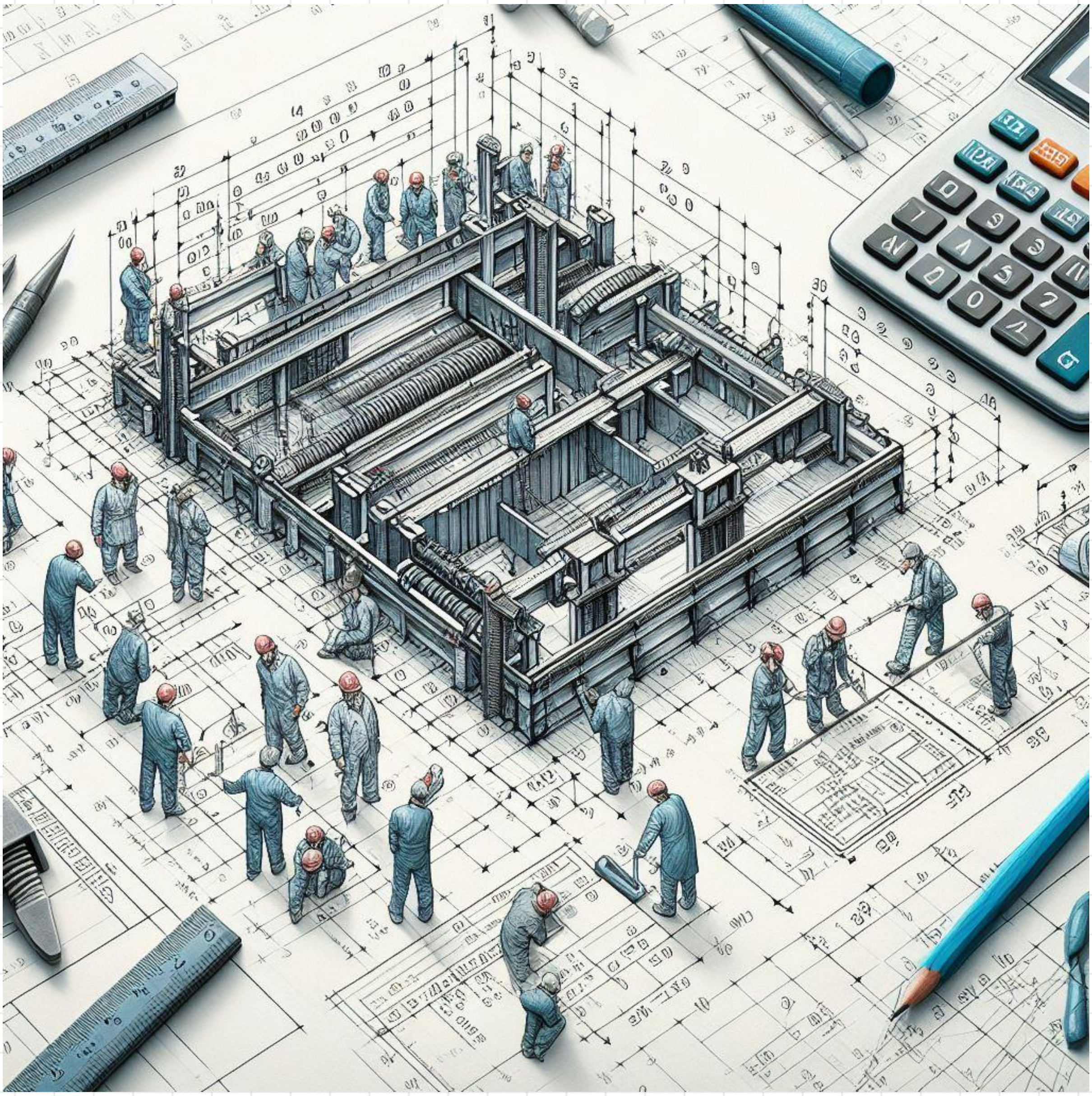
Directional Method for Dimensioning Fillet Weld

After a thorough understanding of the fillet weld dimensioning process and calculation of the geometrical properties of welds, we have reached a point where we can now proceed with the directional method as per the guidelines stated in the Eurocode 1993-1-8. However, it is essential to note that the overall concept may be the same for users of different standards, such as AWS, ASME, CSA, and others.

In order to help you better understand the directional method in accordance with the Eurocode standard, we have created a video that explains the entire process in detail. Additionally, we also have some examples of the directional method in the following videos, which will provide you with a more comprehensive understanding of the topic. We highly recommend watching these videos to gain a deeper insight into this critical aspect of fillet weld dimensioning.



