151	1.80	4.20
x3/4	22.5	18.1	43.6	154	1.76	4.24
x5/8	22.7	18.4	45.7	157	1.72	4.28
x1/2	23.0	18.6	47.9	161	1.68	4.32
x3/8	23.2	18.9	50.4	165	1.64	4.36
L5x5x7/8	18.2	12.3	27.5	85.2	1.55	3.45
x3/4	18.5	12.5	28.8	87.0	1.51	3.49
x1/2	19.0	12.8	32.0	91.4	1.43	3.57
x3/8	19.2	13.0	33.9	94.1	1.39	3.61
x5.16	19.4	13.1	35.0	95.5	1.36	3.64
L4x4x3/4	14.5	7.87	17.3	43.2	1.25	2.75
x5/8	14.7	7.95	18.2	44.3	1.21	2.79
x1/2	15.0	8.07	19.4	45.6	1.18	2.82
x3/8	15.2	8.22	20.8	47.1	1.13	2.87
x5/16	15.4	8.31	21.6	48.0	1.11	2.89
x1/4	15.5	8.41	22.4	48.9	1.09	2.91
L3.5x3.5x3/8	13.2	6.24	15.4	31.1	1.01	2.49
x5/16	13.4	6.31	16.1	31.7	.99	2.51
x1/4	13.5	6.39	16.8	32.4	.97	2.53
L3x3x1/2	11.0	4.45	10.1	18.5	.92	2.08
x3/8	11.2	4.54	10.9	19.2	.88	2.12
x5/16	11.4	4.59	11.4	19.6	.86	2.14
x1/4	11.5	4.66	12.0	20.1	.84	2.16
x3/16	11.6	4.73	12.6	20.6	.82	2.18
L2.5x2.5x3/8	9.25	3.11	7.21	10.9	.75	1.75
x5/16	9.38	3.15	7.58	11.1	.73	1.77
x1/4	9.50	3.20	8.00	11.4	.71	1.79
x3/16	9.63	3.25	8.49	11.8	.69	1.81
L2x2x3/8	7.25	1.97	4.32	5.40	.63	1.37
x5/16	7.38	1.99	4.56	5.54	.61	1.39
x1/4	7.50	2.02	4.85	5.70	.59	1.41
x3/16	7.63	2.05	5.19	5.89	.57	1.43

ANGLES

Unequal legs

(Formula 28)

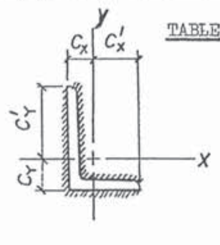


TABLE 9

Angle	L	Sxt	Sxb	Syl	Syr	J	c_x	c'_x	c_y	c'_y
L8x6x1	26.0	30.8	62.8	49.7	18.6	247	1.63	4.37	2.63	5.37
x3/4	26.5	31.5	67.1	54.1	18.9	255	1.55	4.45	2.55	5.45
x1/2	27.0	32.2	72.2	59.7	19.3	266	1.47	4.53	2.47	5.53
L8x4x1	22.0	28.7	47.3	25.7	8.84	169	1.02	2.98	3.02	4.98
x3/4	22.5	29.3	50.5	28.4	8.73	175	.94	3.06	2.94	5.06
x1/2	23.0	30.1	54.3	32.5	8.82	183	.85	3.15	2.85	5.15
L7x4x3/4	20.5	22.8	41.1	25.8	8.56	128	1.00	3.00	2.50	4.50
x1/2	21.0	23.4	44.6	29.5	8.69	134	.91	3.09	2.41	4.59
x3/8	21.2	23.8	46.5	31.9	8.82	138	.87	3.13	2.37	4.63
L6x4x3/4	18.5	17.0	32.5	23.1	8.37	91.6	1.06	2.94	2.06	3.94
x5/8	18.7	17.2	33.9	24.6	8.43	93.7	1.02	2.98	2.02	3.98
x1/2	19.0	17.5	35.5	26.3	8.52	96.1	.98	3.02	1.98	4.02
x3/8	19.2	17.8	37.3	28.3	8.66	98.8	.94	3.06	1.94	4.06
L6x3.5x3/8	18.2	17.4	33.9	23.2	6.69	87.2	.78	2.72	2.03	3.97
x5/16	18.4	17.5	34.8	24.3	6.75	88.5	.76	2.74	2.01	3.99
L5x3.5x3/4	15.5	11.8	22.3	16.4	6.35	54.5	.98	2.52	1.73	3.27
x1/2	16.0	12.1	24.6	18.6	6.44	57.3	.90	2.60	1.65	3.35
x3/8	16.2	12.3	26.0	20.2	6.54	59.1	.86	2.64	1.61	3.39
x5/16	16.4	12.4	26.8	21.2	6.61	60.1	.83	2.67	1.58	3.42
L5x3x1/2	15.0	11.8	22.1	14.6	4.80	49.2	.74	2.26	1.74	3.26
x3/8	15.2	12.0	23.3	16.0	4.86	50.8	.70	2.30	1.70	3.30
x5/16	15.4	12.1	24.0	16.8	4.90	51.7	.68	2.32	1.68	3.32
x1/4	15.5	12.3	24.8	17.8	4.96	52.7	.66	2.34	1.66	3.34
L4x3.5x1/2	14.0	7.91	17.6	15.8	6.24	37.5	.99	2.51	1.24	2.76
x3/8	14.2	8.06	18.8	17.1	6.36	38.8	.95	2.55	1.20	2.80
x5/16	14.4	8.15	19.5	17.8	6.43	39.5	.93	2.57	1.18	2.82
x1/4	14.5	8.25	20.3	18.6	6.51	40.3	.91	2.59	1.16	2.84
L4x3x1/2	13.0	7.71	15.7	12.4	4.65	30.8	.82	2.18	1.32	2.68
x3/8	13.2	7.87	16.8	13.5	4.72	31.9	.78	2.22	1.28	2.72
x5/16	13.4	7.96	17.4	14.2	4.77	32.6	.76	2.24	1.26	2.74
x1/4	13.5	8.06	18.1	14.9	4.84	33.2	.73	2.27	1.23	2.77

Angle	L	Sxt	Sxb	Syl	Syr	J	c_x	c'_x	c_y	c'_y
L3.5x3x3/8	12.2	6.10	13.8	12.2	4.64	24.9	.82	2.18	1.07	2.43
x5/16	12.4	6.17	14.3	12.8	4.69	25.4	.80	2.20	1.05	2.45
x1/4	12.5	6.25	14.9	13.5	4.75	26.0	.78	2.22	1.03	2.47
L3.5x2.5x3/8	11.2	5.92	12.0	9.23	3.27	19.9	.65	1.85	1.15	2.35
x5/16	11.4	6.00	12.5	9.74	3.30	20.4	.63	1.87	1.13	2.37
x1/4	11.5	6.08	13.1	10.3	3.34	20.8	.61	1.89	1.11	2.39
L3x2.5x3/8	10.2	4.41	9.54	8.24	3.20	14.8	.70	1.80	.95	2.05
x1/4	10.5	4.53	10.4	9.18	3.28	15.5	.66	1.84	.91	2.09
x3/16	10.6	4.61	11.0	9.77	3.33	15.9	.64	1.86	.89	2.11
L3x2x3/8	9.25	4.25	8.12	5.79	2.09	11.4	.53	1.47	1.03	1.97
x5/16	9.38	4.31	8.48	6.14	2.11	11.7	.51	1.49	1.01	1.99
x1/4	9.50	4.37	8.88	6.57	2.13	12.0	.49	1.51	.99	2.01
x3/16	9.63	4.45	9.33	7.08	2.17	12.3	.47	1.53	.97	2.03
L2.5x2x3/8	8.25	3.01	6.13	5.07	2.04	7.95	.57	1.43	.82	1.68
x5/16	8.38	3.04	6.43	5.37	2.05	8.14	.55	1.45	.80	1.70
x1/4	8.50	3.09	6.78	5.73	2.08	8.36	.53	1.47	.78	1.72
x3/16	8.63	3.15	7.18	6.16	2.12	8.62	.51	1.49	.76	1.74
L2.5x1.5x x5/16	7.38	2.90	5.24	3.39	1.19	5.99	.39	1.11	.89	1.61
L2x1.5x1/4	6.50	1.93	3.93	3.10	1.16	3.86	.41	1.09	.66	1.34
L2x1.25x1/4	6.00	1.87	3.45	2.32	.82	3.18	.33	.92	.70	1.30
L1.75x1.25x x1/4	5.50	1.45	2.80	2.11	.81	2.40	.35	.90	.60	1.15

ANGLES

Equal legs

(Formula 25)

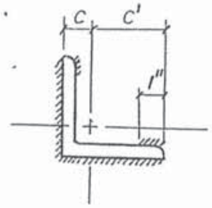


TABLE 10

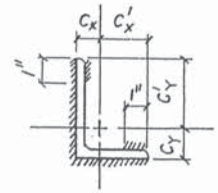
Angle	L	St	Sb	J	c	c'
L8x8x1-1/8	18	23.8	60.5	273	2.26	5.74
x1	18	23.8	60.8	274	2.25	5.75
x7/8	18	23.8	61.2	274	2.24	5.76
x3/4	18	23.9	61.5	275	2.24	5.76
x5/8	18	23.9	61.9	276	2.23	5.77
x1/2	18	23.9	62.3	277	2.22	5.78
L6x6x1	14	14.2	34.5	121	1.75	4.25
x7/8	14	14.2	34.8	121	1.74	4.26
x3/4	14	14.3	35.2	122	1.73	4.27
x5/8	14	14.3	35.5	122	1.72	4.28
x1/2	14	14.3	35.8	123	1.71	4.29
x3/8	14	14.4	36.2	123	1.71	4.29
L5x5x7/8	12	10.3	24.3	72.3	1.49	3.51
x3/4	12	10.3	24.5	72.6	1.48	3.52
x1/2	12	10.4	25.2	73.5	1.46	3.54
x3/8	12	10.4	25.5	74.0	1.45	3.55
x5/16	12	10.4	25.7	74.2	1.44	3.56
L4x4x3/4	10	6.93	15.7	38.4	1.23	2.77
x5/8	10	6.94	16.0	38.7	1.21	2.79
x1/2	10	6.97	16.3	39.0	1.20	2.80
x3/8	10	7.01	16.6	39.4	1.19	2.81
x5/16	10	7.03	16.8	39.6	1.18	2.82
x1/4	10	7.05	17.0	39.8	1.18	2.82
L3.5x3.5x3/8	9	5.52	12.8	27.0	1.06	2.44
x5/16	9	5.54	12.9	27.1	1.05	2.45
x1/4	9	5.56	13.1	27.3	1.04	2.46
L3x3x1/2	8	4.15	9.12	17.1	.94	2.06
x3/8	8	4.17	9.41	17.3	.92	2.08
x5/16	8	4.19	9.57	17.5	.91	2.09
x1/4	8	4.22	9.74	17.6	.91	2.09
x3/16	8	4.24	9.92	17.8	.90	2.10
L2.5x2.5x3/8	7	2.98	6.50	10.2	.79	1.71
x5/16	7	3.00	6.65	10.3	.78	1.72
x1/4	7	3.02	6.81	10.4	.77	1.73
x3/16	7	3.04	6.98	10.6	.76	1.74
L2x2x3/8	6	1.95	4.08	5.28	.65	1.35
x5/16	6	1.96	4.21	5.35	.64	1.36
x1/4	6	1.98	4.35	5.44	.63	1.37
x3/16	6	2.00	4.51	5.54	.61	1.39

