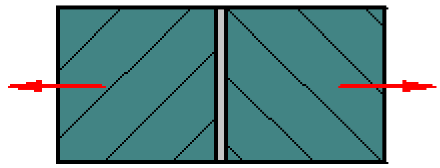
Weld Joint Design Equations and Calculations

Spot Weld Design Equations and Calculations

Welding Types and Processes

Weld Design Menu



Normal Stress

$$\sigma_1 = \frac{F_n}{A} \qquad [MPa, psi]$$

Where :

σ_1 = Normal stress [MPa,psi]

F_n = Normal force [N, lb]

A = Throat area of weld [mm^2, in^2]

Reference Stress

$$\sigma_S = \frac{\sigma_1}{\alpha_1} \qquad [MPa, psi]$$

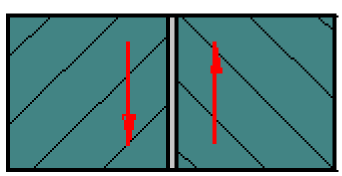
Where:

σ_S = Reference stress [MPa,psi]

σ_1 = Normal stress [MPa,psi]

α_1 = Coefficient of weld joint

Weld Design Menu



Shear Stress

$$\tau = \frac{F_t}{A} \qquad [MPa, psi]$$

Where :

τ = Shear stress [MPa,psi]

F_t = shear force [N, lb]

A = Throat area of the weld [mm^2, in^2]

Reference Stress

$$\sigma_S = \frac{\tau}{\alpha_2} \qquad [MPa,psi]$$

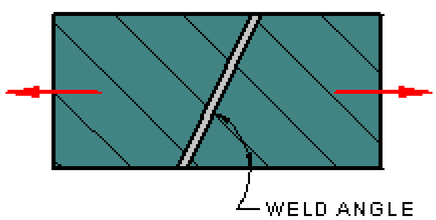
Where :

σ_S = Reference stress [MPa , psi]

τ = Shear stress [MPa, psi]

α_2 = Coefficient of weld joint

Weld Design Menu



Normal Stress

$$\sigma = \frac{F \cdot \cos\delta}{A} \qquad [MPa,psi]$$

Where :

σ = Normal Stress [MPa,psi]

F = Acting force [N, lb]

δ = Weld angle [�]

A = Throat area of the weld [mm^2, in^2]

Shear Stress

$$\tau = \frac{F \cdot \sin\delta}{A} \qquad [MPa, psi]$$

Where :

τ = Shear Stress [MPa,psi]

F = Acting force [N, lb]

δ = Weld direction angle [�]

A = Throat area of the weld [mm^2, in^2]

Resultant reduced stress

$$\sigma_R = \sqrt{\sigma^2 + 3 \cdot \tau^2} \qquad [MPa, psi]$$

Where:

σ_R = Resultant Reduced Stress [MPa,psi]

σ = Normal stress [MPa,psi]

τ = Shear stress [MPa,psi]

Reference Stress

$$\sigma_S = \sqrt{\left(\frac{\sigma}{\alpha_1}\right)^2 + 3 \cdot \left(\frac{\tau}{\alpha_2}\right)^2} \qquad [MPa, psi]$$

Where:

σ_S = Reference Stress [MPa,psi]

σ = Normal stress [MPa,psi]

τ = Shear stress [MPa,psi]

α_1, α_2 = Coefficients of the weld joint

Weld Design Menu

Resultant Reduced Stress

$$\sigma_R = \sqrt{(\sigma_1 + \sigma_2 + \sigma_3)^2 + 3 \cdot (\tau)^2} \qquad [MPa, psi]$$

Where:

σ_R = Resultant Reduced Stress [MPa,psi]

$\sigma_1, \sigma_2,$ = Normal stress [MPa,psi]

τ = Shear stress [MPa,psi]

Reference Stress

$$\sigma_S = \sqrt{\left(\frac{\sigma_1 + \sigma_2 + \sigma_3}{\alpha_1}\right)^2 + 3 \cdot \left(\frac{\tau}{\alpha_2}\right)^2} \quad \text{[MPa, psi]}$$

Where :

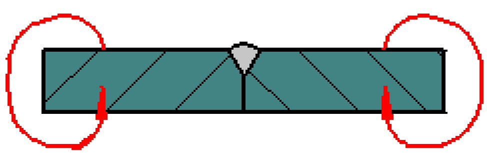
σ_S = Reference Stress [MPa, psi]

$\sigma_1, \sigma_2, \sigma_3$ = Normal Stress [MPa,psi]

τ = Shear stress [MPa,psi]

α_1, α_2 = Coefficient of weld joint

Weld Design Menu



Shear Stress

$$\tau_{max} = \frac{u \cdot T}{W} \quad \text{[MPa,psi]}$$

Where :

τ_{max} = Shear Stress [MPA,psi]

u = constant

- for calculation in metric units u = 1000
- for calculation in imperial units u = 12

T = torque [Nm, lb-ft]

W = section modulus of throat area of the weld [mm^3, in^3]

Reference Stress

$$\sigma_5 = \frac{\tau_{max}}{\alpha_2} \quad [MPa,psi]$$

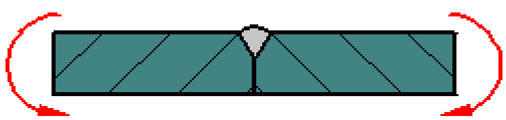
Where :

σ_5 = Reference Stress [MPa,psi]

α_2 = Shear Stress [MPa,psi]

τ_{max} = coefficient of the weld joint

Weld Design Menu



Normal Stress

$$\sigma_3 = \frac{u \cdot M_2}{W} \quad [MPa,psi]$$

Where :

σ_3 = Normal stress [MPa,psi]

u = Constant

- for calculation in metric units u = 1000
- for calculation in imperial units u = 12

M_2 = Bending moment [Nm, lb-ft]

W = Section modulus of throat area of weld [mm^3, in^3]

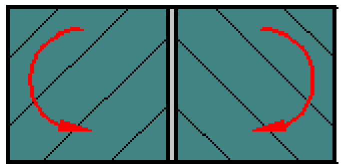
Reference Stress

$$\sigma_5 = \frac{\sigma_3}{\alpha_1} \quad [MPa,psi]$$

Where:	
σ_5	= Reference stress [MPa,psi]
σ_3	= Normal stress [MPa,psi]

α_1	= Coefficient of weld joint

[Weld Design Menu](#)



Normal Stress

$$\sigma_2 = \frac{u \cdot M_1}{W} \qquad [MPa, psi]$$

Where :

σ_2 = Normal stress [MPa,psi]

u = Constant

- for calculation in metric units u = 1000
- for calculation in imperial units u = 12

M_1 = Bending moment [Nm, lb ft]

W = Section modulus of throat area of the weld [mm^3, in^3]

Reference Stress

$$\sigma_5 = \frac{\sigma_2}{\alpha_1} \qquad [MPa, psi]$$

Where:

σ_5 = Reference stress [MPa,psi]

σ_2 = Normal stress [MPa,psi]

α_1 = Coefficient of weld joint

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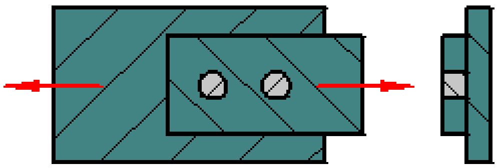


Shear Stress in Weld Base Area

$$\tau_z = \frac{F}{0.5 \cdot d^2 \cdot} \qquad [MPa, psi]$$

Where:

- τ_z = Shear stress in weld base area [MPa,psi]
- F = Shear force [N, lb]
- d = Diameter of plug weld [mm,in]
- i = Number of welds

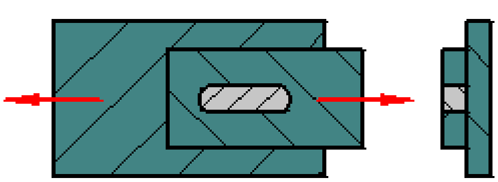
Shear Stress in Weld Peripheral Area

$$\tau_o = \frac{F}{2.2 \cdot d \cdot s \cdot i} \qquad [MPa, psi]$$

Where:

- τ_o = Shear stress in weld peripheral area [MPa,psi]
- F = Shear force [N, lb]
- d = Diameter of plug weld [mm,in]
- s = Plate thickness [mm, in]
- i = Number of welds

[Weld Design Menu](#)



Shear Stress in Weld Base Area

$$\tau_Z = \frac{F}{0.7 \cdot b \cdot L \cdot i} \quad [MPa, psi]$$

Where:

τ_Z = Shear stress in weld base area [MPa,psi]

F = Shear force [N, lb]

b = Width of weld [mm,in]

L = Length of weld [mm,in]

i = Number of welds

Shear Stress in Weld Peripheral Area

$$\tau_O = \frac{F}{1.4 \cdot s \cdot L \cdot i} \quad [MPa, psi]$$

Where:

τ_O = Shear stress in weld peripheral area [MPa,psi]

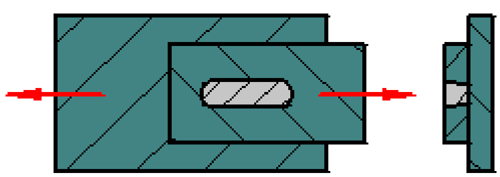
F = Shear force [N, lb]

s = Plate thickness [mm, in]

L = Length of weld [mm,in]

i = Number of welds

Weld Design Menu



Shear Stress in Weld Base Area

$$\tau_Z = \frac{F}{b \cdot L \cdot i} \quad [MPa, psi]$$

Where:

τ_Z = Shear stress in weld base area [MPa,psi]

F = Shear force [N, lb]

b = Width of weld [mm,in]

L = Length of weld [mm,in]
i = Number of welds

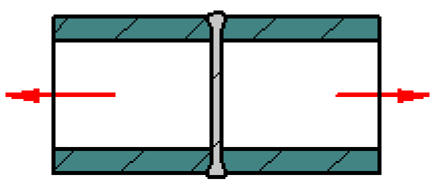
Shear Stress in Weld Peripheral Area

$$\tau_o = \frac{F}{2 \cdot s \cdot L \cdot i} \quad [MPa,psi]$$

Where:

τ_o = Shear stress in weld peripheral area [MPa,psi]
F = Shear force [N, lb]
s = Plate thickness [mm, in]
L = Length of weld [mm,in]
i = Number of welds

[Weld Design Menu](#)



Normal Stress in Weld Base Area

$$\sigma = \frac{F_z}{A} \quad [MPa,psi]$$

Where:

σ = Normal stress [MPa,psi]
F_Z = Applied axial force [N, lb]
A = Throat are of weld [mm^2,in^2]

Comparative Stress

$$\sigma_S = \frac{\sigma}{\alpha_1} \quad [MPa,psi]$$

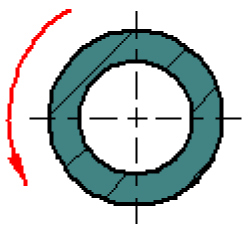
Where:

σ_S = Comparative stress [MPa,psi]

σ = Normal stress [MPa,psi]

α_1 = Conversion coefficient of weld joint

[Weld Design Menu]



Circumference Butt Weld Stress with Torque Shear Stress

$$\tau = \frac{u \cdot T}{W} \quad [MPa, psi]$$

Where:

τ = Shear stress [MPa,psi]

u = Constant

Metric units u=1000

Imperial units u=12

W = Section modulus throat area [mm^3, in^3]

T = Torque applied [Nm, lb-ft]

Comparative Stress

$$\sigma_S = \frac{\tau}{\alpha_2}$$

Where:

σ_S = Comparative stress [MPa,psi]

τ = Shear stress [MPa,psi]

α_2 = Conversion coefficient of weld joint

[Weld Design Menu]

Circumference Butt Weld Stress with Combined Shear and Axial Loading

Resultant Reduced Stress

$$\sigma_R = \sqrt{\sigma^2 + 3 \cdot \tau^2} \qquad [MPa,psi]$$

Where:

σ_R = Resultant seduced stress [MPa,psi]

σ = Normal Stress [MPa,psi]

τ = Shear Stress [MPa,psi]

Comparative Stress

$$\sigma_S = \sqrt{\left(\frac{\sigma}{\alpha_1}\right)^2 + 3 \cdot \left(\frac{\tau}{\alpha_2}\right)^2} \qquad [MPa,psi]$$

Where:

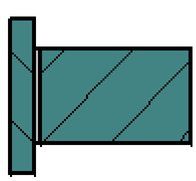
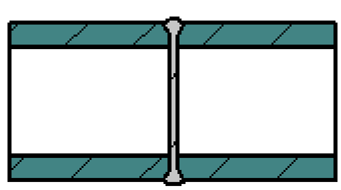
σ_S = Comparative stress [MPa,psi]

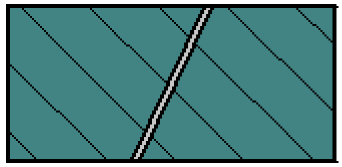
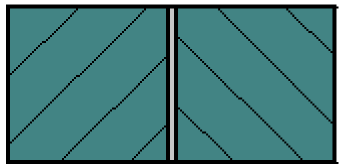
σ = Normal stress [MPa,psi]

τ = Shear stress [MPa,psi]

α_1, α_2 = Conversion coefficient of weld joint

[Weld Design Menu]

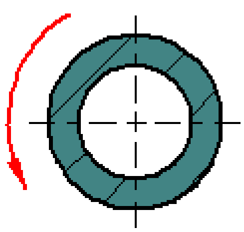
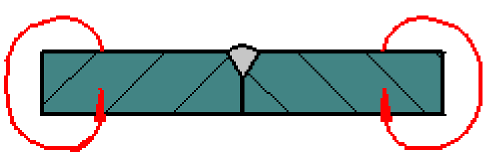
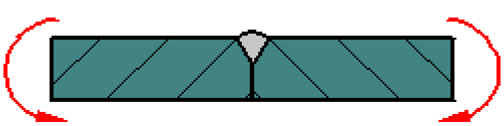
Butt Weld Orientation	Weld Illustration	Throat Area of Butt Weld [mm^2, in^2]	
		Full Weld Length	Active Load-bearing Length
Butt End Tube Weld		$A = s\,L$	$A = s\,(L - 2\,s)$
Circumferential Tube Weld		$A = \pi\,s\,(d - s)$	$A = s\,(L - 2\,s)$

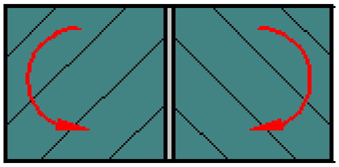
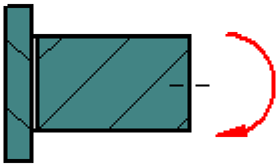
Angled Relative to applied load		$A = s \cdot \frac{L}{\cos \delta}$	$A = s \cdot \left(\frac{L}{\cos \delta} - 2 \cdot s \right)$
Normal to Applied Load		$A = s\,L$	$A = s\,(L - 2\,s)$

Where:

- A = Area in^2
- δ = Weld angle [deg]
- s = Plate or tube thickness [mm, in]
- L = Length of weld [mm, in]
- π = pi (3.14157

[Weld Design Menu]

Weld Illustration	Section Modulus of Throat Area of Butt Weld [mm^3, in^3]	
	Full Weld Length	Active Load-bearing Length
	$W = \frac{\pi}{2} \cdot s \cdot (D - s)^2$	$W = \frac{s \cdot (L - 2 \cdot s)^2}{6}$
	$W = \frac{s^2 \cdot L^2}{3 \cdot L + 1.8 \cdot s}$	$W = \frac{s^2 \cdot (L - 2 \cdot s)^2}{3 \cdot (L - 2 \cdot s) + 1.8 \cdot s}$
	$W = \frac{s^2 \cdot L}{6}$	$W = \frac{s^2 \cdot (L - 2 \cdot s)}{6}$

	$W = \frac{\pi}{2} \cdot s \cdot (D - s)^2$	$W = \frac{s \cdot (L - 2 \cdot s)^2}{6}$
	$W = \frac{s \cdot L^2}{6}$	

Where:

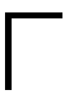
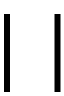
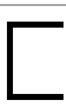
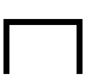
W = Section modulus [mm^3, in^3]

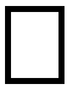
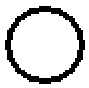
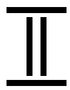
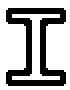
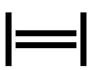
s = Plate or tube thickness [mm, in]

L = Length of weld [mm, in]

π = pi (3.14157)

[**Weld Design Menu**]