4.5.3.2 Directional method

(1) In this method, the forces transmitted by a unit length of weld are resolved into components parallel and transverse to the longitudinal axis of the weld and normal and transverse to the plane of its throat.

(2) The design throat area A_w should be taken as $A_w = \sum a\, \ell_{eff}$.

(3) The location of the design throat area should be assumed to be concentrated in the root.

(4) A uniform distribution of stress is assumed on the throat section of the weld, leading to the normal stresses and shear stresses shown in Figure 4.5, as follows:

- $\sigma_\perp$ is the normal stress perpendicular to the throat
- $\sigma_\parallel$ is the normal stress parallel to the axis of the weld
- $\tau_\perp$ is the shear stress (in the plane of the throat) perpendicular to the axis of the weld
- $\tau_\parallel$ is the shear stress (in the plane of the throat) parallel to the axis of the weld.

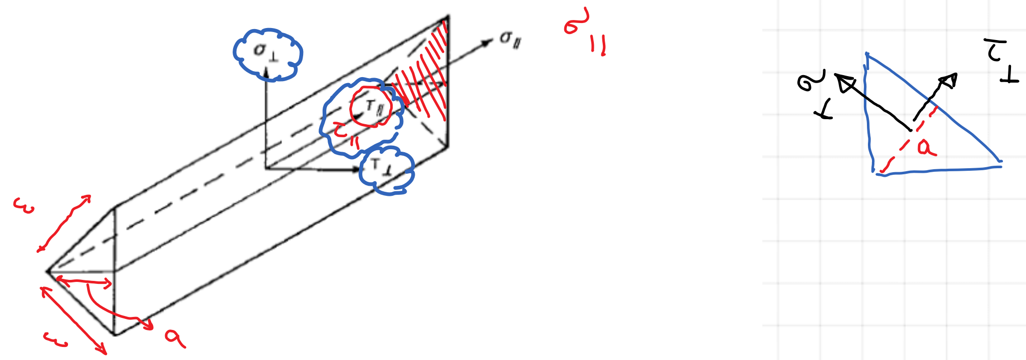


Figure 4.5: Stresses on the throat section of a fillet weld

(5) The normal stress $\sigma_\parallel$ parallel to the axis is not considered when verifying the design resistance of the weld.

(6) The design resistance of the fillet weld will be sufficient if the following are both satisfied:

$$[\sigma_\perp^2 + 3\,(\tau_\perp^2 + \tau_\parallel^2)]^{0,5} \le f_u / (\beta_w\, \gamma_{M2}) \quad \text{and} \quad \sigma_\perp \le 0.9\, f_u / \gamma_{M2} \qquad \text{... (4.1)}$$

where:

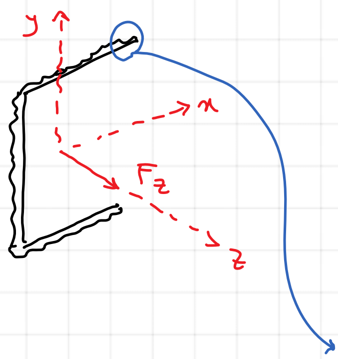
f_u is the nominal ultimate tensile strength of the weaker part joined;

β_w is the appropriate correlation factor taken from Table 4.1.

(7) Welds between parts with different material strength grades should be designed using the properties of the material with the lower strength grade.

Table 4.1: Correlation factor β_w for fillet welds

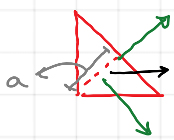
Standard and steel grade			Correlation factor β_w
EN 10025	**EN 10210**	**EN 10219**	
S 235 S 235 W	S 235 H	S 235 H	0,8
S 275 S 275 N/NL S 275 M/ML	S 275 H S 275 NH/NLH	S 275 H S 275 NH/NLH S 275 MH/MLH	0,85
S 355 S 355 N/NL S 355 M/ML S 355 W	S 355 H S 355 NH/NLH	S 355 H S 355 NH/NLH S 355 MH/MLH	0,9
S 420 N/NL S 420 M/ML		S 420 MH/MLH	1,0
S 460 N/NL S 460 M/ML S 460 Q/QL/QL1	S 460 NH/NLH	S 460 NH/NLH S 460 MH/MLH	1,0



$$\sigma = \frac{F_z}{A_w} = \frac{F_z}{\Sigma \ell \; t}$$

↳ weld leg size

$$\sigma = \frac{F_z}{A_w} = \frac{f_z}{A_{sw}}$$



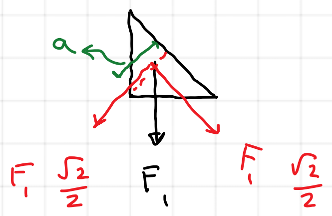
$$\tau_\perp = f_z \; \sqrt{2}/2$$

$$F_\perp = f_z \cdot \sqrt{2}/2$$

$$\tau_\perp = \sigma_\perp = \frac{f_z \; \sqrt{2}/2}{a \cdot \ell} = \frac{f_z \cdot \sqrt{2}}{2 \cdot a \cdot L} \cdot \frac{\sqrt{2}}{\sqrt{2}}$$

