

### Design Example 1:

Design a Lap joint between plates 100 × 8 so as to transmit a factored load of 100 kN using black bolts of 12mm diameter and grade 4.6. The plates are made of steel of grade ST-42-S.

#### Solution:

##### 1) Strength Calculations:

Nominal diameter of bolt  $d = 12 \text{ mm}$

For grade 4.6 bolt,  $f_u = 40 \text{ kgf / mm}^2 = 392.4 \text{ MPa}$ ,  $\gamma_{mb} = 1.25$

Assuming threads in the shear plane,  $n_n = 1$ ,  $n_s = 0$

Shear Area of one bolt  $A_{nb} = 0.8 A_{sb} = 0.8 \times 113.1 = 90.5 \text{ mm}^2$

Design shear strength per bolt  $V_{nsb} = f_u A_{nb} / \gamma_{mb} \sqrt{3} = 16.4 \text{ kN}$  (Cl. 10.3.2)

Design bearing strength per bolt  $V_{npb} = 2.5 d t f_u$   
 $= 2.5 \times 12 \times 8 \times 392.4 \times 10^{-3} = 75.2 \text{ kN}$  (Cl. 10.3.3)

Therefore, bolt value = 16.4 kN

No. of bolts required =  $100 / 16.4 = 6.1$  say 7 bolts

##### 2) Detailing:

Minimum pitch =  $2.5 d = 30 \text{ mm}$  (Cl. 10.2.1)

Minimum edge distance =  $1.4 D = 16.8 \text{ mm}$  say 20 mm (Cl. 10.2.3)

Provide 8 bolts as shown in Fig. E1.

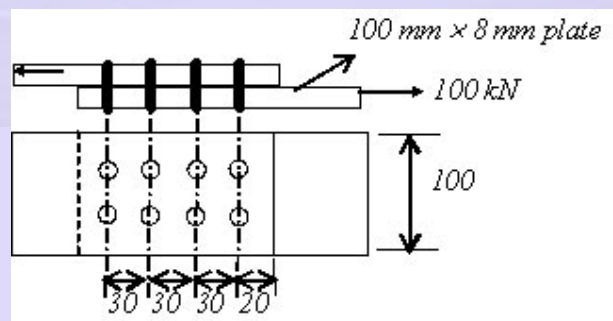


Fig. E1

## Design Example 2:

Design a hanger joint along with an end plate to carry a downward load of  $2T = 330$  kN. Use end plate size 240 mm x 160 mm and appropriate thickness and 2 nos of M25 Gr.8.8 HSFG bolts ( $f_o = 565$  MPa ).

### Solution

Assume 10mm fillet weld between the hanger plate and the end plate

Distance from center line of bolt to toe of fillet weld  $l_v = 60$  mm

1) For minimum thickness design,  $M = T l_v / 2 = 165 \times 60 / 2 = 4950$  N-m

$$\therefore t_{\min} = \sqrt{\frac{1.15 \times 4 \times 4950 \times 10^3}{236 \times 160}} = 24.56 \text{ say } 25 \text{ mm}$$

$$M_p = Z_p \cdot f_y = \frac{W t^2}{4} \cdot \frac{f_y}{\gamma_{m0}}$$

$$t = \sqrt{4 M_p \gamma_{m0} / f_y \times w}$$

2) Check for prying forces distance '  $l_e$  ' from center line of bolt to prying force is the minimum of edge distance or  $1.1t$

$$\sqrt{(\beta p_o / f_y)} = 1.1 \times 25 \sqrt{(2 \times 565 / 236)} = 60 \text{ mm} \quad (\text{Cl. 10.4.7})$$

$$l_e = 40 \text{ mm}$$

$$\text{prying force } Q = M / l_e = 4950 / 40 = 123.75 \text{ kN}$$

$$\text{bolt load} = 165 + 123.75 = 288.75 \text{ kN} \quad (\text{Cl. 10.4.5})$$

$$\text{tension capacity of 25 mm dia HSFG bolt} = 0.9 F_u A_{nb} / \gamma_{mb} = 222 \text{ kN} \ll 288.75$$

Load carrying Capacity  $\ll$  Required load Capacity

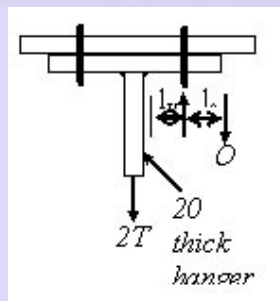


Fig E2

In order to reduce the load on bolt to a value less than the bolt capacity, a thicker end plate will have to be used.

Allowable prying force  $Q = 222 - 165 = 57 \text{ kN}$

Trying a 36 mm thick end plate gives  $l_e = 40 \text{ mm}$  as before

Moment at toe of weld =  $T l_v - Q l_e = 165 \times 60 - 57 \times 40 = 7620 \text{ N-m}$

Moment capacity =  $(236 / 1.10) (160 \times 36^2 / 4) \times 10^{-3} = 11122 \text{ N-m} > 7620 \text{ OK}$

Minimum prying force

$$Q = \frac{l_v}{2l_e} \left[ T - \frac{\beta \gamma p_o b_e t^4}{27l_e l_v^2} \right] = \frac{60}{2 \times 40} \left[ 165 - \frac{2 \times 1.5 \times 0.565 \times 160 \times 36^4}{27 \times 40 \times 60^2} \right] \quad (\text{Cl. 10.4.7})$$

$$= 36 \text{ kN} < 57 \text{ kN safe!}$$

Therefore, 36 mm end plate needs to be used to avoid significant prying action.