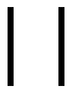
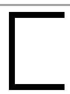
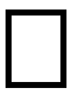
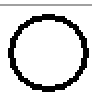
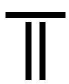
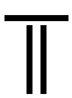
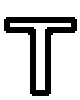
Weld	Polar Moment of Inertia	
	Fillet "J" Weld [mm^4, in^4]	Location Center o
	$J = a \cdot \frac{L^3}{12}$	$\bar{X} = \frac{L}{2}$ $\bar{Y}$
	$J = a \cdot \left(\frac{(H+B)^4 - 6 \cdot H^2 \cdot B^2}{12 \cdot (H+B)} \right)$	$\bar{X} = \frac{B^2}{2 \cdot (H+B)}$ $\bar{Y}$
	$J = a \cdot \left(\frac{H \cdot (3 \cdot B^2 + H^2)}{6} \right)$	$\bar{X} = \frac{B^2}{2 \cdot (H+B)}$ $\bar{Y}$
	$J = a \cdot \left(\frac{H \cdot (3 \cdot B^2 + H^2)}{6} \right)$	$\bar{X} = \frac{B}{2}$ $\bar{Y}$
	$J = a \cdot \left(\frac{8 \cdot B^3 + 6 \cdot B \cdot H^2 + H^3}{12} - \frac{B^4}{2 \cdot B + H} \right)$	$\bar{X} = \frac{B^2}{2 \cdot B + H}$
	$J = a \cdot \left(\frac{8 \cdot H^3 + 6 \cdot H \cdot B^2 + B^3}{12} - \frac{H^4}{2 \cdot H + B} \right)$	$\bar{X} = \frac{B}{2}$ $\bar{Y} =$

	$J = a \cdot \frac{(H+B)^3}{16}$	$\bar{X} = \frac{B}{2}$ $\bar{Y}$
	$J = 2 \pi a (r + a/2)^3$	-
	$J = a \cdot \left(\frac{H^3 + B^3}{6} + \frac{B \cdot H^2}{2} \right)$ $J = a \cdot \left(\frac{(H-2 \cdot t)^3 + 3 \cdot (H-2 \cdot t) \cdot s^2 + B^3 + 3 \cdot B \cdot H^2}{6} \right)$	-
	$J = a \cdot \left(\frac{B^3 + 2 \cdot H^3}{6} + H \cdot B^2 \right)$ $J = a \cdot \left(\frac{B^3 + 2 \cdot H^3 - s^3}{6} + H \cdot B^2 + \frac{B \cdot s^2 - s \cdot B^2}{2} - 2 \cdot (H-s) \cdot (B \cdot t - t^2) \right)$	-
	$J = a \cdot \left(\frac{H^3 + B^3}{6} + \frac{H \cdot B^2}{2} \right)$ $J = a \cdot \left(\frac{(B-2 \cdot t)^3 + 3 \cdot (B-2 \cdot t) \cdot s^2 + H^3 + 3 \cdot H \cdot B^2}{6} \right)$	

Where:

J	Polar Moment of inertia [mm^4, in^4]
$\bar{X}$	= Center of Gravity Location [mm, in]
$\bar{Y}$	= Center of Gravity Location [mm, in]
A	= Height fillet weld [mm, in]
B	= Width of weld [mm, in]
s	= Web thickness [mm, in]
L	= Length of weld [mm, in]
r	= Weld radius [mm, in]
t	= Flange thickness [mm, in]
H	= Height of fillet weld group [mm, in]

Weld Design Menu

Weld	Moment of Inertia	
	Fillet "I" Weld [mm⁴, in⁴]	Location Center of Gravit
	$I = a \cdot \frac{L^3}{12}$	$\bar{Y} = \frac{L}{2}$
	$I = a \cdot \frac{H^3}{6}$	$\bar{Y} = \frac{H}{2}$
	$I = a \cdot \frac{B \cdot H^2}{2}$	$\bar{Y} = \frac{H}{2}$
	$I = a \cdot \frac{(6 \cdot B + H) \cdot H^2}{12}$	$\bar{Y} = \frac{H}{2}$
	$I = a \cdot \left(\frac{2 \cdot H^3}{3} - 2 \cdot \bar{Y} \cdot H^2 + (B + 2 \cdot H) \cdot \bar{Y}^2 \right)$	$\bar{Y} = \frac{H^2}{2 \cdot H + B}$
	$I = a \cdot \frac{(3 \cdot B + H) \cdot H^2}{6}$	$\bar{Y} = \frac{H}{2}$
	$I = \pi a (r + a/2)^3$	-
	$I = a \cdot \frac{(3 \cdot B + H) \cdot H^2}{6}$ $I = a \cdot \left(\frac{(H - 2 \cdot t)^2}{6} + \frac{B \cdot H^2}{2} \right)$	$\bar{Y} = \frac{H}{2}$
	$I = a \cdot \left(\frac{2 \cdot H^3}{3} - 2 \cdot \bar{Y} \cdot H^2 + (B + 2 \cdot H) \cdot \bar{Y}^2 \right)$ $I = a \cdot \left(\frac{(H - t)^3}{6} + 2 \cdot H \cdot \left(\frac{H + t}{2} - \bar{Y} \right)^2 + B \cdot \bar{Y}^2 \right)$	$\bar{Y} = \frac{H^2}{2 \cdot H + B}$ $\bar{Y} = \frac{H^2 - t^2}{2 \cdot H + B - 2 \cdot t}$
	$I = a \cdot \left(\frac{2 \cdot H^3}{3} - 2 \cdot \bar{Y} \cdot H^2 + 2 \cdot (B + H) \cdot \bar{Y}^2 \right)$ $I = a \cdot \left(\frac{2 \cdot H^3}{3} - 2 \cdot \bar{Y} \cdot H^2 + 2 \cdot (B + H) \cdot \bar{Y}^2 - B \cdot t \cdot (2 \cdot \bar{Y} - t) \right)$	$\bar{Y} = \frac{H^2}{2 \cdot (H + B)}$ $\bar{Y} = \frac{H^2 + B \cdot t}{2 \cdot (H + B)}$

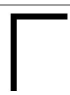
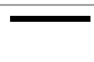
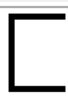
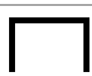
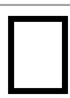
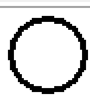
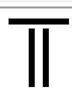
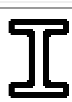
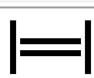
Where:

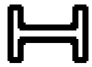
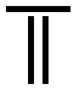
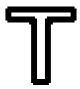
I = Moment of inertia [mm⁴, in⁴]

$\bar{Y}$ = Center of Gravity Location [mm, in]

a = Height fillet weld [mm, in]
B = Width of weld [mm, in]
s = Web thickness [mm, in]
L = Length of weld [mm, in]
r = Weld radius [mm, in]
t = Flange thickness [mm, in]
H = Height of fillet weld group [mm, in]

Weld Design Menu

Weld	Throat Area of Fillet Weld A [mm^2, in^2]	
	Full Weld Length	Active Load-bearing Length
	A = a L	A = s (L - 2 a)
	A = a (H + B)	A = a (H + B - 2 a)
	A = a 2 H	A = a 2 (H - 2 a)
	A = a 2 B	A = a 2 (B - 2 a)
	A = a (H + 2 B)	A = a (H + 2 B - 2 a)
	A = a (2 H + B)	A = a (2 H + B - 2 a)
	A = a 2 (H + B)	-
	A = 2 π a (r + a / 2)	-
	A = a 2 (H + B) A = a 2 (H + B - 2 t)	A = a 2 (H + B - 4 a) A = a 2 (H + B - 2 t - 4 a)
	A = a 2 (H + 2 B) A = a 2 (H +2 B - s)	-
	A = a 2 (H + B) A = a 2 (H + B - 2 t)	A = a 2 (H + B - 4 a) A = a 2 (H + B - 2 t - 4 a)

	A = a 2 (2 H + B) A = a 2 (2 H + B - s)	-
	A = a (2 H + B) A = a (2 H + B - 2 t)	A = a (2 H + B - 6 a) A = a (2 H + B - 2 t - 6 a)
	A = a 2 (H + B)	-
	A = a 2 L	A= a 2 (L - 2 a)

Where:

A = Throat area of fillet weld [mm^2, in^2]

B = Width of weld [mm, in]

s = Web thickness [mm, in]

L = Length of weld [mm, in]

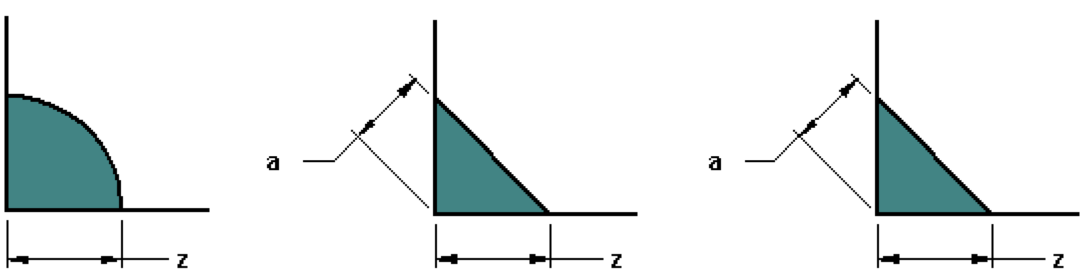
r = Weld radius [mm, in]

t = Flange thickness [mm, in]

H = Height of fillet weld [mm, in]

[Weld Design Menu](#)

The **active fillet weld height specification** is the largest isosceles triangle which may be inscribed with the theoretical weld cross-section.