TABLE 11

ANGLES

Unequal legs

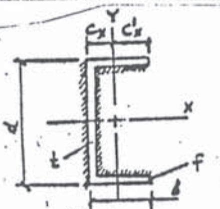
(Formula 25)



Angle	L	Sxt	Sxb	Syl	Syr	J	c_x	c_x'	c_y	c_y'
L8x6x1	16	22.9	49.6	43.0	14.7	191	1.53	4.47	2.53	5.47
x3/4	16	23.0	50.2	43.6	14.7	192	1.52	4.48	2.52	5.48
x1/2	16	23.1	50.9	44.4	14.8	194	1.50	4.50	2.50	5.50
L8x4x1	14	21.7	38.3	26.3	7.57	134	.89	3.11	2.89	5.11
x3/4	14	21.8	38.9	26.9	7.52	135	.88	3.12	2.88	5.12
x1/2	14	22.0	39.5	27.6	7.52	137	.86	3.14	2.86	5.14
L7x4x3/4	13	17.5	32.6	24.1	7.42	102	.94	3.06	2.44	4.56
x1/2	13	17.6	33.3	24.7	7.42	103	.92	3.08	2.42	4.58
x3/8	13	17.7	33.6	25.1	7.44	104	.91	3.09	2.41	4.59
L6x4x3/4	12	13.5	26.7	21.3	7.29	75.6	1.02	2.98	2.02	3.98
x5/8	12	13.6	27.0	21.6	7.29	76.0	1.01	2.99	2.01	3.99
x1/2	12	13.6	27.3	21.9	7.31	76.5	1.00	3.00	2.00	4.00
x3/8	12	13.7	27.6	22.3	7.33	77.0	.99	3.01	1.99	4.01
L6x3.5x3/8	11.5	13.5	25.5	19.0	5.86	68.6	.83	2.67	2.08	3.92
x5/16	11.5	13.5	25.7	19.2	5.87	68.8	.82	2.68	2.07	3.93
L5x3.5x3/4	10.5	9.84	19.3	15.6	5.72	47.2	.94	2.56	1.69	3.31
x1/2	10.5	9.92	19.8	16.1	5.73	47.9	.92	2.58	1.67	3.33
x3/8	10.5	9.98	20.2	16.5	5.75	48.3	.90	2.60	1.65	3.35
x5/16	10.5	10.0	20.3	16.7	5.76	48.5	.90	2.60	1.65	3.35
L5x3x1/2	10	9.73	18.1	13.3	4.43	41.6	.75	2.25	1.75	3.25
x3/8	10	9.79	18.4	13.6	4.44	42.0	.74	2.26	1.74	3.26
x5/16	10	9.83	18.6	13.8	4.44	42.2	.73	2.27	1.73	3.27
x1/4	10	9.86	18.7	14.0	4.46	42.4	.73	2.27	1.73	3.27
L4x3.5x1/2	9.5	6.85	14.8	13.7	5.58	32.6	1.01	2.49	1.26	2.74
x3/8	9.5	6.90	15.2	14.0	5.61	33.0	1.00	2.50	1.25	2.75
x5/16	9.5	6.92	15.3	14.2	5.62	33.2	.99	2.51	1.24	2.76
x1/4	9.5	6.95	15.5	14.4	5.64	33.4	.99	2.51	1.24	2.76
L4x3x1/2	9.0	6.72	13.4	11.2	4.31	27.2	.83	2.17	1.33	2.67
x3/8	9.0	6.77	13.7	11.5	4.32	27.6	.82	2.18	1.32	2.68
x5/16	9.0	6.79	13.9	11.7	4.34	27.7	.81	2.19	1.31	2.69
x1/4	9.0	6.82	14.1	11.9	4.35	27.9	.81	2.19	1.31	2.69

Angle	L	Sxt	Sxb	Syl	Syr	J	c_x	c'_x	c_y	c'_y
L3.5x3x3/8	8.5	5.41	11.5	10.5	4.26	22.0	.87	2.13	1.12	2.38
x5/16	8.5	5.44	11.7	10.6	4.27	22.1	.86	2.14	1.11	2.39
x1/4	8.5	5.46	11.9	10.8	4.29	22.3	.85	2.15	1.10	2.40
L3.5x2.5x3/8	8.0	5.29	10.3	8.22	3.12	17.9	.69	1.81	1.19	2.31
x5/16	8.0	5.32	10.5	8.38	3.13	18.0	.68	1.82	1.18	2.32
x1/4	8.0	5.35	10.6	8.55	3.14	18.2	.67	1.83	1.17	2.33
L3x2.5x3/8	7.5	4.08	8.36	7.36	3.06	13.6	.73	1.77	.98	2.02
x1/4	7.5	4.12	8.68	7.68	3.09	13.9	.72	1.78	.97	2.03
x3/16	7.5	4.15	8.85	7.85	3.11	14.0	.71	1.79	.96	2.04
L3x2x3/8	7.0	3.96	7.31	5.41	2.07	10.7	.55	1.45	1.05	1.95
x5/16	7.0	3.98	7.46	5.55	2.08	10.8	.54	1.46	1.04	1.96
x1/4	7.0	4.02	7.61	5.70	2.09	10.9	.54	1.46	1.04	1.96
x3/16	7.0	4.05	7.78	5.87	2.10	11.1	.53	1.47	1.03	1.97
L2.5x2x3/8	6.5	2.89	5.65	4.75	2.02	7.61	.60	1.40	.85	1.65
x5/16	6.5	2.91	5.79	4.88	2.02	7.70	.59	1.41	.84	1.66
x1/4	6.5	2.93	5.94	5.03	2.04	7.81	.58	1.42	.83	1.67
x3/16	6.5	2.96	6.10	5.19	2.05	7.93	.57	1.43	.82	1.68

	L	Sx	Sy	Sy'	J	Cx	Cx'
C 15x50	34.7	104	38.4	8.39	803	.666	3.050
x40	34.7	104	39.7	7.42	799	.555	2.965
x33.9	34.7	104	41.4	6.91	797	.486	2.914
C 12x30	28.3	69.3	28.8	5.95	431	.544	2.626
x25	28.3	69.3	29.9	5.49	430	.473	2.574
x20.7	28.3	69.3	31.6	5.15	429	.412	2.530
C 10x30	23.8	49.0	21.2	5.49	258	.624	2.409
x25	23.8	49.0	21.4	4.91	257	.539	2.347
x20	23.8	49.0	22.2	4.40	255	.454	2.285
x15.3	23.8	49.0	23.9	4.00	254	.373	2.227
C 9x20	21.6	39.9	18.3	4.10	189	.485	2.163
x15	21.6	39.9	19.4	3.62	187	.390	2.095
x13.4	21.6	39.9	20.1	3.49	187	.360	2.073
C8x18.75	19.3	31.8	15.1	3.73	135	.501	2.026
x13.75	19.3	31.8	15.9	3.20	133	.393	1.950
x11.5	19.3	31.8	16.7	3.00	133	.344	1.916
C7x14.75	17.0	24.6	12.4	3.06	91.7	.454	1.845
x12.25	17.0	24.6	12.8	2.78	91.0	.392	1.802
x9.8	17.0	24.6	13.5	2.55	90.5	.331	1.759
C 6x13	14.7	18.3	9.85	2.67	59.3	.460	1.697
x10.5	14.7	18.3	10.1	2.37	58.7	.387	1.647
x8.2	14.7	18.3	10.7	2.14	58.2	.319	1.601
C 5x9	12.5	12.9	7.71	2.01	35.2	.390	1.495
x6.7	12.5	12.9	8.21	1.76	34.7	.309	1.441
C 4x7.25	10.2	8.30	5.67	1.65	18.9	.387	1.334
x5.4	10.2	8.30	5.98	1.42	18.6	.304	1.280
C 3x6	7.93	4.81	3.91	1.37	8.84	.415	1.181
x5	7.93	4.81	3.94	1.22	8.61	.354	1.144
x4.1	7.93	4.81	4.09	1.10	8.44	.300	1.110



$a = b - t;\ g = b + t;\ e = d - 2f$

$L = 2(a + e + f)$

$$C_x = \frac{et + ag}{L}$$

$$I_x = \frac{d^3 + e^3}{12} + \frac{ae^2}{2}$$

$$I_y = dC_x^2 + e(C_x - t)^2 + \frac{a^3}{6} + 2a\left(\frac{g}{2} - C_x\right)^2$$

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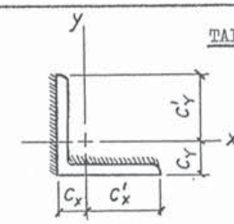
TABLE 12

ANGLES

Equal legs

(Formula 27)