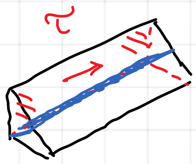
$$\tau_\perp = \sigma_\perp = \frac{f_z}{\sqrt{2}\, a \cdot L}$$

$$\sigma = \frac{f_z}{t \; L}$$



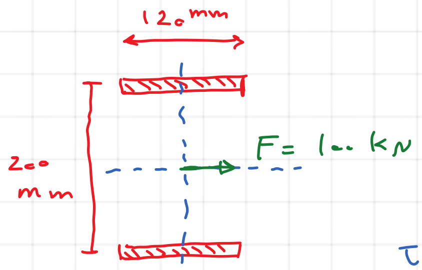
$$\sigma_\perp = \tau_\perp = \frac{F_1 \sqrt{2}/2}{a \cdot L} = \frac{F_1}{\sqrt{2} \cdot a\, L}$$

$$\tau = \frac{F_1}{t \cdot L}$$



$$\tau = \frac{F}{t\, L}$$

$$\tau = \frac{F}{a\, L}$$



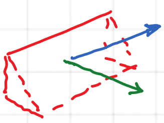
$\longrightarrow M_x = 20\ kN\cdot m$

$$A_w = 2 \times 120\,mm \times t = 240\,t \quad (mm^2)$$

$$I_x = 2 \times 120\,mm \times t \times (100\,mm)^2 = 2.4\times10^6\, t \ (mm^4)$$

$$\tau_x = \frac{100\ kN}{240\,t\ mm^2} = \frac{417}{t} \quad MPa$$

$$\sigma_z = \frac{M_x\, y}{I_x} = \frac{20\ kN\cdot m \times 100\ mm}{2.4\times10^6\ t\ (mm^4)} = \frac{833}{t} \quad MPa$$

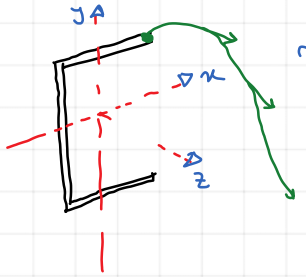


$\tau = \frac{417}{t}$

$\sigma_z = \frac{833}{t}$

$$\sigma\big|_{t=a\sqrt{2}} \rightarrow \quad \sigma_\perp = \tau_\perp = \frac{833}{\sqrt{2}\, a}$$

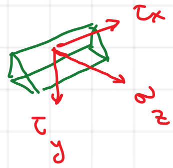
$$\tau\big|_{t=a} \quad \tau_\parallel = \frac{417}{a}$$



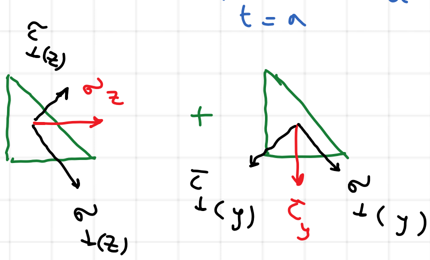
$$\tau_x = \frac{100}{t} \quad MPa \rightarrow$$

$$\tau_y = \frac{200}{t} \quad MPa \downarrow$$

$$\sigma_z = \frac{300}{t} \quad MPa \ (\text{tension})$$



$$\tau_{\parallel} = \tau_x \Big|_{t=a} = \frac{100}{a} \quad (MPa)$$



$$\sigma_{\perp} = \tau_{\perp} = \frac{300}{t} \Big|_{t=a\sqrt{2}} \quad (\sigma_z)$$

$$\sigma_{\perp} = \tau_{\perp} = \frac{200}{t} \Big|_{t=a\sqrt{2}} \quad (\tau_y)$$

$$\sigma_{\perp} = \tau_{\perp} = \frac{300}{a\sqrt{2}} \qquad \sigma_{\perp} = \tau_{\perp} = \frac{200}{a\sqrt{2}}$$

$$\sigma_{\perp}(\text{total}) = \frac{300+200}{a\sqrt{2}} = \frac{500}{\sqrt{2}\,a}$$

$$\tau_{\perp}(\text{total}) = \frac{300-200}{a\sqrt{2}} = \frac{100}{\sqrt{2}\,a}$$