The theoretical fillet weld size height approximately specifies a = .7 as given by trigonometry, where z is the fillet weld width. The minimum fillet weld height should be selected based on the actual thickness of the thickest weld part and the strength of the material.

Recommended Minimum Fillet Height Chart			
Thickest Welded Part		Minimum Fillet Weld Thickness [mm] fro Steel	
Over	To	370 - 420	520 MPa

		MPa	
-	10	3	4
10	20	4	5
20	30	6	7
30	50	7	9
50		9	10

[Weld Design Menu]

The following are recommended values for weld joint coefficient conversion.

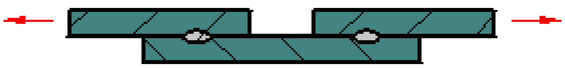
Type of Weld	Loading	Coefficient of Weld joint			
butt[1]	Compression	α_1	1.00		
	Tension		.85	.900[2]	1.00[3]
	Shear	α_2	.70		
Fillet	End Load	α_3	.75[4]	.90[5]	1.00[6]
	Side	α_4	.65[4]	.80[5]	.90[6]
Groove and Plug	Shear	α	.65		
Spot	Shear	α	.65		
	Tear-out	α	.5		

1. Coefficient of weld joint for loading along the axis of weld joint a = 1
2. Contact resistance welding
3. Butt welds manually welded and supported by the weld from the root side after grooving butt welds bilaterally penetrated, automatic welding under flux or in CO2 made at least from one side electro-slag welds
4. Manual arc welding while the strength of used electrode corresponds to the strength of basic material.
5. Applies to:

- Manual arc welding of basic materials whose minimum tensile strength is 20 % lower than minimum strength of weld metal of used electrode
- Semi-automatic submerged welding, semi-automatic and automatic welding shielded by CO2 atmosphere and even for automatic submerged welding of single-pass or multi-pass welds for the weld height a 8 mm

6. Automatic submerged welding of single-pass welds for the weld height a < 8 mm

7. **Weld Design Menu**



8.

9. **Shear of Point**

10. $$\tau_1 = \frac{4 \cdot F}{i \cdot \pi \cdot d^2} \quad [MPa,psi]$$

11. **Tear Loading of Point along Cylindrical Surface**

12. $$\tau_2 = \frac{F}{i \cdot \pi \cdot d \cdot s} \quad [MPa,psi]$$

13. **Comparative Stress**

14. $$\sigma_S = \max\left(\frac{\tau_1}{\alpha}, \frac{\tau_2}{\alpha}\right) \quad [MPa,psi]$$

Where:

τ_1 = Shear stress [MPa,psi]

τ_2 = Tear stress [MPa,psi]

σ_S = Comparative stress [MPa,psi]

F = Applied force [N, lb]

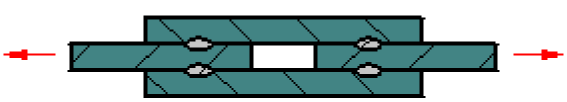
s = Thickness, plate [mm, in]

d = Spot weld diameter [mm, in]

i = Number of welds

α = Coefficient of weld joint

Weld Design Menu



Shear of Point

$$\tau_1 = \frac{2 \cdot F}{i \cdot \pi \cdot d^2} \quad [MPa,psi]$$

Tear Loading of Point along Cylindrical Surface

$$\tau_2 = \frac{F}{2 \cdot i \cdot \pi \cdot d \cdot s} \qquad [MPa,psi]$$

Comparative Stress

$$\sigma_S = \max\left\langle \frac{\tau_1}{\alpha}, \frac{\tau_2}{\alpha} \right\rangle \qquad [MPa,psi]$$

Where:

τ_1 = Shear stress [MPa,psi]

τ_2 = Tear stress [MPa,psi]

σ_S = Comparative stress [MPa,psi]

F = Applied force [N, lb]

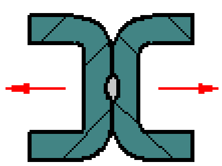
s = Thickness, plate [mm, in]

d = Spot weld diameter [mm, in]

i = Number of welds

α = Coefficient of weld joint

Weld Design Menu



Tear-off Loading of Weld Area

$$\tau = \frac{4 \cdot F}{i \cdot \pi \cdot d^2} \qquad [MPa,psi]$$

Comparative Stress

$$\sigma_S = \frac{\tau}{\alpha} \qquad [MPa,psi]$$

Where:

τ = Shear stress [MPa,psi]

σ_S = Comparative stress [MPa,psi]

F	=	Applied force [N, lb]
d	=	Spot weld diameter [mm, in]
i	=	Number of welds
α	=	Coefficient of weld joint

Introduction

The following notes are general guidance notes showing methods of calculation of the strength and size of welds. Welded joints are often crucially important affecting the safety of the design systems. It is important that the notes and data below are only used for preliminary design evaluations. Final detail design should be completed in a formal way using appropriate codes and standards and quality reference documents

Relevant Standards

BS 5950-1:2000 ..Structural use of steelwork in building. Code of practice for design. Rolled and welded sections

BS EN 10025-1:2004 - Hot rolled products of structural steels. General technical delivery conditions

Variables related to welded joints

1. Strength of deposited weld material
2. Type of joint and weld..important
3. Size of weld ..important
4. Location of weld in relation to parts joined..important
5. Types of stress to which the weld is subjected
6. Conditions under which weld is carried out
7. Type of equipment used for welding
8. Skill of welder

Guidance Principles

A generous factor of safety should be used (3-5) and if fluctuating loads are present then additional design margins should be included to allow for fatigue

Use the minimum amount of filler material consistent with the job requirement

Try to design joint such that load path is not not through the weld

The table below provides provides approximate stresses in, hopefully, a convenient way.

For the direct loading case the butt weld stresses are tensile/ compressive σ_t for the fillet welds the stresses are assumed to be shear τ_s applied to the weld throat.

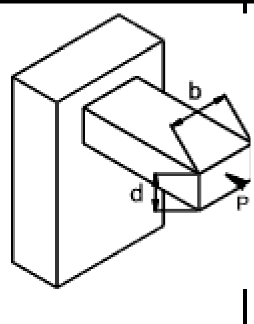
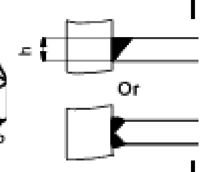
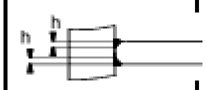
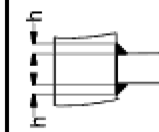
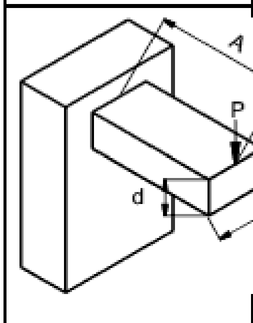
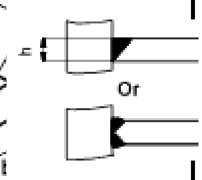
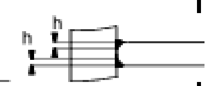
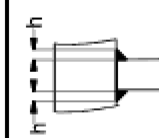
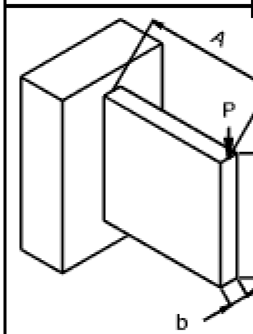
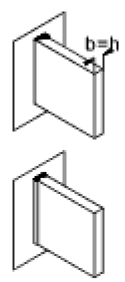
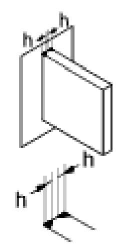
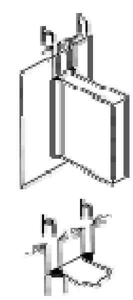
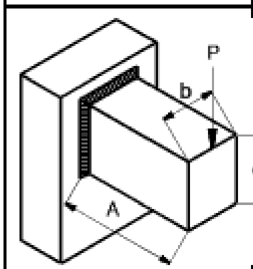
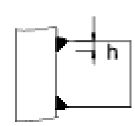
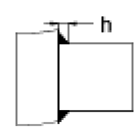
For butt welded joints subject to bending the butt weld stresses result from a tensile/compressive stress σ_b and a direct shear stress τ_s .
In these cases the design basis stress should be $\sigma_r = \text{Sqrt}(\sigma_b^2 + 4\tau_s^2)$

For Fillet welded joints subject to bending the stresses in the fillet welds are all shear stresses.
From bending τ_b and from shear τ_s
In these cases the design basis stress is generally $\tau_r = \text{Sqrt}(\tau_b^2 + \tau_s^2)$

The stresses from joints subject to torsion loading include shear stress from the applied load and shear stresses from the torque loading. The resulting stresses should be added vectorially taking care to choose the location of the highest stresses.