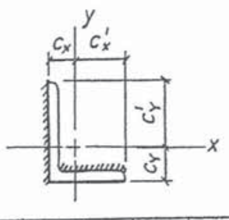
Angle	L	Sxb	Sxt	Syl	Syr	J	c_x	c'_x	c_y	c'_y
L8x8x1-1/8	14.9	27.4	13.7	49.3	17.7	177	2.11	5.89	2.67	5.33
x1	15.0	29.3	14.1	49.6	17.7	180	2.10	5.90	2.60	5.40
x7/8	15.1	31.4	14.5	49.9	17.7	184	2.09	5.91	2.53	5.47
x3/4	15.2	33.7	14.9	50.3	17.7	187	2.08	5.92	2.45	5.55
x5/8	15.4	36.3	15.4	50.7	17.7	191	2.07	5.93	2.38	5.62
x1/2	15.5	39.1	15.8	51.1	17.7	195	2.06	5.94	2.31	5.69
L6x6x1	11.0	13.8	7.40	27.5	9.94	72.7	1.59	4.41	2.09	3.91
x7/8	11.1	15.1	7.66	27.7	9.94	74.4	1.58	4.42	2.02	3.98
x3/4	11.2	16.5	7.94	27.9	9.93	76.1	1.58	4.43	1.95	4.05
x5/8	11.4	18.1	8.25	28.1	9.93	78.0	1.57	4.43	1.88	4.12
x1/2	11.5	19.9	8.56	28.4	9.94	80.1	1.55	4.45	1.80	4.20
x3/8	11.6	22.0	8.90	28.7	9.94	82.3	1.54	4.46	1.73	4.27
L5x5x7/8	9.13	9.28	5.07	19.1	6.90	41.7	1.33	3.67	1.77	3.23
x3/4	9.25	10.3	5.28	19.2	6.90	42.8	1.32	3.68	1.70	3.30
x1/2	9.50	12.8	5.77	19.6	6.90	45.4	1.30	3.70	1.55	3.45
x3/8	9.63	14.4	6.04	19.8	6.90	46.9	1.29	3.71	1.48	3.52
x5/16	9.69	15.3	6.18	20.0	6.91	47.6	1.29	3.71	1.44	3.56
L4x4x3/4	7.25	5.65	3.18	12.2	4.42	21.1	1.06	2.94	1.44	2.56
x5/8	7.38	6.42	3.34	12.3	4.42	21.8	1.06	2.94	1.37	2.63
x1/2	7.50	7.33	3.53	12.4	4.42	22.6	1.05	2.95	1.30	2.70
x3/8	7.63	8.44	3.73	12.6	4.42	23.4	1.04	2.96	1.23	2.77
x5/16	7.69	9.07	3.84	12.7	4.42	23.9	1.03	2.97	1.19	2.81
x1/4	7.75	9.76	3.96	12.8	4.42	24.4	1.03	2.97	1.15	2.85
L3.5x3.5x3/8	6.63	6.08	2.79	9.56	3.38	15.4	.91	2.59	1.10	2.40
x5/16	6.69	6.59	2.88	9.64	3.38	15.8	.91	2.59	1.06	2.44
x1/4	6.75	7.17	2.98	9.73	3.38	16.1	.90	2.60	1.03	2.47
L3x3x1/2	5.50	3.46	1.85	6.89	2.48	9.09	.80	2.20	1.05	1.95
x3/8	5.63	4.12	1.99	6.98	2.48	9.52	.79	2.21	.98	2.03
x5/16	5.69	4.53	2.06	7.04	2.48	9.76	.78	2.22	.94	2.06
x1/4	5.75	4.98	2.14	7.10	2.48	10.0	.78	2.22	.90	2.10
x3/16	5.81	5.49	2.23	7.19	2.49	10.3	.77	2.23	.86	2.14
L2.5x2.5x3/8	4.63	2.57	1.32	4.80	1.73	5.35	.66	1.84	.85	1.65
x5/16	4.69	2.86	1.38	4.84	1.72	5.51	.66	1.84	.81	1.69
x1/4	4.75	3.20	1.44	4.89	1.72	5.67	.65	1.85	.78	1.72
x3/16	4.81	3.59	1.51	4.96	1.73	5.86	.65	1.85	.74	1.76
L2x2x3/8	3.63	1.41	.79	3.05	1.11	2.64	.53	1.47	.72	1.28
x5/16	3.69	1.60	.84	3.07	1.10	2.72	.53	1.47	.69	1.31
x1/4	3.75	1.83	.88	3.10	1.10	2.82	.53	1.48	.65	1.35
x3/16	3.81	2.11	.93	3.14	1.10	2.93	.52	1.48	.61	1.39

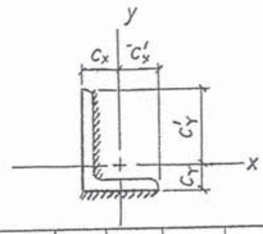
TABLE 13

ANGLES

Unequal legs

(Formula 27)





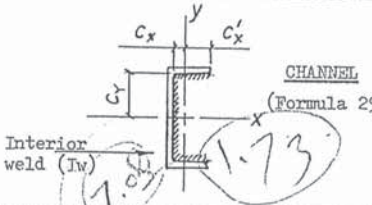
Angle	L	Sxb	Sxt	Syl	Syr	J	c_x	c'_x	c_y	c'_y	Sxb	Sxt	Syl	Syr	J	c_x	c'_x	c_y	c'_y
L8x6x1	13.0	24.7	13.6	35.7	10.3	118	1.35	4.65	2.85	5.15	38.8	16.9	16.1	7.58	125	1.92	4.08	2.42	5.58
x3/4	13.2	28.1	14.4	36.0	10.3	124	1.34	4.66	2.71	5.29	39.5	16.9	19.6	8.18	129	1.77	4.23	2.39	5.61
x1/2	13.5	32.1	15.2	36.5	10.3	131	1.32	4.68	2.57	5.43	40.4	16.9	24.1	8.85	134	1.61	4.39	2.36	5.64
L8x4x1	11.0	19.6	12.9	23.3	4.79	78.2	.68	3.32	3.18	4.82	28.0	15.6	5.78	2.99	88.0	1.36	2.64	2.86	5.14
x3/4	11.2	21.9	13.6	23.2	4.80	83.0	.69	3.31	3.06	4.94	28.8	15.7	7.84	3.34	90.5	1.19	2.81	2.82	5.18
x1/2	11.5	24.7	14.3	23.2	4.80	88.4	.68	3.32	2.93	5.07	29.7	15.7	11.0	3.76	93.5	1.02	2.98	2.77	5.23
L7x4x3/4	10.2	17.3	10.4	20.4	4.74	60.7	.75	3.25	2.63	4.37	24.1	12.3	7.39	3.31	66.1	1.24	2.76	2.36	4.64
x1/2	10.5	19.8	11.0	20.5	4.73	65.0	.75	3.25	2.50	4.50	24.9	12.3	10.2	3.72	68.6	1.07	2.93	2.32	4.68
x3/8	10.6	21.3	11.4	20.6	4.73	67.3	.75	3.25	2.43	4.57	25.3	12.4	12.1	3.96	70.1	.99	3.01	2.30	4.70
L6x4x3/4	9.25	13.0	7.56	17.7	4.66	43.4	.83	3.17	2.21	3.79	19.8	9.28	6.88	3.28	46.8	1.29	2.71	1.92	4.08
x5/8	9.38	14.1	7.83	17.7	4.66	44.9	.83	3.17	2.15	3.86	20.1	9.29	7.98	3.47	47.8	1.21	2.79	1.90	4.10
x1/2	9.50	15.3	8.11	17.8	4.66	46.6	.83	3.17	2.08	3.92	20.4	9.31	9.32	3.68	48.9	1.13	2.87	1.88	4.12
x3/8	9.63	16.7	8.42	17.9	4.65	48.3	.82	3.18	2.01	3.99	20.7	9.33	10.9	3.90	50.1	1.05	2.95	1.86	4.14
L6x3.5x3/8	9.13	15.3	8.25	15.5	3.62	42.4	.66	2.84	2.10	3.90	18.7	9.11	8.48	2.95	44.4	.90	2.60	1.96	4.04
x5/16	9.19	16.0	8.40	15.5	3.62	43.3	.66	2.84	2.07	3.93	18.9	9.12	9.36	3.05	45.0	.86	2.64	1.95	4.05
L5x3.5x3/4	7.75	8.44	5.08	12.9	3.55	25.6	.75	2.75	1.88	3.12	14.1	6.50	4.57	2.39	27.7	1.20	2.30	1.58	3.42
x1/2	8.00	10.2	5.51	13.0	3.55	27.7	.75	2.75	1.75	3.25	14.5	6.51	6.35	2.71	29.1	1.05	2.45	1.55	3.45
x3/8	8.13	11.3	5.76	13.1	3.54	28.9	.75	2.75	1.68	3.32	14.8	6.52	7.59	2.90	30.0	.97	2.53	1.53	3.47
x5/16	8.19	12.0	5.89	13.2	3.54	29.9	.74	2.76	1.65	3.35	14.9	6.53	8.32	3.00	30.4	.93	2.57	1.52	3.48