$$a \geq 2 \cdot \frac{\beta_w}{\sqrt{2}} \cdot \frac{\gamma_{M2}}{\gamma_{M0}} \cdot \frac{f_y}{f_u} \cdot t \qquad (3.24)$$

where t is the wall thickness

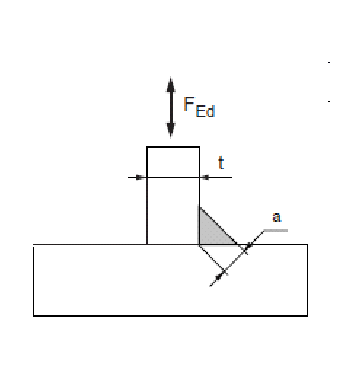
f_y is the nominal yield strength of the material

f_u is the nominal ultimate tensile strength of the material

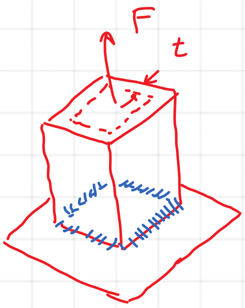
β_w is the appropriate strength factor (Table 3.8)

γ_{M2} and γ_{M0} are partial safety factors for resistance (Table 2.5)

Table 3.9 The required throat thickness for an equal strength fillet weld made around the perimeter of the hollow section which is subject to axial tension, compression and/or bending

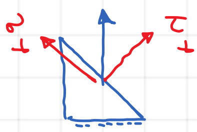


Steel grade	Yield strength a) f_y (N/mm²)	Ultimate tensile strength a) f_u (N/mm²)	Throat thickness of the weld b)
S235H	235	360	0,92·t
S275H	275	430	0,96·t
S355H	**355**	**510**	**1,11·t**
S275NH	275	370	1,12·t
S355NH	355	470	1,20·t
S460NH	460	550	1,48·t
S275MH	275	360	1,15·t
S355MH	355	470	1,20·t
S420MH	**420**	**500**	**1,48·t**
S460MH	460	530	1,53·t



$$A_w = \Sigma l \, t_w$$

$$\sigma_z = \frac{F}{A_w} = \frac{F}{\Sigma l \, t_w}$$



$$\sigma_\perp = \tau_\perp = \frac{F}{\Sigma l \cdot a\sqrt{2}}$$

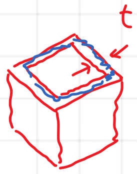
$$[\sigma_\perp^2 + 3(\tau_\perp^2 + \tau_\parallel^2)]^{0,5} \leq f_u / (\beta_w \gamma_{M2})$$

$$\left[\left(\frac{F}{\Sigma L \, a\sqrt{2}}\right)^2 + 3\left(\frac{F}{\Sigma L \, a\sqrt{2}}\right)^2\right]^{0.5} \leq \frac{f_u}{\beta_w \, \gamma_{M2}}$$

$$2\frac{F}{\Sigma L \, a\sqrt{2}} \leq \frac{f_u}{\beta_w \, \gamma_{M2}} \rightarrow F_w \leq \frac{f_u \cdot \Sigma L \, a\sqrt{2}}{2 \, \beta_w \cdot \gamma_{M2}}$$

$F_w \geq$ total axial capacity of the profile

$$F_{\text{cross section}} = A_{\text{section}} \frac{f_y}{\gamma_{M0}}$$



$$A_{cs} = \Sigma \ell \cdot t$$

$$F_{\text{cross section}} = \Sigma L \, t \, \frac{f_y}{\gamma_{M0}}$$

$$2 \cdot \frac{F}{\Sigma L \cdot a\sqrt{2}} \leq \frac{f_u}{\beta_w \cdot \gamma_{M2}} \rightarrow F_w \leq \frac{f_u \cdot \Sigma L \cdot a\sqrt{2}}{2 \cdot \beta_w \cdot \gamma_{M2}}$$

$F_w \geq$ total axial capacity of the profile

$$F_w = \Sigma L \, t \, f_y / \gamma_{M0}$$

$$\Sigma L \cdot t \frac{f_y}{\gamma_{M0}} \leq \frac{f_u \, \Sigma L \, a\sqrt{2}}{2 \cdot \beta_w \, \gamma_{M2}} \Rightarrow a \geq 2 \frac{\beta_w}{\sqrt{2}} \cdot \frac{\gamma_{M2}}{\gamma_{M0}} \cdot \frac{f_y}{f_u} \, t$$

$$a \geq 2 \cdot \frac{\beta_w}{\sqrt{2}} \cdot \frac{\gamma_{M2}}{\gamma_{M0}} \cdot \frac{f_y}{f_u} \cdot t \qquad (3.24)$$