Table of bracket weld subject to direct and bending stresses

Method of Loading	Weldment	Stress in Weld σ_b τ_s Weld size (h)	Weldment	Stress in Weld σ_b τ_s Weld size (h)	Weldment	Stress in Weld τ_b τ_s Weld size (h)

		$\sigma_t = \frac{P}{b.h}$ $h = \frac{P}{b\,\sigma_t}$		$\sigma_t = \frac{0,5.P}{b.h}$ $h = \frac{0,5.P}{b.\sigma_t}$		$\tau_s = \frac{0,71.P}{b.h}$ $h = \frac{0,71.P}{b.\tau_s}$
		$\sigma_b = \frac{6.P.A}{b.h^2}$ $\tau_d = \frac{P}{b.h}$ $h = \sqrt{\frac{6.P.A}{b.\sigma_b}}$		$x = d^3 - (d-2h)^3$ $\sigma_b = \frac{6.P.A.d}{b.x}$ $\tau_s = \frac{P}{2.b.h}$		$x = (d+2h)^3 - d^3$ $\tau_b = \frac{8,5.P.A.(d+2h)}{b.x}$ $\tau_s = \frac{0,71.P}{b.h}$
		$\sigma_b = \frac{6.P.A}{h.d^2}$ $\tau_s = \frac{P}{d.h}$ $h = \frac{6.P}{\sigma_b d^2}$		$\sigma_b = \frac{3.P.A}{h.d^2}$ $\tau_s = \frac{P}{2.d.h}$ $h = \frac{3.P.A}{\sigma_b d^2}$		$\tau_b = \frac{4,24.P.A}{bd^2}$ $\tau_s = \frac{0,71.P}{bd}$ $h = \frac{2.121.P.A}{\tau_b d^2}$
				$x = (b-2h).(d-2h)^3$ $y = (b-2h).(d-2h)$ $\sigma_b = \frac{6.P.A.d}{bd^3 - x}$ $\tau_s = \frac{P}{(bd-y)}$		$x = (b+2h).(d+2h)$ $y = (b+2h).(d+2h)$ $\tau_b = \frac{8.49.P.A.d}{x-b.d^3}$ $\tau_s = \frac{1.41.P}{(y-bd)}$

Assessment of Fillet Weld Groups ref notes and table Properties of Fillet Welds as lines

Important note: The methods described below is based on the simple method of calculation of weld stress as identified in BS 5950- clause 6.7.8.2 . The other method identifed in BS 5950 - 1 clause 6.7.8.3 as the direction method uses the method of resolving the forces transmitted by unit thickness welds per unit length into traverse forces (F_T) and longitudinal forces (F_L). I have, to some extent, illustrated this method in my examples below

The method of assessing fillet welds groups treating welds as lines is reasonably safe and conservative and is very convenient to use.

a) Weld subject to bending....See table below for typical unit areas and unit Moments of Inertia

A fillet weld subject to bending is easily assessed as follows.

1) The area of the fillet weld A_u..(unit thickness) is calculated assuming the weld is one unit thick..
2) The (unit) Moment of Inertia I_u is calculated assuming the weld is one unit thick..
3) The maximum shear stress due to bending is determined...$\tau_b = M.y/I_u$
4) The maximum shear stress due to direct shear is determined.. $\tau_s = P/A$
5) The resultant stress $\tau_r = \text{Sqrt}(\tau_b^2 + \tau_s^2)$
6) By comparing the design strength p_w with the resultant stress τ_r the value of the weld throat thickness is calculated and then the weld size.
i.e. if the $\tau_r/p_w = 5$ then the throat thickess t = 5 units and the weld leg size h = 1,414t

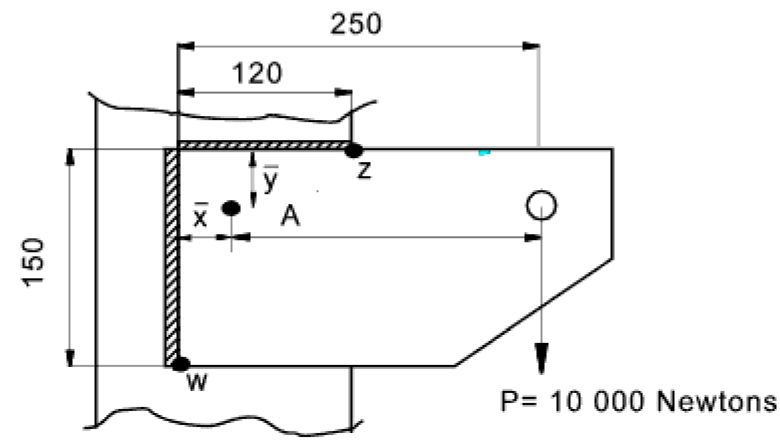
a) Weld subject to torsion...See table below for typical unit areas and unit Polar moments of Inertia

A fillet weld subject to torsion is easily assessed as follows.

1) The area of the fillet weld A_u (unit thickness) is calculated assuming the weld is one unit thick
2) The (unit) Polar Moment of Inertia J_u is calculated assuming the weld is one unit thick.. The polar moment of inertia $J = I_{xx} + I_{yy}$
3) The maximum shear stress due to torsion is determined...$\tau_t = T.r/J_u$
4) The maximum shear stress due to direct shear is determined.. $\tau_s = P/A_u$
5) The resultant stress τ_r is the vector sum of τ_t and τ_s. r is chosen to give the highest value of τ_r
6) By comparing the design strength p_w with the resultant stress τ_r the value of the weld throat thickness is calculated and then the weld size.
i.e. if the $\tau_r/p_w = 5$ then the throat thickess t = 5 units and the weld leg size h = 1,414.t

Examples of Fillet Weld Calculations

Example of Weld in Torsion..



P = Applied load = 10 000N

P_w = Design Strength = 220 N/mm ^{2} (Electrode E35 steel S275) Design Strength

b = 120mm.

d = 150 mm

x = $b^2 / 2(b+d)$ = 27mm.. (From table below)

y = $d^2 / 2(b+d)$ = 42mm..(From table below)

Simple Method as BS 5950 clause 6.8.7.2	Direction Method as BS 5950 clause 6.8.7.3
..The vector sum of the stresses due to forces and moments should not exceed the design strength P_w A_u = Unit Throat Area = (From table below) b + d = (120 + 150) = 270mm^2 To obtain radius of Force from weld centre of gravity A = 250-27 =223mm Moment M = P.r = 10000.223 = $2{,}23.10^6$ N.mm $J_u = [(b+d)^4 - 6b^2d^2] / 12 (b+d) = 1{,}04.10^6$..(From Table) It is necessary to locate the point subject to the highest shear stress..For a weld subject to only torsion this would be simply at the point furthest from the COG. However because the weld is subject to torsion and direct shear the problem is	L = Length of weld 1 unit thick = (From table below) b + d = (120 + 150) = 270mm To obtain radius of Force from weld Centre of Gravity (Cog) . A = 250-27 =223mm Moment M = P.r = 10000.223 = $2{,}23.10^6$ N.mm J_u = Polar Moment of inertia for weld 1unit(mm) thick. $= [(b+d)^4 - 6b^2d^2] / 12 (b+d) = 1{,}04.10^6$ mm^4 /mm..(From Table) It is necessary to locate the point subject to the highest shear stress..For a weld subject to only torsion this would be simply at the point furthest from the COG. However because the weld is subject to torsion and direct shear the problem is more complicated. A normal method of determining the stresses in these cases is to use

more complicated. A normal method of determining the stresses in these cases is to use vector addition.