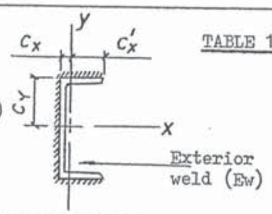
Angle	L	Sxb	Sxt	Syl	Syr	J	c_x	c'_x	c_y	c'_y	Sxb	Sxt	Syl	Syr	J	c_x	c'_x	c_y	c'_y
L5x3x1/2	7.50	9.32	5.39	11.0	2.65	23.5	.58	2.42	1.83	3.17	12.8	6.33	4.50	1.93	25.3	.90	2.10	1.65	3.35
x3/8	7.63	10.3	5.63	11.0	2.65	24.6	.58	2.42	1.77	3.23	13.1	6.35	5.57	2.09	25.9	.82	2.18	1.63	3.37
x5/16	7.69	10.8	5.75	11.1	2.65	25.2	.58	2.42	1.74	3.26	13.3	6.36	6.22	2.17	26.3	.78	2.22	1.62	3.38
x1/4	7.75	11.4	5.88	11.1	2.65	25.8	.58	2.42	1.70	3.30	13.4	6.37	6.98	2.26	26.7	.73	2.27	1.61	3.39
L4x3.5x1/2	7.00	6.77	3.48	10.6	3.45	18.3	.86	2.64	1.36	2.64	11.0	4.32	5.61	2.66	18.7	1.13	2.38	1.13	2.88
x3/8	7.13	7.74	3.67	10.7	3.44	19.1	.85	2.65	1.29	2.71	11.2	4.33	6.61	2.83	19.4	1.05	2.45	1.11	2.89
x5/16	7.19	8.30	3.78	10.8	3.44	19.5	.85	2.65	1.25	2.75	11.3	4.33	7.19	2.93	19.8	1.01	2.49	1.11	2.89
x1/4	7.25	8.91	3.89	10.9	3.45	20.0	.84	2.66	1.22	2.78	11.4	4.33	7.85	3.03	20.2	.97	2.53	1.10	2.90
L4x3x1/2	6.50	6.18	3.41	8.93	2.58	14.8	.67	2.33	1.42	2.58	9.70	4.21	4.02	1.90	15.6	.96	2.04	1.21	2.79
x3/8	6.63	7.02	3.60	9.00	2.58	15.5	.67	2.33	1.36	2.64	9.88	4.22	4.89	2.05	16.1	.88	2.12	1.20	2.80
x5/16	6.69	7.50	3.70	9.06	2.58	15.9	.67	2.33	1.32	2.68	9.98	4.22	5.42	2.13	16.4	.85	2.15	1.19	2.81
x1/4	6.75	8.02	3.81	9.12	2.58	16.4	.66	2.34	1.29	2.71	10.1	4.23	6.03	2.21	16.8	.81	2.19	1.18	2.82
L3.5x3x3/8	6.13	5.52	2.74	7.99	2.54	12.2	.72	2.28	1.16	2.34	8.39	3.30	4.52	2.02	12.5	.93	2.07	.99	2.51
x5/16	6.19	5.96	2.83	8.05	2.54	12.5	.72	2.28	1.13	2.37	8.47	3.30	4.99	2.10	12.7	.89	2.11	.98	2.52
x1/4	6.25	6.46	2.92	8.11	2.54	12.8	.72	2.29	1.09	2.41	8.56	3.30	5.51	2.18	13.0	.85	2.15	.98	2.53
L3.5x2.5x3/8	5.63	4.93	2.68	6.50	1.80	9.60	.54	1.96	1.23	2.27	7.21	3.20	3.10	1.36	10.1	.76	1.74	1.08	2.42
x5/16	5.69	5.31	2.76	6.53	1.80	9.89	.54	1.96	1.20	2.30	7.29	3.20	3.50	1.43	10.3	.72	1.78	1.07	2.43
x1/4	5.75	5.72	2.85	6.58	1.80	10.2	.54	1.96	1.16	2.34	7.39	3.21	3.96	1.50	10.5	.68	1.82	1.06	2.44
L3x2.5x3/8	5.13	3.70	1.94	5.65	1.77	7.19	.60	1.90	1.03	1.97	5.96	2.41	2.85	1.34	7.44	.80	1.70	.86	2.14
x1/4	5.25	4.42	2.09	5.74	1.77	7.64	.59	1.91	.96	2.04	6.10	2.42	3.60	1.47	7.80	.73	1.77	.85	2.15
x3/16	5.31	4.85	2.17	5.79	1.77	7.89	.58	1.92	.93	2.07	6.18	2.42	4.07	1.54	8.01	.69	1.81	.84	2.16
L3x2x3/8	4.63	3.24	1.89	4.42	1.17	5.43	.42	1.58	1.10	1.90	4.95	2.32	1.72	.82	5.85	.65	1.35	.96	2.04
x5/16	4.69	3.52	1.96	4.43	1.16	5.62	.42	1.58	1.07	1.93	5.02	2.32	2.00	.87	5.97	.61	1.39	.95	2.05
x1/4	4.75	3.83	2.03	4.45	1.16	5.82	.41	1.59	1.04	1.96	5.09	2.33	2.33	.92	6.11	.57	1.43	.94	2.06
x3/16	4.81	4.17	2.10	4.49	1.16	6.04	.41	1.59	1.01	1.99	5.18	2.33	2.74	.98	6.26	.53	1.47	.93	2.07
L2.5x2x3/8	4.13	2.27	1.29	3.73	1.14	3.80	.47	1.53	.91	1.59	3.95	1.66	1.58	.81	4.00	.68	1.32	.74	1.76
x5/16	4.19	2.51	1.34	3.75	1.14	3.93	.47	1.53	.87	1.63	4.00	1.66	1.81	.85	4.10	.64	1.36	.73	1.77
x1/4	4.25	2.78	1.40	3.78	1.14	4.08	.46	1.54	.84	1.66	4.05	1.67	2.09	.90	4.21	.60	1.40	.73	1.77
x3/16	4.31	3.10	1.47	3.81	1.14	4.24	.46	1.54	.80	1.70	4.12	1.67	2.44	.96	4.34	.56	1.44	.72	1.78

TABLE 14

CHANNEL

(Formula 29)

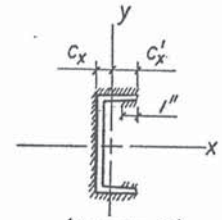




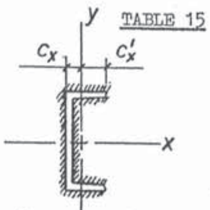
Channel	Weld	L	Sx	Sy	Sy'	J	c_x	c_x'	c_y
C 15	Iw	19.7	72.4	30.4	5.46	510	.46	2.54	6.85
x50		22.4	93.2	41.8	8.29	725	.62	3.10	
x40	Ew	22.0	90.3	39.3	7.48	699	.56	2.96	7.50
x33.9		21.8	88.5	37.8	6.99	684	.53	2.87	
C 12	Iw	16.3	49.4	21.9	4.26	281	.43	2.23	5.50
x30		18.3	62.0	28.7	6.00	388	.55	2.62	
x25	Ew	18.1	60.6	27.5	5.56	377	.51	2.54	6.00
x20.7		17.9	59.3	26.4	5.20	369	.48	2.46	
C 10	Iw	13.8	35.4	16.2	3.33	168	.40	1.96	4.56
x30		16.1	47.0	23.3	5.42	248	.57	2.46	
x25	Ew	15.8	45.5	22.0	4.93	239	.53	2.36	5.00
x20		15.5	44.1	20.8	4.46	230	.48	2.26	
x15.3		15.2	42.7	19.6	4.04	222	.44	2.16	
C 9	Iw	12.6	29.1	13.6	2.88	124	.38	1.82	4.09
x20		14.3	37.3	18.2	4.14	177	.49	2.16	
x15	Ew	14.0	35.9	17.0	3.67	169	.44	2.05	4.50
x13.4		13.9	35.4	16.6	3.53	166	.43	2.00	
C 8	Iw	11.3	23.4	11.2	2.47	88.7	.37	1.67	3.61
x18.75		13.0	30.9	15.6	3.75	131	.49	2.04	
x13.75	Ew	12.7	29.4	14.3	3.25	124	.43	1.91	4.00
x11.5		12.5	28.7	13.8	3.03	121	.41	1.85	
C 7	Iw	10.0	18.3	9.03	2.08	60.6	.35	1.53	3.13
x14.75		11.6	24.3	12.5	3.09	90.6	.46	1.84	
x12.25	Ew	11.4	23.5	11.8	2.83	87.3	.42	1.77	3.50
x9.8		11.2	22.8	11.2	2.58	84.2	.39	1.70	
C 6	Iw	8.75	13.8	7.08	1.73	39.2	.34	1.38	2.66
x13		10.3	18.9	10.2	2.69	61.4	.45	1.71	
x10.5	Ew	10.1	18.2	9.52	2.41	58.5	.41	1.62	3.00
x8.2		9.84	17.5	8.91	2,16	55.9	.37	1.55	
C 5	Iw	7.48	9.97	5.35	1.41	23.5	.33	1.23	2.18
x9	Ew	8.77	13.6	7.47	2.04	37.0	.41	1.48	2.50
x6.7		8.50	12.9	6.85	1.78	34.8	.36	1.39	
C 4	Iw	6.21	6.71	3.83	1.12	12.6	.32	1.08	1.70
x7.25	Ew	7.44	9.55	5.58	1.68	21.3	.40	1.32	2.00
x5.4		7.17	9.00	5.06	1.44	19.8	.35	1.23	
C 3	Iw	4.93	4.05	2.54	.85	5.76	.31	.93	1.23
x6		6.19	6.29	4.04	1.40	11.1	.41	1,19	
x5	Ew	6.00	5.99	3.74	1.25	10.4	.37	1.13	1.50
x4.1		5.82	5.73	3.48	1.11	9.78	.34	1.07	

TABLE 15

CHANNEL



(Formula 31)



(Formula 32)

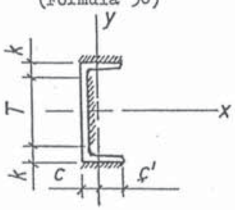
Channel	L	Sx	Sy	Sy'	J	c_x	c_x'	L	Sx	Sy	Sy'	J	c_x	c_x'
C15x50	24.4	106	46.2	13.3	831	.83	2.89	42.1	159	48.9	15.1	1238	.88	2.84
x40	24.0	103	43.5	12.1	804	.77	2.75	41.7	156	49.9	13.7	1211	.76	2.76
x33.9	23.8	101	41.8	11.4	788	.73	2.67	41.5	155	51.2	12.9	1195	.69	2.71
C12x30	20.3	72.1	31.7	9.95	457	.76	2.41	34.7	107	36.2	10.9	671	.73	2.44
x25	20.1	70.6	30.3	9.31	446	.72	2.33	34.4	106	37.0	10.2	659	.66	2.39
x20.7	19.9	69.4	29.1	8.78	436	.68	2.26	34.2	105	38.2	9.68	650	.59	2.35
C10x30	18.1	55.3	25.7	9.06	297	.79	2.24	29.9	79.3	27.0	9.76	418	.81	2.22
x25	17.8	53.9	24.3	8.34	287	.74	2.15	29.6	77.9	27.0	8.90	409	.72	2.17
x20	17.5	52.4	22.9	7.64	278	.69	2.05	29.3	76.4	27.6	8.15	399	.62	2.12
x15.3	17.2	51.0	21.5	6.99	269	.64	1.96	29.0	75.0	28.8	7.53	391	.54	2.06
C9x20	16.3	44.8	20.1	7.13	215	.69	1.96	26.9	63.8	23.0	7.49	302	.65	2.00
x15	16.0	43.3	18.6	6.40	207	.64	1.85	26.5	62.3	23.8	6.76	293	.55	1.94
x13.4	15.9	42.8	18.2	6.17	204	.62	1.81	26.4	61.8	24.2	6.55	291	.52	1.91
C8x18.75	15.0	37.4	17.2	6.49	161	.69	1.84	24.3	52.0	19.1	6.73	221	.66	1.87
x13.75	14.7	35.9	15.7	5.70	153	.62	1.72	24.0	50.5	19.6	5.93	213	.55	1.79
x11.5	14.5	35.3	15.0	5.36	150	.59	1.67	23.8	49.9	20.1	5.62	209	.49	1.77
C7x14.75	13.6	29.9	13.7	5.43	113	.65	1.65	21.6	40.7	15.6	5.55	152	.60	1.70
x12.25	13.4	29.1	12.9	5.01	110	.61	1.58	21.4	39.9	15.8	5.13	148	.54	1.65
x9.8	13.2	28.4	12.2	4.60	106	.57	1.52	21.2	39.2	16.4	4.77	145	.47	1.62
C6x13	12.3	23.6	11.1	4.76	78.1	.65	1.51	19.1	31.2	12.5	4.80	101	.60	1.56
x10.5	12.1	22.9	10.3	4.30	74.9	.60	1.43	18.8	30.5	12.6	4.35	98.0	.52	1.51
x8.2	11.8	22.2	9.65	3.89	72.0	.55	1.37	18.6	29.8	13.0	3.99	95.2	.45	1.47
C5x9	10.8	17.4	8.10	3.66	48.2	.59	1.30	16.2	22.3	9.67	3.66	60.7	.52	1.37
x6.7	10.5	16.7	7.40	3.21	45.7	.53	1.22	16.0	21,6	9.94	3.27	58.3	.43	1.32
C4x7.25	9.44	12.4	6.03	3.01	28.4	.57	1.15	13.6	15.3	7.15	2.98	34.1	.51	1.21
x5.4	9.17	11.9	5.45	2.59	26.6	.51	1.07	13.4	14.7	7.29	2.62	32.5	.42	1.16
C3x6	8.19	8.30	4.39	2.49	15.0	.58	1.02	11.1	9.60	5.02	2.46	17.0	.53	1.07
x5	8.00	8.00	4.06	2.22	14.1	.53	.97	10.9	9.30	4.97	2.22	16.2	.46	1.04
x4.1	7.82	7.74	3.77	1.99	13.4	.49	.92	10.7	9.04	5.01	2.03	15.6	.41	1.00

