WORKED EXAMPLE 3.2
Welds of a Fin Plate Connection

Check the resistance of the fillet-welded connection of the fin plate, shown in Figure 1WE3-2.
The connection is subject to the vertical factored force $V_{sd} = 300$ kN, acting at an eccentricity $e = 60$ mm.
The steel is Grade S235, and the material partial safety factors are $\gamma_M = 1.0$ and $\gamma_M = 1.25$.

The structural welds should be (i) longer than $40$ mm, and (ii) longer than $6a_u = 6 \times 4 = 24$ mm. Both of these are satisfied. The full length of the weld can be taken into account in the strength calculation, because $150a_u = 50 \times 4 = 600$ mm $> 300$ mm.

The shear stress perpendicular to the weld cross-section is

$$\tau = \frac{V_{sd}}{a_u L} = \frac{300 \times 10^3}{4 \times 2 \times 300} = 125.0 \text{ MPa}.$$  

The maximum normal stress parallel to the weld cross-section, based on an elastic distribution of bending stresses is

$$\sigma = \frac{M}{W_{el,u}} = \frac{V_{sd} e}{2 a_u L^2} = \frac{300 \times 10^3 \times 60}{2 \times 4 \times 300^2} = 150.0 \text{ MPa},$$

which may be decomposed (see Fig. 3WE22) into the shear across the critical plane (the weld throat) and the normal stress perpendicular to this plane:

$$\tau = \sigma = \frac{\sigma}{\sqrt{2}} = \frac{150}{\sqrt{2}} = 106.1 \text{ MPa}.$$

Check of the weld design resistance:

$$\sqrt{\sigma^2 + 3(\tau^2 + \tau^2)} = \sqrt{106.1^2 + 3(106.1^2 + 125.0^2)} = 303.2 \text{ MPa} < \frac{f_c}{\beta_u \gamma_{Mv}} = \frac{360}{0.8 \times 1.25} = 360.0 \text{ MPa},$$
The weld strength is satisfactory.

\[ \sigma_\perp = 106.1 \text{ MPa} < \frac{f_\perp}{\gamma_{M0}} = \frac{360}{1.25} = 288 \text{ MPa} . \]

Note:
1) The weld resistance may conservatively be checked independent of the loading direction as follows:
\[ \sqrt{\sigma_\perp^2 + \tau^2} = \sqrt{150^2 + 125^2} = 195.3 \text{ MPa} < \frac{f_\perp}{\beta_\perp \gamma_{M0} \sqrt{3}} = \frac{360}{0.8 \times 1.25 \times \sqrt{3}} = 207.8 \text{ MPa} . \]

2) The plate’s resistance in shear is
\[ V_{pl,Rd} = \frac{A f_\perp}{\gamma_{M0} \sqrt{3}} = \frac{15 \times 300 \times 235}{10 \times \sqrt{3}} = 610.5 \times 10^3 \text{ N} > V_{sd} = 300 \text{ kN} . \]

and in bending:
\[ M_{c,Rd} = W_{el} f_\gamma / \gamma_{M0} = \frac{15 \times 300^2}{6} \times 235 / 10 = 52.9 \times 10^4 \text{ Nmm} \]
\[ > M_{sd} = 300 \times 10^4 \times 60 = 18 \times 10^4 \text{ Nmm} . \]
The interaction of bending and shear need not be checked, because the shear resistance is more than double the shear force acting:
\[ 610.5 \times 10^3 / 2 = 305.2 \times 10^3 \text{ N} > 300kN . \]

3) The elastic distribution of stresses in the welds is used because the above is an elastic check of the fin-plate connection. A plastic check of the welds may be performed, based on the expression
\[ \sigma_w = \frac{M}{W_{pl.w}} = \frac{V_{sd} e}{2 a_w L} . \]

Prepared based on [Wald et al, 2001].