It is generally prudent to calculate the total shear stress at both positions, using the method below, and select the highest.. For this example the method used is to resolve the stresses in the x and y directions

---

First considering point Z

Horizontal distance from centroid r_{zh} = 120-27= 93mm
Vertical distance from centroid r_{zv} = 42mm

The vertical stress $\tau_v = \tau_{sv} + \tau_{tv}$
$\tau_{sv} = P / A_u = 10000/270 = 37\ N/mm^2$
$\tau_{tv} = M.r_{zh} / J_u = 2,23.10^6.93/1,04.10^6 = 199\ N/mm^2$
$\tau_v = 236,45\ N/mm^2$

The horizontal stress $\tau_h = \tau_{sh} + \tau_{th}$
$\tau_{sh} = 0$
$\tau_{th} = M.r_{zv} / J_u = 2,23.10^6.42/1,04.10^6 = 90\ N/mm^2$
$\tau_h = 90\ N/mm^2$
The resultant stress on the weld at z
$\tau_r = Sqrt(\tau_h^2 + \tau_v^2) = 253\ N/mm^2$

Now considering point w

Horizontal distance from centroid r_{wh} = 27mm
Vertical distance from centroid r_{wv} = 150-42= 108mm

The vertical stress $\tau_v = \tau_{sv} - \tau_{tv}$
$\tau_{sv} = P / A_u = 10000/270 = 37\ N/mm^2$

vector addition.

It is generally prudent to calculate the total shear stress at both positions, using the method below, and select the highest.. For this example the method used is to resolve the stresses in the x and y directions

---

First considering point Z

Horizontal distance from centroid r_{zh} = 120-27= 93mm
Vertical distance from centroid r_{zv} = 42mm

The vertical force /mm run $F_v = F_{sv} + F_{tv}$
$F_{sv} = P / L = 10000/270 = 37$ N/mm run
$F_{tv} = M.r_{zh} / J_u = 2,23.10^6.93/1,04.10^6 = 199$ N/mm run
$F_v = 236,45$ N/mm run

The horizontal force /mm run for unit(mm) weld width $F_h = F_{sh} + F_{th}$
$F_{sh} = 0$
$F_{th} = M.r_{zv} / J_u = 2,23.10^6.42/1,04.10^6 = 90$ N/mm run
$F_h = 90$ N/mm run
The resultant force on the weld/mm run at z
$F_r = Sqrt(F_h^2 + F_v^2) = 253$ N/mm run

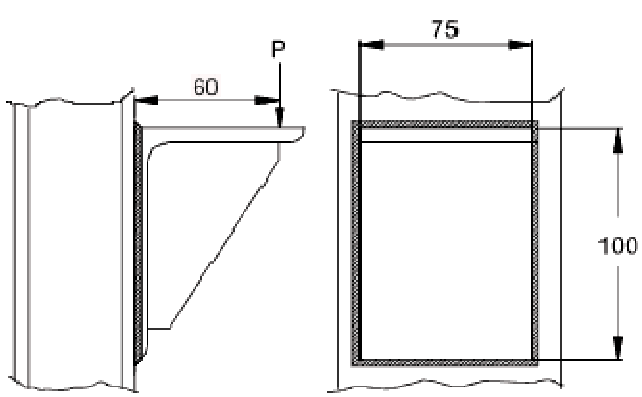
Now considering point w

Horizontal distance from centroid r_{wh} = 27mm
Vertical distance from centroid r_{wv} = 150-42= 108mm

The vertical forces per mm run $F_v = F_{sv} - F_{tv}$
$F_{sv} = P / L = 10000/270 = 37$ N/mm run

$\tau_{tv} = M.r_{wh} / J_u = 2{,}23.10^6.27/1{,}04.10^6 = 57{,}9$ N/mm^2 $\tau_v = 20{,}86$ N/mm^2 The horizontal stress $\tau_h = \tau_{sh} + \tau_{th}$ $\tau_{sh} = 0$ $\tau_{th} = T.r_{wv} / J_u = 2{,}23.10^6.108/1{,}04.10^6 = 231{,}6$ N/mm^2 $\tau_h = 231{,}6$ N/mm^2 The resultant stress on the weld at w $\tau_r = Sqrt(\tau_h^2 + \tau_v^2) = 232{,}5$ N/mm^2 The maximum stress is similar but greatest at z .... The design strength p_w for the weld material is 220 N/mm $_2$ The weld throat thickness should be 253 /220 = 1,15mm . The weld size is therefore 1,414. 1,15 = 1,62mm use 3mm fillet weld	$F_{tv} = M.r_{wh} / J_u = 2{,}23.10^6.27/1{,}04.10^6 = 57{,}9$ N/mm run $F_v = 20{,}86$ N/mm run The horizontal force /mm run = $F_h = F_{sh} + F_{th}$ $F_{sh} = 0$ $F_{th} = M.r_{wv} / J_u = 2{,}23.10^6.108/1{,}04.10^6 = 231{,}6$ N/mm run $F_h = 231{,}6$ N/mm run The specific force on the weld at w $F_r = Sqrt(F_h^2 + F_v^2) = 232{,}5$ N/mm run The maximum specific is greatest at z = 253 N/mm run.... Referring to weld capacities for longitudinal stresses P_L for fillet welds Capacities of Fillet Welds the weld capacity for a 3mm weld with and E35 Electrode S275 Steel is 462N /mm run. This weld would be more than sufficient.

Example of Weld in Bending..



P= 30000 Newtons

d= 100mm

b= 75mm

y = 50mm

Design Stress p_w = 220 N/mm ^{2} (Electrode E35 steel S275) Design Strength

Moment = M = 30000*60=18.10 ^{5} Nmm

Simple Method as BS 5950 clause 6.8.7.2

Unit Weld Area = A_u = 2(d+b) =2(100+75) =350mm ^{2}

Unit Moment of Inertia = I_u

= d ^{2}(3b+d) / 6 = 100 ^{2} (3.75 +100) / 6 =5,42.10^5 mm^4

τ_r = Sqrt($\tau_s^2 + \tau_b^2$)

τ_s = P / A_u = 30000/350 = 85,71 N/mm ^{2}

τ_b = M.y / I_u = 18.10^5 . 50 / 5,42.10^5 = 166,05 N/mm ^{2}

τ_r = Sqrt(85,71 ^{2} + 166.05^2) =186,86 N/mm^2

τ_r / p_w = 186,86 / 220 = 0,85 = Throat Thickness.....

(Throat thickness for τ = 220 N/mm^2)

Leg Length = Throat thickness *1,414 = 1,2mm use 3mm weld thickness

Note : If a leg length h= 1,2mm is used in the equations in relevant part of the "Table of bracket weld subject to direct and bending stresses" above a value of τ_b = 198 N/mm and a value of τ_s = 100 N/mm^2 results with a resultant stress of Sqrt ($\tau_b^2 + \tau_s^2$) = 222N/mm^2..Which is in general agreement with the above result

Direction Method as BS 5950 clause 6.8.7.3

Length of Weld of unit thickness = L = 2(d+b) =2(100+75) =350mm

Moment of Inertia / mm throat thickness = I_u / mm

= d ^{2}(3b+d) / 6 = 100 ^{2} (3.75 +100) / 6 =5,42.10^5 mm ^{4} / mm

F_r = Resultant force per unit length of weld.

F_s = Shear force per unit length of weld.

F_b = Bending force per unit length of weld.

F_r = Sqrt($F_s^2 + F_b^2$)

F_s = P / L = 30000/350 = 85,71 N per mm length of weld

F_b = M.y / I_u

= 18.10^5 . 50 / 5,42.10^5 = 166,05 N per mm length of weld

F_r = Sqrt(85,71 ^{2} + 166.05^2) =186,86 N per mm length of weld.

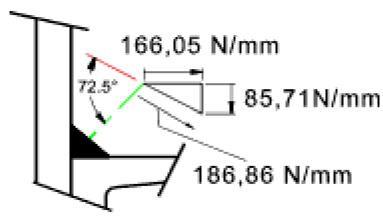
For this case for the welds under greatest loading the type of loading is traverse loading. The bending stress is in line with horizontal element and the shear stress is in line with vertical member.