$$Sy = \frac{I_y}{c_x}; \qquad S_y' = \frac{I_y}{c_x'};$$

TABLE 16

CHANNEL

(Formula 30)



$$Sy = \frac{Iy}{c}$$

$$S'y = \frac{Iy}{c'}$$

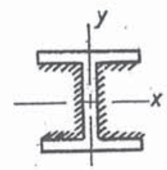
Channel	L	Sx	Sy	S'y	J	c	c'
C 15x50	19.6	75.5	12.7	5.67	581	1.15	2.57
x40	19.2	72.6	14.5	5.55	559	.98	2.54
x33.9	18.9	70.8	16.0	5.49	545	.87	2.53
C 12x30	16.1	50.9	10.4	4.36	315	.93	2.24
x25	15.8	49.4	11.6	4.30	306	.82	2.22
x20.7	15.6	48.2	12.9	4.26	298	.73	2.21
C 10x30	14.1	38.9	6.85	3.56	201	1.04	2.00
x25	13.8	37.4	7.50	3.45	194	.91	1.98
x20	13.5	35.9	8.46	3.38	186	.78	1.96
x15.3	13.2	34.5	9.84	3.33	179	.66	1.94
C 9x20	12.4	30.5	6.60	2.97	143	.82	1.83
x15	12.1	29.1	7.73	2.90	136	.68	1.81
x13.4	12.0	28.6	8.22	2.89	134	.63	1.80
C 8x18.75	11.2	25.0	5.20	2.58	104	.84	1.69
x13.75	10.8	23.5	6.10	2.49	98.3	.68	1.66
x11.5	10.6	22.9	6.72	2.47	95.5	.61	1.65
C 7x14.75	9.85	19.5	4.39	2.17	71.7	.76	1.54
x12.25	9.64	18.8	4.81	2.12	69.0	.67	1.52
x9.8	9.43	18.1	5.42	2.08	66.4	.58	1.51
C 6x13	8.69	15.3	3.40	1.83	48.4	.76	1.40
x10.5	8.44	14.5	3.74	1.77	46.0	.65	1.38
x8.2	8.22	13.8	4.25	1.73	43.9	.56	1.36
C 5x9	7.27	10.8	2.80	1.46	28.9	.65	1.24
x6.7	7.00	10.2	3.22	1.41	27.2	.53	1.22
C 4x7.25	6.07	7.64	2.05	1.17	16.6	.63	1.09
x5.4	5.79	7.09	2.31	1.12	15.4	.52	1.07
C 3x6	4.82	5.03	1.37	.94	8.43	.65	.95
x5	4.62	4.73	1.41	.88	7.91	.58	.92
x4.1	4.45	4.47	1.50	.85	7.46	.51	.90

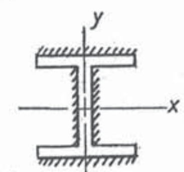
For "k" and "T" dim's ref. to AISC.

TABLE 17

W and M SHAPES

(Formula 38)





(Formula 43)

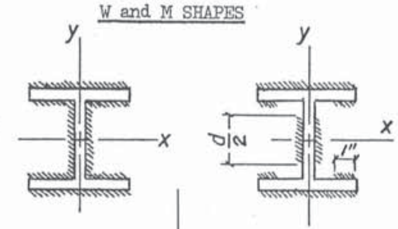
	L	Sx	Sy	J	L	Sx	Sy	J
W 4x13	14.5	17.1	5.56	41.0	15.1	20.2	5.56	53.4
W 5x16	18.1	26.6	8.38	77.9	18.6	30.3	8.38	96.9
x19	18.1	26.6	8.49	78.3	18.6	31.0	8.50	101
W 6x9	18.5	30.6	5.21	93.9	18.8	32.5	5.21	106
x12	18.5	30.6	5.40	94.5	18.9	33.2	5.41	111
x16	18.5	30.6	5.50	94.8	19.0	34.0	5.51	118
x15	22.5	41.5	12.0	149	22.9	45.0	12.0	171
x20	22.5	41.5	12.1	150	23.0	46.1	12.1	180
x25	22.5	41.5	12.4	151	23.1	47.3	12.4	189
W 8x10	22.5	46.8	5.23	185	22.8	48.8	5.23	203
x13	22.5	46.8	5.43	186	23.0	49.4	5.43	208
x15	22.5	46.8	5.48	186	23.0	49.8	5.49	213
x18	25.0	56.2	9.26	234	25.5	59.9	9.26	268
x21	25.0	56.2	9.35	235	25.5	60.5	9.35	275
x24	26.8	61.5	14.1	265	27.2	66.7	14.1	310
x28	26.8	61.5	14.3	266	27.3	67.7	14.3	319
x31	29.7	71.9	21.4	342	30.2	79.1	21.4	402
x35	29.7	71.9	21.5	343	30.3	80.0	21.5	411
x40	29.7	71.9	21.8	344	30.4	81.2	21.8	423
x48	29.7	71.9	22.1	346	30.5	83.1	22.1	443
x58	29.7	71.9	22.7	350	30.7	85.7	22.7	469
x67	29.7	71.9	23.1	352	30.8	87.9	23.1	491
W 10x12	26.4	65.4	5.31	320	26.8	67.6	5.31	344
x15	26.4	65.4	5.46	320	26.9	68.1	5.46	351
x17	26.4	65.4	5.49	320	26.9	68.4	5.50	357
x19	26.4	65.4	5.53	320	26.9	68.6	5.53	362
x22	29.9	81.8	11.1	419	30.4	86.1	11.1	470
x26	29.9	81.8	11.2	419	30.4	86.8	11.2	481
x30	29.9	81.8	11.4	420	30.5	87.7	11.4	492
x33	33.1	94.1	21.2	501	33.6	101	21.2	577
x39	33.1	94.1	21.4	502	33.7	103	21.4	594
x45	33.1	94.1	21.6	503	33.8	104	21.6	611
x49	37.0	112	33.4	662	37.7	123	33.4	781
x54	37.0	112	33.6	664	37.8	124	33.6	795
x60	37.0	112	34.0	666	37.9	126	34.0	814
x68	37.0	112	34.4	669	38.0	128	34.4	838
x77	37.0	112	34.8	673	38.1	130	34.9	866

	L	Sx	Sy	J	L	Sx	Sy	J
W 12x14	30.5	87.0	5.37	509	30.9	89.4	5.37	543
x16	30.5	87.0	5.44	509	30.9	89.7	5.45	548
x19	30.5	87.0	5.50	509	30.9	90.0	5.50	558
x22	30.5	87.0	5.60	510	31.0	90.4	5.61	567
x26	35.4	115	14.1	708	35.9	120	14.1	781
x30	35.4	115	14.3	708	36.0	121	14.3	794
x35	35.4	115	14.5	709	36.0	122	14.5	811
x40	37.2	124	21.5	761	37.8	132	21.5	873
x45	37.2	124	21.7	763	37.9	133	21.7	889
x50	37.2	124	21.9	764	38.0	134	21.9	905
x53	41.1	145	33.4	958	41.8	156	33.4	1110
x58	41.1	145	33.5	959	41.8	157	33.5	1128
x65	45.0	166	48.1	1196	45.8	181	48.1	1387
x72	45.0	166	48.5	1199	45.9	183	48.5	1412
x79	45.0	166	48.8	1202	46.0	184	48.8	1437
x87	45.0	166	49.2	1206	46.1	186	49.2	1467
x96	45.0	166	49.6	1209	46.1	189	49.6	1500
W 14x22	35.7	119	8.47	801	36.1	123	8.47	865
x26	35.7	119	8.58	801	36.2	123	8.59	880
x30	39.1	141	15.2	975	39.6	147	15.2	1068
x34	39.1	141	15.3	976	39.6	147	15.3	1083
x38	39.1	141	15.5	976	39.7	148	15.5	1097
x43	40.6	150	21.4	1030	41.2	158	21.4	1165
x48	40.6	150	21.7	1031	41.3	159	21.7	1184
x53	40.6	150	21.9	1032	41.3	160	21.9	1202
x61	44.4	174	33.5	1264	45.2	187	33.5	1465
x68	44.4	174	33.8	1266	45.3	188	33.8	1492
x74	44.4	174	34.0	1268	45.3	190	34.1	1516
x82	44.4	174	34.5	1272	45.5	192	34.5	1545
x90	53.4	230	70.4	1962	54.2	251	70.4	2272
W 16x26	40.5	154	10.2	1181	41.0	158	10.2	1268
x31	40.5	154	10.4	1182	41.0	159	10.4	1288
x36	43.4	175	16.4	1373	44.0	182	16.4	1498
x40	43.4	175	16.5	1373	44.0	182	16.5	1517
x45	43.4	175	16.7	1374	44.1	183	16.7	1537
x50	43.4	175	17.0	1375	44.1	184	17.0	1557
x57	43.4	175	17.3	1377	44.2	185	17.3	1585
W 18x35	45.1	191	12.2	1643	45.7	196	12.2	1774
x40	45.1	191	12.3	1644	45.7	197	12.3	1798
x46	45.1	191	12.6	1645	45.8	198	12.6	1824
M 4x13	13.9	15.5	5.23	35.6	14.4	18.6	5.23	47.6
5x18.9	17.7	25.3	8.42	73.8	18.3	29.8	8.43	95.7
6x4.4	14.8	20.5	1.17	59.0	15.0	21.1	1.17	64.5
6x20	21.9	39.0	11.8	137	22.4	43.6	11.8	166
8x6.5	19.5	35.7	1.79	138	19.8	36.7	1.80	149
10x9	24.2	54.9	2.50	267	24.6	56.3	2.50	285
12x11.8	28.9	77.8	3.25	454	29.2	79.6	3.25	482
14x18	34.5	111	5.49	760	34.9	114	5.49	809

TABLE 18

W and M SHAPES

(Formula 45)

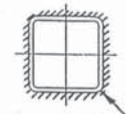


(Formula 46)

