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 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 \( A_{nb} = 0.8 \times A_{sb} = 0.8 \times 113.1 = 90.5 \text{ mm}^2 \)
Design shear strength per bolt \( V_{nsb} = \frac{f_u A_{nb}}{\gamma_{mb}} \sqrt{3} = 16.4 \text{ kN} \)  \( \text{(Cl. 10.3.2)} \)
Design bearing strength per bolt \( V_{npb} = 2.5 \times d \times t \times f_u \)
\[ = 2.5 \times 12 \times 8 \times 392.4 \times 10^{-3} = 75.2 \text{ kN} \]  \( \text{(Cl. 10.3.3)} \)
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 mm \( \text{(Cl. 10.2.1)} \)
Minimum edge distance = 1.4 D = 16.8 mm say 20 mm \( \text{(Cl. 10.2.3)} \)
Provide 8 bolts as shown in 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 $240 \text{ mm} \times 160 \text{ mm}$ and appropriate thickness and 2 nos of M25 Gr.8.8 HSFG bolts ($f_0 = 565 \text{ MPa}$).

**Solution**

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

Distance from center line of bolt to toe of fillet weld $l_v = 60 \text{ mm}$

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

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

\[
M_p = \frac{Zp.fy}{4} \cdot \frac{fy}{\gamma m0}
\]

\[
t = \sqrt{\frac{4M_p \gamma m0}{fy \cdot w}}
\]

2) Check for prying forces distance $l_e$ from center line of bolt to prying force is the minimum of edge distance or $1.1t$

\[
\sqrt{\frac{\beta_p}{f_y}} = 1.1 \times 25 \sqrt{\frac{2 \times 565}{236}} = 60\text{ mm} \quad \text{(Cl. 10.4.7)}
\]

\[l_e = 40 \text{ mm}\]

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

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

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

Load carrying Capacity $<<$ 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 = \( T \cdot l_v - Q \cdot l_e = 165 \times 60 - 57 \times 40 = 7620 \text{ N-m} \)

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

Minimum prying force

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

\[
= 36 \text{ kN} < 57 \text{ kN safe!}
\]

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