The angle of the resulting specific load to the horizontal element

= arctan(85,71/166,5)= 27,5^o.

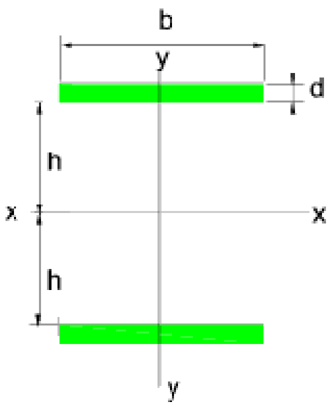
This is an angle with the weld throat $\theta = 45^o + 27{,}5^o = 72{,}5^o$ Referring to weld capacities table below.Weld Capacities K is calculated at 1,36 for this resultant direction of forces.

$P_T = a.K.p_w$for a E35 Weld electrode used with S275 steel
$p_w = 220\ N/mm^2$ and therefore $P_T = a*300N/mm^2$..
A 3mm weld (a = 2,1mm) therefore will therefore have a design capacity of 630 N/mm run and will easily be able to support the load of 186,86 N per mm run



Properties of weld groups with welds treated as lines -

It is accepted that it is reasonably accurate to use properties based on unit weld thickness in calculation to determine the strength of welds as shown in the examples on this page. The weld properties I_{xx} I_{yy} and J are assumed to be proportional to the weld thickness. The typical accuracy of this method of calculation is shown below...



$I_{xx} = 2\,[(bd^3/12) + bd(h+0{,}5d)^2]$

If weld thickness d is small compared to h and b then

$I_{xx} = 2\,bdh^2$ with little loss of accuracy

$I_{yy} = 2\,(db^3\ /\ 12)$

$J = I_{xx} + I_{yy}$

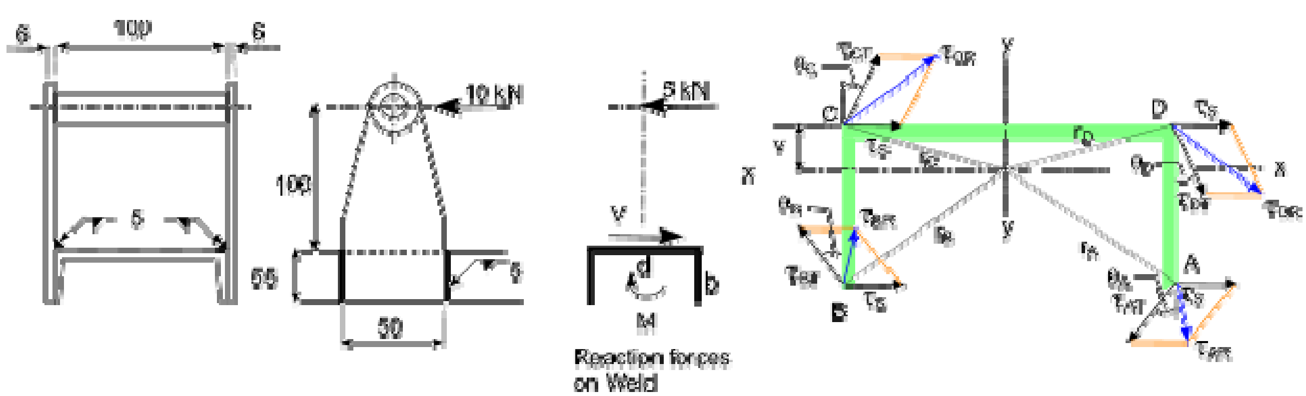
It is clear when d is small compared to b and h then J, I_{xx}, I_{yy}, are all proportional to the width of the weld (d)

This is illustrated in the tabled values below

	d	b	h	I_{xx}	I_{yy}	$J = I_{xx} + I_{yy}$
Accurate	3	60	50	955080	108000	1063080
Simple	3	60	50	900000	108000	1008000
Error				6%	0	5%

Note: The error identified with this method is lower as h increases relative to d. This error is such that the resulting designs are conservative.

Example illustrating use of stress vectors



Calculation based on real weld sizes

1) The area of the welds
(based on throat weld thickness at 0,707.5 = 3,5mm)

Area = (57.3,5 + 2.55.3,5) = 584,5mm^2

2) The moment of area about x-x =

M of Area = (57.3,5.3,5/2 + 2.55.3,5.(27.5 + 3,5)) = 12 284mm^3

3) The centroid v = Moment of Area/Area

M of Area / Area = 21 mm

4) The radii r_A, r_B, r_C & r_D are calculated ..

r_A = r_B = Sqrt ((58,5-21)^2 + 28,5^2) = 47,1
r_C = r_D = Sqrt ((21)^2 + 28,5^2) = 35,40...

5) The angles θ_A, θ_B, θ_C & θ_D are calculated ..

θ_A = θ_B = tan^{-1} ((58,5-21)/ 28,5) = 52,7^o
θ_C = θ_D = tan^{-1} ((21)/28,5) = 36,4^o...

6) The direct shear stress on the area = Force /Area

τ_S = 5000/584 = 8,56 N/mm^2

7) The Moment on the weld group = Force.Distance to centroid

M = 5000.(100+21) = 6,05.10^{5}Nmm

8) The polar moment of inertia of the weld group = J = I_{xx} + I_{yy}

I_{yy} = 2.[55.3,5^3 /12 + 3,5.55.(50/2 + 3,5/2)^2] + 57^3.3,5/12 = 3,3.10^{5}mm^4
I_{xx} = 2.[55^3.3,5/12 + 3,5.55.(55/2 + 3,5 - 21)^2] + 3,5^{3}57 / 12 + 3,5.57.(21-3,5/2)^2 = 2,097 .10^{5}mm^4

Calculations based on unit values

This calculation uses equations from table below for Area, centroid, and J_u

1) Area of weld = 0,707.5.(2b+d)

Area = 0,707.5.(2.55 + 50) = 565.6mm^2

2) There is no need to calculate the Moment of Area with this method

3) The centroid v = b^2 /(2b+d)

v = 55^2/(2.55+50)= 18,9mm

4) The radii r_A, r_B, r_C & r_D are calculated ..

r_A = r_B = Sqrt ((55-18,9)^2 + 25^2) = 43,9
r_C = r_D = Sqrt (18,9^2 + 25^2) = 31,34

5) The angles θ_A, θ_B, θ_C & θ_D are calculated ..

θ_A = θ_B = tan^{-1} ((55-18,9)/ 25) = 55,29^o
θ_C = θ_D = tan^{-1} ((18,9)/25) = 37^o...

6) The direct shear stress on the area = Force /Area

τ_S = 5000/565,5 = 8,84 N/mm^2

7) The Moment on the weld group = Force .distance to centroid

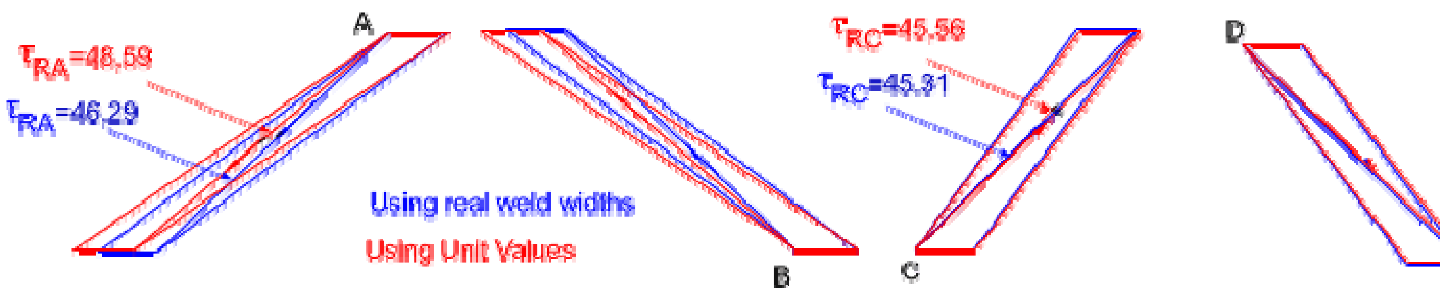
M = 5000.(100+18,9) = 5.94.10^{5}Nmm

8) The Unit Polar moment of inertia of the weld group =
J_u = 0.707.5.(8.b^3 +6bd^2+d^3)/12 + b^4/(2b+d)