	L	Sx	Sy	J	L	Sx	Sy	J
W 4x13	22.6	31.2	11.0	87.3	16.3	23.4	10.3	69.6
W 5x16	28.1	47.8	16.7	161	19.0	33.4	14.9	121
x19	28.2	48.0	16.9	166	19.2	34.2	15.1	126
W 6x9	26.4	51.6	10.4	173	17.8	34.8	9.75	122
x12	26.5	51.9	10.7	178	18.0	35.6	10.0	127
x16	26.5	52.0	10.9	185	18.3	36.5	10.2	135
x15	34.4	73.8	24.0	293	22.0	47.4	20.4	203
x20	34.5	73.9	24.2	302	22.2	48.6	20.6	213
x25	34.6	74.4	24.7	312	22.5	49.9	21.0	223
W 8x10	30.4	75.5	10.4	318	19.8	47.9	9.76	208
x13	30.5	75.8	10.8	324	20.0	48.6	10.0	214
x15	30.5	75.8	10.9	329	20.1	49.1	10.1	219
x18	35.5	94.4	18.4	433	22.6	59.2	16.2	239
x21	35.5	94.4	18.6	440	22.8	60.0	16.3	291
x24	39.7	107	28.2	515	24.9	66.9	23.5	342
x28	39.8	107	28.6	525	25.1	68.0	23.8	352
x31	45.7	128	42.7	683	28.0	79.3	33.7	452
x35	45.7	128	43.0	693	28.2	80.4	33.9	462
x40	45.8	129	43.5	707	28.4	81.7	34.2	475
x48	45.9	129	44.0	728	28.7	83.9	34.6	497
x58	46.1	131	45.3	757	29.2	86.7	35.4	525
x67	46.2	131	46.0	782	29.6	89.2	35.9	550
W 10x12	34.4	102	10.5	523	21.8	61.2	9.87	322
x15	34.4	102	10.8	530	22.0	62.0	10.0	330
x17	34.5	102	10.8	536	22.1	62.5	10.1	336
x19	34.5	102	10.9	542	22.3	63.0	10.2	343
x22	41.4	134	22.1	748	25.7	80.4	19.0	463
x26	41.5	134	22.3	759	25.9	81.3	19.2	475
x30	41.5	135	22.6	771	26.1	82.5	19.4	488
x33	49.0	163	42.3	962	29.6	97.5	33.4	608
x39	49.0	163	42.6	980	29.9	99.1	33.6	626
x45	49.1	164	43.0	998	30.1	101	33.9	645
x49	57.0	199	66.8	1327	34.0	120	49.7	845
x54	57.1	199	67.2	1343	34.1	121	49.9	861
x60	57.2	200	67.9	1364	34.4	123	50.4	881
x68	57.3	201	68.6	1390	34.7	125	50.8	907
x77	57.4	201	69.5	1421	35.0	127	51.4	938

	L	Sx	Sy	J	L	Sx	Sy	J
W 12x14	38.4	131	10.6	801	23.9	75.2	9.93	468
x16	38.4	131	10.7	807	24.0	75.7	10.0	474
x19	38.5	131	10.8	816	24.2	76.5	10.1	485
x22	38.5	131	11.0	826	24.4	77.3	10.2	496
x26	48.4	188	28.2	1238	29.2	107	23.5	730
x30	48.5	188	28.5	1251	29.4	108	23.7	744
x35	48.6	188	28.8	1269	29.6	109	24.0	763
x40	53.2	209	42.8	1417	31.9	121	33.8	860
x45	53.3	209	43.3	1434	32.1	123	34.1	878
x50	53.4	209	43.7	1452	32.3	124	34.4	896
x53	61.1	252	66.7	1851	36.0	146	49.6	1130
x58	61.1	252	66.9	1869	36.2	148	49.8	1150
x65	69.0	295	96.1	2366	40.1	171	68.3	1447
x72	69.1	296	96.8	2394	40.3	173	68.7	1474
x79	69.2	296	97.5	2422	40.5	175	69.1	1502
x87	69.3	297	98.0	2455	40.8	177	69.6	1534
x96	69.4	297	98.8	2491	41.0	180	70.0	1569
W 14x22	45.7	182	16.8	1293	27.7	101	14.9	734
x26	45.7	182	17.0	1308	28.0	102	15.1	751
x30	52.5	267	30.3	1670	31.3	126	25.0	955
x34	52.5	226	30.5	1686	31.5	127	25.1	972
x38	52.6	226	30.7	1701	31.6	128	25.3	988
x43	56.6	247	42.8	1861	33.6	140	33.7	1092
x48	56.6	248	43.2	1881	33.8	142	34.0	1113
x53	56.7	248	43.5	1900	34.0	143	34.2	1134
x61	64.4	297	66.8	2395	37.9	170	49.6	1427
x68	64.5	297	67.3	2424	38.1	172	50.0	1456
x74	64.6	298	67.8	2450	38.3	173	50.3	1482
x82	64.7	298	68.7	2482	38.6	176	50.9	1515
x90	82.4	411	141	3900	47.1	234	95.6	2337
W 16x26	51.5	233	20.3	1886	30.7	125	17.7	1031
x31	51.5	233	20.5	1907	30.9	127	17.8	1054
x36	57.3	277	32.7	2308	33.8	150	26.7	1280
x40	57.4	276	32.8	2326	34.0	151	26.8	1301
x45	57.4	277	33.2	2347	34.2	152	27.1	1323
x50	57.5	277	33.6	2369	34.4	154	27.3	1346
x57	57.6	277	34.2	2398	34.7	156	27.7	1377
W 18x35	57.1	288	24.2	2619	33.7	151	20.6	1401
x40	57.1	287	24.4	2644	33.9	153	20.7	1429
x46	57.2	287	24.8	2670	34.2	154	21.0	1459
M 4x13	21.8	28.4	10.4	77.3	15.9	21.7	9.76	62.7
5x18.9	27.7	46.1	16.8	157	19.0	33.0	14.9	120
6x4.4	18.5	30.4	2.31	93.2	–	–	–	–
6x20	33.7	69.7	23.6	279	21.9	46.3	20.1	199
8x6.5	24.1	52.3	3.53	213	16.6	35.4	3.50	146
10x9	29.6	79.6	4.91	404	19.4	49.4	4.83	254
12x11.8	35.0	112	6.38	680	22.1	65.0	6.19	400
14x18	42.5	163	10.8	1163	26.0	90.0	10.1	650

TABLE 19



R = 2t

STRUCTURAL TUBING, SQUARE

(Formula 49)

TS	L	S	J
16x16x1/2	62.3	327	5233
x3/8	62.7	331	5291
x5/16	63.0	333	5320
14x14x1/2	54.3	249	3483
x3/8	54.7	252	3528
x5/16	54.9	254	3550
12x12x1/2	46.3	181	2174
x3/8	46.7	184	2208
x5/16	46.9	185	2224
x1/4	47.1	187	2241
10x10x5/8	37.8	122	1218
x1/2	38.3	124	1242
x3/8	38.7	127	1266
x5/16	38.9	128	1278
x1/4	39.1	129	1289
8x8x5/8	29.8	75.9	607
x1/2	30.3	77.9	623
x3/8	30.7	79.9	639
x5/16	30.9	80.8	647
x1/4	31.1	81.8	654
x3/16	31.4	82.7	661
7x7x1/2	26.3	58.8	411
x3/8	26.7	60.5	424
x5/16	26.9	61.4	430
x1/4	27.1	62.2	435
x3/16	27.4	63.0	441
6x6x1/2	22.3	42.3	254
x3/8	22.7	43.8	263
x5/16	22.9	44.6	267
x1/4	23.1	45.3	272
x3/16	23.4	46.0	276
5x5x1/2	18.3	28.5	143
x3/8	18.7	29.8	149
x5/16	18.9	30.4	152
x1/4	19.1	31.0	155
x3/16	19.4	31.6	158

TS	L	S	J
4x4x1/2	14.3	17.4	69.5
x3/8	14.7	18.5	73.8
x5/16	14.9	19.0	75.9
x1/4	15.1	19.5	77.9
x3/16	15.4	20.0	79.9
3.5x3.5x5/16	12.9	14.2	49.9
x1/4	13.1	14.7	51.4
x3/16	13.4	15.1	53.0
3x3x5/16	10.9	10.2	30.5
x1/4	11.1	10.6	31.7
x3/16	11.4	11.0	32.9
2.5x2.5x1/4	9.14	7.13	17.8
x3/16	9.36	7.45	18.6
2x2x1/4	7.14	4.34	8.69
x3/16	7.36	4.61	9.23

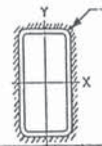


TABLE 20

STRUCTURAL TUBING, RECTANGULAR

(Formula 49)

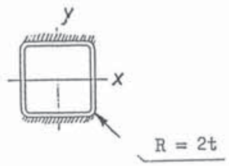
TS	L	Sx	Sy	J
20x12x1/2	62.3	356	277	5219
x3/8	62.7	360	280	5281
x5/16	62.9	362	281	5312
20x8x1/2	54.3	276	174	3452
x3/8	54.7	280	176	3505
x5/16	54.9	282	177	3531
20x4x1/2	46.3	196	81.4	2119
x3/8	46.7	200	82.5	2166
x5/16	46.9	202	83.0	2190
18x6x1/2	46.3	200	114	2143
x3/8	46.7	204	116	2184
x5/16	46.9	206	117	2205
16x12x1/2	54.3	263	229	3479
x3/8	54.7	267	232	3526
x5/16	54.9	269	233	3548
16x8x1/2	46.3	199	142	2160
x3/8	46.7	203	144	2197
x5/16	46.9	205	145	2216
16x4x1/2	38.3	135	65.4	1211
x3/8	38.7	139	66.5	1243
x5/16	38.9	141	67.0	1258
14x10x1/2	46.3	193	164	2170
x3/8	46.7	196	167	2205
x5/16	46.9	198	168	2222
14x6x1/2	38.3	137	90.3	1228
x3/8	38.7	140	91.8	1256
x5/16	38.9	142	92.6	1269
x1/4	39.1	143	93.3	1282
14x4x1/2	34.3	109	57.4	876
x3/8	34.7	112	58.5	901
x5/16	34.9	114	59.0	913
x1/4	35.1	115	59.5	925
12x8x5/8	37.8	130	108	1213
x1/2	38.3	133	110	1239
x3/8	38.7	136	112	1263
x5/16	38.9	137	113	1275
x1/4	39.1	139	114	1287

TS	L	Sx	Sy	J
12x6x1/2	34.3	109	78.3	890
x3/8	34.7	112	79.8	911
x5/16	34.9	113	80.6	922
x1/4	35.1	115	81.3	932
x3/16	35.4	116	82.0	942
12x4x1/2	30.3	85.1	49.4	610
x3/8	30.7	88.0	50.5	629
x5/16	30.9	89.3	51.0	638
x1/4	31.1	90.7	51.5	647
x3/16	31.4	92.1	52.0	656
12x2x1/4	27.1	66.7	24.3	425
x3/16	27.4	68.1	24.6	433
10x6x1/2	30.3	84.2	66.3	620
x3/8	30.7	86.6	67.8	636
x5/16	30.9	87.7	68.6	644
x1/4	31.1	88.9	69.3	652
x3/16	31.4	90.0	70.0	660
10x4x1/2	26.3	64.2	41.4	404
x3/8	26.7	66.6	42.5	418
x5/16	26.9	67.7	43.0	425
x1/4	27.1	68.9	43.5	431
x3/16	27.4	70.0	44.0	438
10x2x3/8	22.7	46.6	19.8	253
x5/16	22.9	47.7	20.1	259
x1/4	23.1	48.9	20.3	265
x3/16	23.4	50.0	20.6	271
8x6x1/2	26.3	61.9	54.3	411
x3/8	26.7	63.9	55.8	423
x5/16	26.9	64.8	56.6	429
x1/4	27.1	65.8	57.3	435
x3/16	27.4	66.7	58.0	441
8x4x1/2	22.3	45.9	33.4	250
x3/8	22.7	47.9	34.5	260
x5/16	22.9	48.8	35.0	265
x1/4	23.1	49.8	35.5	270
x3/16	23.4	50.7	36.0	275

TS	L	Sx	Sy	J
8x3x3/8	20.7	39.9	24.8	197
x5/16	20.9	40.8	25.2	201
x1/4	21.1	41.8	25.6	205
x3/16	21.4	42.7	26.0	210
8x2x3/8	18.7	31.9	15.8	143
x5/16	18.9	32.8	16.1	147
x1/4	19.1	33.8	16.3	151
x3/16	19.4	34.7	16.6	155
7x5x1/2	22.3	44.8	38.5	253
x3/8	22.7	46.5	39.8	262
x5/16	22.9	47.4	40.4	267
x1/4	23.1	48.2	41.0	271
x3/16	23.4	49.0	41.6	276
7x4x3/8	20.7	39.5	30.5	199
x5/16	20.9	40.4	31.0	203
x1/4	21.1	41.2	31.5	207
x3/16	21.4	42.0	32.0	211
7x3x3/8	18.7	32.5	21.8	146
x5/16	18.9	33.4	22.2	150
x1/4	19.1	34.2	22.6	154
x3/16	19.4	35.0	23.0	157
6x4x1/2	18.3	30.3	25.4	142
x3/8	18.7	31.8	26.5	148
x5/16	18.9	32.6	27.0	152
x1/4	19.1	33.3	27.5	155
x3/16	19.4	34.0	28.0	158
6x3x3/8	16.7	25.8	18.8	106
x5/16	16.9	26.6	19.2	108
x1/4	17.1	27.3	19.6	111
x3/16	17.4	28.0	20.0	114
6x2x3/8	14.7	19.8	11.8	71.3
x5/16	14.9	20.6	12.1	73.8
x1/4	15.1	21.3	12.3	76.2
x3/16	15.4	22.0	12.6	78.6
5x4x3/8	16.7	24.8	22.5	107
x5/16	16.9	25.4	23.0	110
x1/4	17.1	26.0	23.5	112
x3/16	17.4	26.6	24.0	115

TS	L	Sx	Sy	J
5x3x1/2	14.3	18.5	14.9	68.7
x3/8	14.7	19.8	15.8	73.2
x5/16	14.9	20.4	16.2	75.4
x1/4	15.1	21.0	16.6	77.5
x3/16	15.4	21.6	17.0	79.5
5x2x5/16	12.9	15.4	10.1	48.7
x1/4	13.1	16.0	10.3	50.5
x3/16	13.4	16.6	10.6	52.2
4x3x5/16	12.9	15.0	13.2	49.7
x1/4	13.1	15.5	13.6	51.3
x3/16	13.4	16.0	14.0	52.9
4x2x5/16	10.9	11.0	8.06	30.0
x1/4	11.1	11.5	8.34	31.3
x3/16	11.4	12.0	8.61	32.5
3x2x1/4	9.14	7.58	6.34	17.7
x3/16	9.36	7.96	6.61	18.6

TABLE 21



STRUCTURAL TUBING

Square

(Formula 50)

TS	L	Sx	Sy	J
16x16x1/2	31.1	249	81.5	2616
x3/8	31.4	250	82.5	2646
x5/16	31.5	251	83.0	2660
14x14x1/2	27.1	189	62.0	1741
x3/8	27.4	191	62.8	1764
x5/16	27.5	192	63.3	1775
12x12x1/2	23.1	138	45.1	1087
x3/8	23.4	140	45.8	1104
x5/16	23.5	141	46.2	1112
x1/4	23.6	141	46.6	1120
10x10x5/8	18.9	93.7	30.3	609
x1/2	19.1	95.1	30.9	621
x3/8	19.4	96.4	31.5	633
x5/16	19.5	97.1	31.8	639
x1/4	19.6	97.7	32.1	645
8x8x5/8	14.9	58.7	18.9	304
x1/2	15.1	59.9	19.4	312
x3/8	15.4	61.1	19.9	319
x5/16	15.5	61.6	20.1	323
x1/4	15.6	62.1	20.4	327
x3/16	15.7	62.6	20.6	331
7x7x1/2	13.1	45.4	14.6	206
x3/8	13.4	46.4	15.1	212
x5/16	13.5	46.9	15.3	215
x1/4	13.6	47.3	15.5	218
x3/16	13.7	47.8	15.7	221
6x6x1/2	11.1	32.8	10.5	127
x3/8	11.4	33.7	10.9	131
x5/16	11.5	34.1	11.1	134
x1/4	11.6	34.6	11.3	136
x3/16	11.7	34.9	11.5	138

TS	L	Sx	Sy	J
5x5x1/2	9.14	22.2	7.09	71.3
x3/8	9.36	23.0	7.42	74.5
x5/16	9.46	23.4	7.57	76.1
x1/4	9.57	23.8	7.73	77.6
x3/16	9.68	24.1	7.88	79.1
4x4x1/2	7.14	13.7	4.33	34.7
x3/8	7.36	14.4	4.59	36.9
x5/16	7.46	14.7	4.72	37.9
x1/4	7.57	15.0	4.85	39.0
x3/16	7.68	15.3	4.97	39.9
3.5x3.5x5/16	6.46	11.1	3.54	24.9
x1/4	6.57	11.3	3.66	25.7
x3/16	6.68	11.6	3.77	26.5
3x3x5/16	5.46	7.96	2.53	15.3
x1/4	5.57	8.20	2.63	15.9
x3/16	5.68	8.43	2.73	16.4
2.5x2.5x1/4	4.57	5.56	1.77	8.91
x3/16	4.68	5.76	1.85	9.32
2x2x1/4	3.57	3.42	1.08	4.34
x3/16	3.68	3.59	1.15	4.61

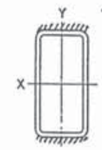
TABLE 22

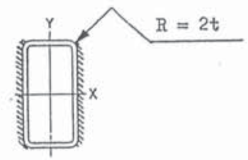
STRUCTURAL TUBING

Rectangular

(Formula 50)

Type of weld:





TS	L	Sx	Sy	J	L	Sx	Sy	J
20x12x1/2	23.1	231	45.1	2565	39.1	129	234	2654
x3/8	23.4	233	45.8	2597	39.4	130	236	2684
x5/16	23.5	234	46.2	2613	39.5	130	237	2699
20x8x1/2	15.1	151	19.4	1580	39.1	129	156	1872
x3/8	15.4	153	19.9	1607	39.4	130	157	1898
x5/16	15.5	154	20.1	1621	39.5	130	158	1910
20x4x1/2	7.14	70.8	4.33	715	39.1	129	77.7	1403
x3/8	7.36	73.2	4.59	740	39.4	130	78.4	1426
x5/16	7.46	74.4	4.72	752	39.5	130	78.7	1437
18x6x1/2	11.1	99.6	10.5	925	35.1	104	105	1217
x3/8	11.4	102	10.9	947	35.4	105	106	1237
x5/16	11.5	103	11.1	958	35.5	105	106	1247
16x12x1/2	23.1	185	45.1	1734	31.1	81.5	186	1746
x3/8	23.4	186	45.8	1757	31.4	82.5	188	1768
x5/16	23.5	187	46.2	1769	31.5	83.0	189	1780
16x8x1/2	15.1	121	19.4	1036	31.1	81.5	124	1124
x3/8	15.4	122	19.9	1055	31.4	82.5	125	1142
x5/16	15.5	123	20.1	1065	31.5	83.0	126	1151
16x4x1/2	7.14	56.5	4.33	459	31.1	81.5	61.7	752
x3/8	7.36	58.5	4.59	476	31.4	82.5	62.4	766
x5/16	7.46	59.5	4.72	484	31.5	83.0	62.7	774
14x10x1/2	19.1	133	30.9	1079	27.1	62.0	135	1091
x3/8	19.4	135	31.5	1097	27.4	62.8	136	1108
x5/16	19.5	136	31.8	1105	27.5	63.3	137	1117
14x6x1/2	11.1	77.4	10.5	570	27.1	62.0	80.8	658
x3/8	11.4	79.1	10.9	584	27.4	62.8	81.7	671
x5/16	11.5	80.0	11.1	591	27.5	63.3	82.1	678
x1/4	11.6	80.8	11.3	598	27.6	63.7	82.6	684
14x4x1/2	7.14	49.4	4.33	353	27.1	62.0	53.7	523
x3/8	7.36	51.1	4.59	366	27.4	62.8	54.4	535
x5/16	7.46	52.0	4.72	373	27.5	63.3	54.7	541
x1/4	7.57	52.8	4.85	379	27.6	63.7	55.0	546