J_u = 0,707.5.(8.55^3+6.55.50^2 + 50^3)/12 - 55^3/(2.55+50) = 4,69.10^5

9) The stress due to torsion

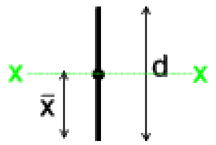
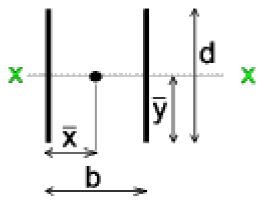
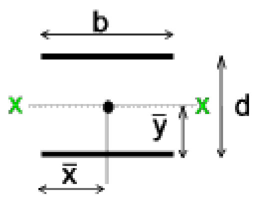
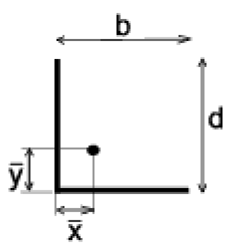
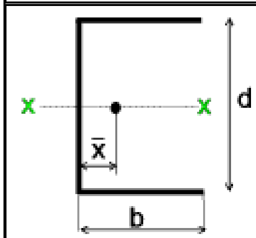
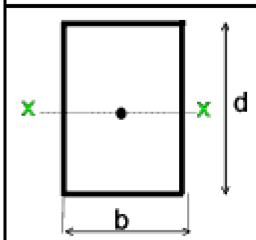
$J = I_{xx} + I_{yy} = 5{,}4.10^5 mm^4$ 9) The stress due to torsion $\tau_{TA} = \tau_{TB} = M.r_A/J$.. and ..$\tau_{TC} = \tau_{TD} = M.r_C/J$ $\tau_{TA} = 6.05^5 Nmm.47{,}1mm / 5{,}4.10^5 mm^4 = 52{,}8$ N/mm^2 $\tau_{TC} = \tau_{TD} = 6.05^5 Nmm.35{,}4mm /$ $5{,}4.10^5 mm^4 = 39{,}70 N/mm^2$ 10) The resultant stresses τ_{RA}, $= \tau_{RB}$ and τ_{RA}, $= \tau_{RB}$ are obtained by adding the stress vectos graphically as shown below $\tau_{RA} = \tau_{RB} = 46{,}29 N/mm^2$ $\tau_{RC} = \tau_{RD} = = 45{,}31 N/mm^2$	$\tau_{TA} = \tau_{TB} = M.r_A/J$.. and ..$\tau_{TC} = \tau_{TD} = M.r_C/J$ $\tau_{TA} = 5{,}94.10^5 Nmm.43{,}9mm /$ $4{,}69.10^5 mm^4 = 55{,}6 N/mm^2$ $\tau_{TC} = \tau_{TD} = 5{,}94^5 Nmm.31{,}34mm /$ $4{,}69.10^5 mm^4 = 39{,}69 N/mm^2$ 10) The resultant stresses τ_{RA}, $= \tau_{RB}$ and τ_{RA}, $= \tau_{RB}$ are obtained by adding the stress vectos graphically as shown below $\tau_{RA} = \tau_{RB} = 48{,}59 N/mm^2$ $\tau_{RC} = \tau_{RD} = 45{,}56 N/mm^2$



Note: The example above simply illustrates the vector method adding direct and torsional shear stresses and compares the difference in using the unit weld width method and using real weld sizes. The example calculates the stress levels in an existing weld group it is clear that the weld is oversized for the loading scenario. The difference in the resulting values are in less than 4%. If the welds were smaller i.e 3mm then the differences would be even smaller.

Table properties of a range of fillet weld groups with welds treated as lines -

Weld	Throat Area Unit Area	Location of COG **x** **y**	I_{xx}-(unit)	J-(Unit)

	0,707hd d	$\bar{x} = 0$ $\bar{y} = d / 2$	$I_{xx} = \frac{d^3}{12}$	$J = \frac{d^3}{12}$
	1,414hd 2d	$\bar{x} = b/2$ $\bar{y} = d/2$	$I_{xx} = \frac{d^3}{6}$	$J = \frac{d\,(3b^2 + d^2)}{6}$
	1,414hb 2.b	$\bar{x} = b/2$ $\bar{y} = d/2$	$I_{xx} = \frac{bd^2}{2}$	$J = \frac{b\,(3d^2 + b^2)}{6}$
	0,707 h (b+d) b + d	$\bar{x} = \frac{b^2}{2(b+d)}$ $\bar{y} = \frac{d^2}{2(b+d)}$	-	$J = \frac{(b+d)^4 - 6b^2d^2}{12(b+d)}$
	0,707h(2b+d) 2b +d	$\bar{x} = b^2/(2b+d)$ $\bar{y} = d/2$	$I_{xx} = \frac{d^2(6b + d)}{12}$	$z = 8b^3 + 6bd^2 + d^3$ $J = \frac{z}{12} - \frac{b^4}{2b+d}$
	1,414 h(b+d) 2(b +d)	$\bar{x} = b/2$ $\bar{y} = d/2$	$I_{xx} = \frac{d^2(3b + d)}{6}$	$J = \frac{(b+d)^3}{6}$

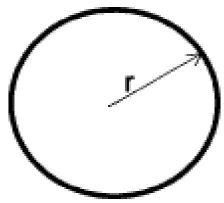
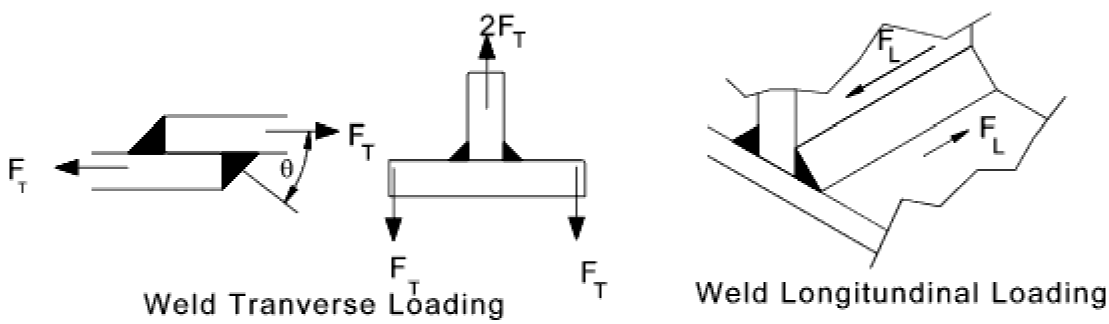
	1,414 πhr 2πr	-	$I = \pi r^3$	$J = 2\pi r^3$

Table Of Weld Capacities

The fillet weld capacity tables related to the type of loading on the weld. Two types of loading are identified traverse loading and longitudinal loading as show below



The weld loading should be such that

$$\{ (F_L/P_L)^2 + (F_T/P_T)^2 \} \leq 1$$

The following table is in accord with data in BS 5950 part 1. Based on design strengths as shown in table below ... Design Strength

$P_L = a.p_w$
$P_T = a.K.p_w$

a = weld throat size.

$K = 1,25 \sqrt{(1,5 / (1 + \cos^2 \theta)}$

P_T based on elements transmitting forces at 90_o i.e $\theta = 45_o$ and K = 1,25

Weld Capacity E35 Electrode S275 Steel				Weld Capacity E42 Electrode S355 Steel			
Leg	Throat	Longitudinal	Transverse	Leg	Throat	Longitudinal	Transverse

Length	Thickness	Capacity	Capacity	Length	Thickness	Capacity	Capacity
		P_L(kN/mm)	P_T (kN/mm)			P_L	P_T
mm	mm	kN/mm	kN/mm	mm	mm	kN/mm	kN/mm
3	2,1	0,462	0,577	3	2,1	0,525	0,656
4	2,8	0,616	0,720	4	2,8	0,700	0,875
5	3,5	0,770	0,963	5	3,5	0,875	1,094
6	4,2	0,924	1,155	6	4,2	1,050	1,312
8	5,6	1,232	1,540	8	5,6	1,400	1,750
10	7,0	1,540	1,925	10	7,0	1,750	2,188
12	8,4	1,848	2,310	12	8,4	2,100	2,625
15	10,5	2,310	2,888	15	10,5	2,625	3,281
18	12,6	2,772	3,465	18	12,6	3,150	3,938
20	14,0	3,08	3,850	20	14,0	3,500	4,375
22	15,4	3,388	4,235	22	15,4	3,850	4,813
25	17,5	3,850	4,813	25	17,5	4,375	5,469

Design Strength p_w of fillet welds

	Electrode classification

Steel Grade	35	43	50
	N/mm^2	N/mm^2	N/mm^2
S275	220	220	220
S355	220	250	250
S460	220	250	280