TS	L	Sx	Sy	J	L	Sx	Sy	J
12x8x5/8	14.9	88.6	18.9	600	22.9	44.4	90.7	613
x1/2	15.1	90.2	19.4	613	23.1	45.1	91.9	625
x3/8	15.4	91.8	19.9	626	23.4	45.8	93.1	637
x5/16	15.5	92.5	20.1	632	23.5	46.2	93.6	643
x1/4	15.6	93.3	20.4	638	23.6	46.6	94.1	649
12x6x1/2	11.1	66.2	10.5	426	23.1	45.1	68.8	464
x3/8	11.4	67.8	10.9	437	23.4	45.8	69.7	474
x5/16	11.5	68.5	11.1	442	23.5	46.2	70.1	479
x1/4	11.6	69.3	11.3	448	23.6	46.6	70.6	484
x3/16	11.7	70.0	11.5	453	23.7	46.9	70.9	489
12x4x1/2	7.14	42.2	4.33	261	23.1	45.1	45.7	349
x3/8	7.36	43.8	4.59	271	23.4	45.8	46.4	358
x5/16	7.46	44.5	4.72	276	23.5	46.2	46.7	362
x1/4	7.57	45.3	4.85	281	23.6	46.6	47.0	367
x3/16	7.68	46.0	4.97	285	23.7	46.9	47.3	371
12x2x1/4	3.57	21.3	1.08	129	23.6	46.6	23.4	296
x3/16	3.68	22.0	1.15	133	23.7	46.9	23.6	300
10x6x1/2	11.1	55.1	10.5	304	19.1	30.9	56.8	316
x3/8	11.4	56.4	10.9	312	19.4	31.5	57.7	324
x5/16	11.5	57.1	11.1	317	19.5	31.8	58.1	328
x1/4	11.6	57.7	11.3	321	19.6	32.1	58.6	332
x3/16	11.7	58.3	11.5	325	19.7	32.4	58.9	335
10x4x1/2	7.14	35.1	4.33	183	19.1	30.9	37.7	221
x3/8	7.36	36.4	4.59	190	19.4	31.5	38.4	227
x5/16	7.46	37.1	4.72	194	19.5	31.8	38.7	231
x1/4	7.57	37.7	4.85	197	19.6	32.1	39.0	234
x3/16	7.68	38.3	4.97	201	19.7	32.4	39.3	237
10x2x3/8	3.36	16.4	.95	82.9	19.4	31.5	19.0	170
x5/16	3.46	17.1	1.02	86.2	19.5	31.8	19.2	173
x1/4	3.57	17.7	1.08	89.4	19.6	32.1	19.4	175
x3/16	3.68	18.3	1.15	92.5	19.7	32.4	19.6	178
8x6x1/2	11.1	43.9	10.5	204	15.1	19.4	44.8	206
x3/8	11.4	45.1	10.9	211	15.4	19.9	45.7	212
x5/16	11.5	45.6	11.1	214	15.5	20.1	46.1	215
x1/4	11.6	46.1	11.3	217	15.6	20.4	46.6	218
x3/16	11.7	46.6	11.5	220	15.7	20.6	46.9	221
8x4x1/2	7.14	28.0	4.33	119	15.1	19.4	29.7	131
x3/8	7.36	29.1	4.59	124	15.4	19.9	30.4	136
x5/16	7.46	29.6	4.72	127	15.5	20.1	30.7	138
x1/4	7.57	30.1	4.85	129	15.6	20.4	31.0	141
x3/16	7.68	30.6	4.97	132	15.7	20.6	31.3	143
8x3x3/8	5.36	21.1	2.44	87.4	15.4	19.9	22.7	109
x5/16	5.46	21.6	2.53	89.8	15.5	20.1	23.0	111
x1/4	5.57	22.1	2.63	92.1	15.6	20.4	23.2	113
x3/16	5.68	22.6	2.73	94.3	15.7	20.6	23.4	115

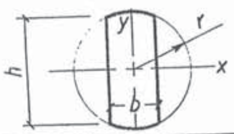
TS	L	Sx	Sy	J	L	Sx	Sy	J
8x2x3/8	3.36	13.1	.95	53.0	15.4	19.9	15.0	90.2
x5/16	3.46	13.6	1.02	55.3	15.5	20.1	15.2	92.1
x1/4	3.57	14.1	1.08	57.4	15.6	20.4	15.4	93.9
x3/16	3.68	14.6	1.15	59.5	15.7	20.6	15.6	95.8
7x5x1/2	9.14	31.4	7.09	125	13.1	14.6	32.2	128
x3/8	9.36	32.4	7.42	130	13.4	15.1	33.0	132
x5/16	9.46	32.9	7.57	133	13.5	15.3	33.4	134
x1/4	9.57	33.3	7.73	135	13.6	15.5	33.8	136
x3/16	9.68	33.8	7.88	137	13.7	15.7	34.1	139
7x4x3/8	7.36	25.4	4.59	97.1	13.4	15.1	26.4	102
x5/16	7.46	25.9	4.72	99.2	13.5	15.3	26.7	104
x1/4	7.57	26.3	4.85	101	13.6	15.5	27.0	106
x3/16	7.68	26.8	4.97	103	13.7	15.7	27.3	108
7x3x3/8	5.36	18.4	2.44	67.5	13.4	15.1	19.7	79.0
x5/16	5.46	18.9	2.53	69.4	13.5	15.3	20.0	80.6
x1/4	5.57	19.3	2.63	71.3	13.6	15.5	20.2	82.3
x3/16	5.68	19.8	2.73	73.0	13.7	15.7	20.4	83.9
6x4x1/2	7.14	20.8	4.33	69.8	11.1	10.5	21.7	71.9
x3/8	7.36	21.7	4.59	73.3	11.4	10.9	22.4	75.1
x5/16	7.46	22.1	4.72	75.0	11.5	11.1	22.7	76.6
x1/4	7.57	22.6	4.85	76.7	11.6	11.3	23.0	78.2
x3/16	7.68	22.9	4.97	78.2	11.7	11.5	23.3	79.7
6x3x3/8	5.36	15.7	2.44	50.3	11.4	10.9	16.7	55.4
x5/16	5.46	16.1	2.53	51.8	11.5	11.1	17.0	56.7
x1/4	5.57	16.6	2.63	53.2	11.6	11.3	17.2	58.0
x3/16	5.68	16.9	2.73	54.6	11.7	11.5	17.4	59.3
6x2x3/8	3.36	9.72	.95	29.9	11.4	10.9	11.0	41.3
x5/16	3.46	10.1	1.02	31.3	11.5	11.1	11.2	42.5
x1/4	3.57	10.6	1.08	32.6	11.6	11.3	11.4	43.6
x3/16	3.68	10.9	1.15	33.9	11.7	11.5	11.6	44.7
5x4x3/8	7.36	18.0	4.59	53.3	9.36	7.42	18.4	53.6
x5/16	7.46	18.4	4.72	54.6	9.46	7.57	18.7	54.9
x1/4	7.57	18.8	4.85	55.9	9.57	7.73	19.0	56.2
x3/16	7.68	19.1	4.97	57.2	9.68	7.88	19.3	57.4
5x3x1/2	5.14	12.2	2.23	33.3	9.14	7.09	13.1	35.3
x3/8	5.36	13.0	2.44	35.7	9.36	7.42	13.7	37.4
x5/16	5.46	13.4	2.53	36.9	9.46	7.57	14.0	38.5
x1/4	5.57	13.8	2.63	38.0	9.57	7.73	14.2	39.5
x3/16	5.68	14.1	2.73	39.1	9.68	7.88	14.4	40.5
5x2x5/16	3.46	8.42	1.02	21.9	9.46	7.57	9.23	26.8
x1/4	3.57	8.77	1.08	22.9	9.57	7.73	9.42	27.6
x3/16	3.68	9.11	1.15	23.8	9.68	7.88	9.59	28.4

TS	L	Sx	Sy	J	L	Sx	Sy	J
4x3x5/16	5.46	10.7	2.53	24.7	7.46	4.72	11.0	25.0
x1/4	5.57	11.0	2.63	25.5	7.57	4.85	11.2	25.8
x3/16	5.68	11.3	2.73	26.3	7.68	4.97	11.4	26.5
4x2x5/16	3.46	6.69	1.02	14.2	7.46	4.72	7.23	15.8
x1/4	3.57	6.99	1.08	14.9	7.57	4.85	7.42	16.4
x3/16	3.68	7.27	1.15	15.6	7.68	4.97	7.59	17.0
3x2x1/4	3.57	5.20	1.08	8.73	5.57	2.63	5.42	8.98
x3/16	3.68	5.43	1.15	9.07	5.68	2.73	5.59	9.38

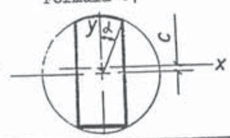
TABLE 23

TRIMMED ROUND BAR
(as a function of α)

Formula 66



Formula 67

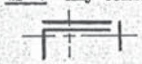


α	b	h	L	Ix	Iy	L	c	Ix	Iy
10	.347r	1.970r	4.637r	$1.965r^3$	$.126r^3$	4.636r	.001r	$1.956r^3$	$.126r^3$
20	.684r	1.879r	5.155r	$2.447r^3$	$.495r^3$	5.141r	.008r	$2.381r^3$	$.494r^3$
30	1.000r	1.732r	5.558r	$2.779r^3$	$1.047r^3$	5.511r	.024r	$2.569r^3$	$1.040r^3$
40	1.286r	1.532r	5.857r	$2.980r^3$	$1.678r^3$	5.746r	.052r	$2.529r^3$	$1.649r^3$
45	1.414r	1.414r	5.970r	$3.042r^3$	$1.985r^3$	5.813r	.071r	$2.434r^3$	$1.935r^3$
50	1.532r	1.286r	6.062r	$3.084r^3$	$2.269r^3$	5.849r	.094r	$2.301r^3$	$2.189r^3$
60	1.732r	1.000r	6.189r	$3.127r^3$	$2.728r^3$	5.826r	.149r	$1.951r^3$	$2.547r^3$
70	1.879r	.684r	6.255r	$3.140r^3$	$3.009r^3$	5.691r	.217r	$1.548r^3$	$2.662r^3$
80	1.970r	.347r	6.280r	$3.142r^3$	$3.124r^3$	5.457r	.298r	$1.148r^3$	$2.536r^3$

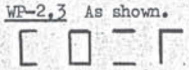
List of available programs for TI-59 programmable calculator.

WELD PROPERTIES

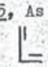
WP-1 Any combination of welds parallel to X and Y axes.



WP-2,3 As shown.



WP-25, As shown.



WP-27 As shown.

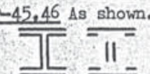
WP-28 As shown.

WP-30 As shown.

WP-32 As shown.

WP-38,43 As shown.

WP-45,46 As shown.

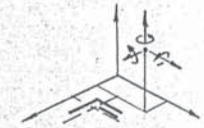


WP-31 Three-dimensional welds. Any combination of straight line welds.

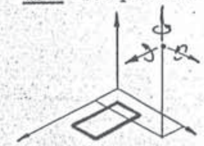
WP-49,50 As shown.

WELD STRESS

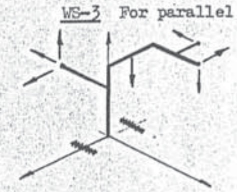
WS-1 For given weld properties calculates stress at any point of weld.



WS-2 For parallel or rectangular weld calculates stress at four points of weld.



WS-3 For parallel weld calculates maximum stress due to number of applied forces.



WS-31 Calculates weld stress at any point of any three-dimensional weld pattern due to applied forces and moments.

Each program consists of complete description and protected magnetic card.
Price per program - $3.00 (Postage and tax included) Each additional magnetic card - $1.25
Total set of 15 programs - $25.00