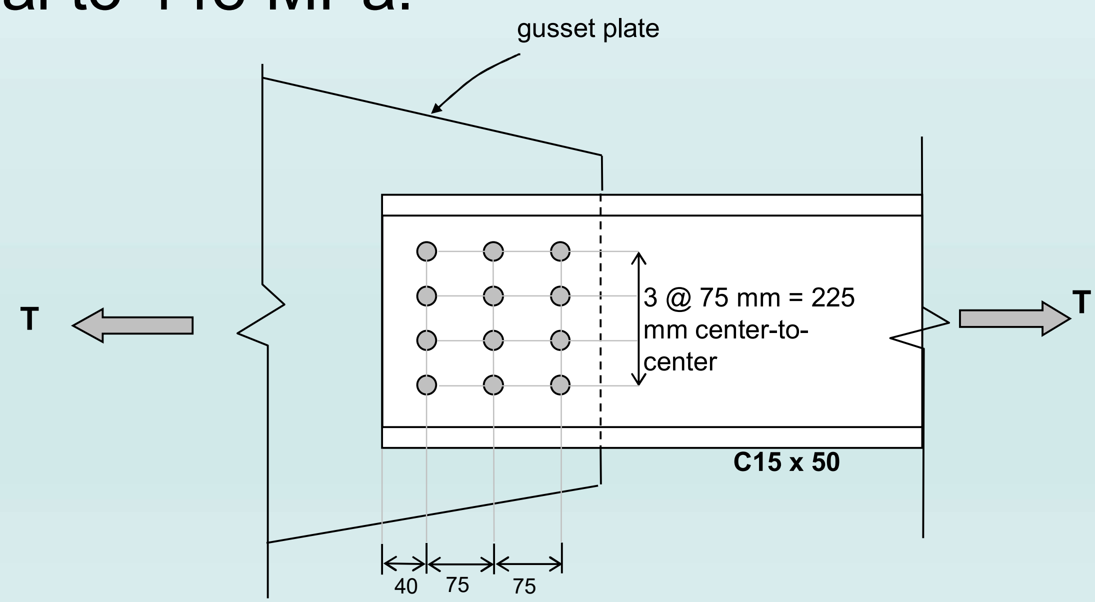
Ex. 2.6 – Design Tensile Strength

- Determine the design tension strength for a single channel C15 x 50 connected to a 15 mm thick gusset plate as shown in Figure. Assume that the holes are for 20 mm diameter bolts. Also, assume structural steel with yield stress (F_y) equal to 344 MPa & ultimate stress (F_u) equal to 448 MPa.



Ex. 2.6 – Design Tensile Strength

- **Limit state of yielding due to tension:**

$$\phi T_n = 0.9 * 344 * 9480 / 1000 = 2935\ kN$$

- **Limit state of fracture due to tension:**

$$A_n = A_g - n d_e t = 9480 - 4\left(18.2\right)\left(23.2\right) = 7791\ mm^2$$

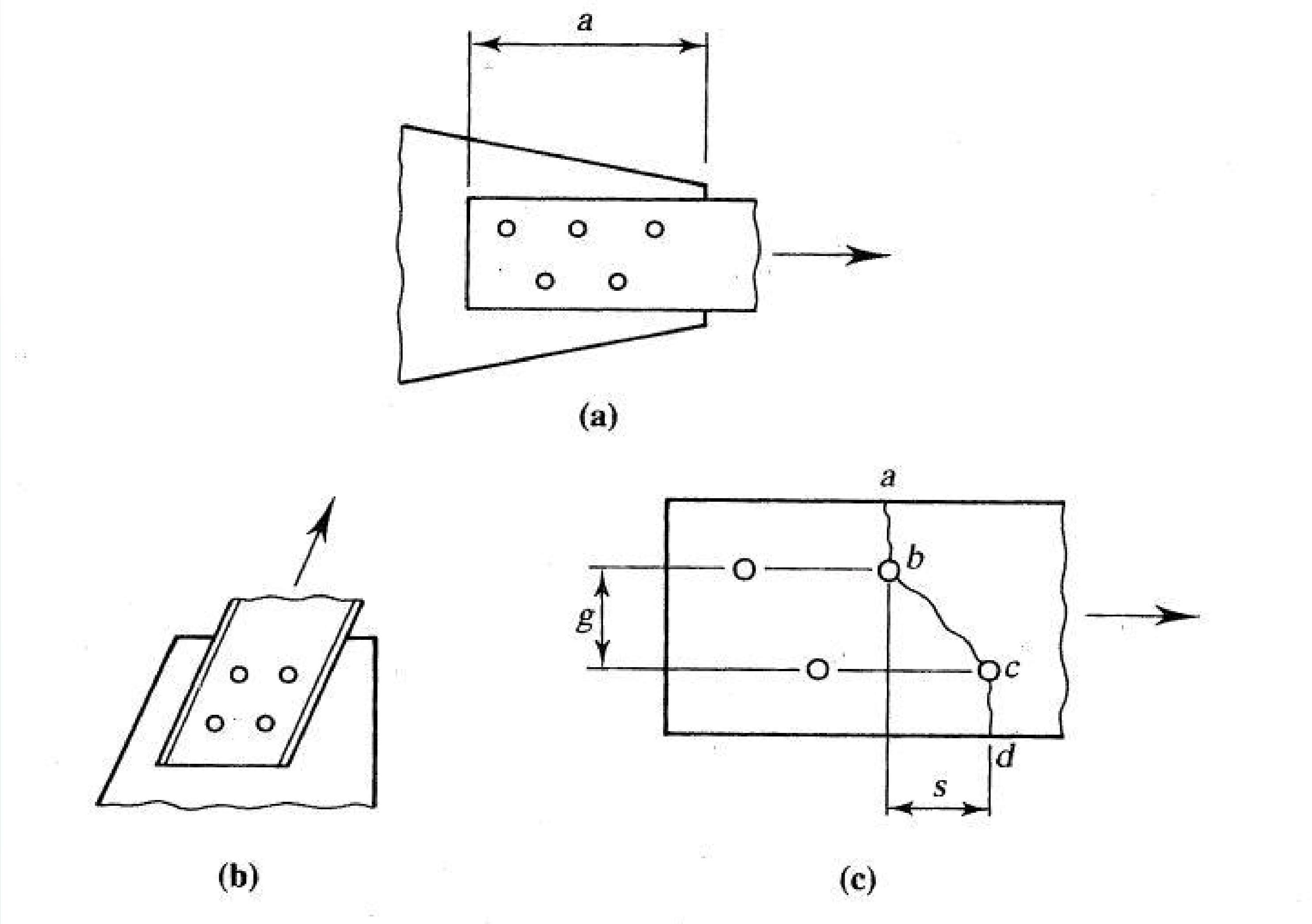
$$A_e = UA_n = \left(1 - \frac{x}{L}\right) A_n = \left(1 - \frac{20.3}{150}\right) * 7791 = 6736.6\ mm^2$$

- **Check**: $U = 0.867 \leq 0.9$ OK.

- **Note**: The connection eccentricity, x, for a C15X50 can be found in section property tables.

$$\phi T_n = 0.75 * 448 * 6736.6 / 1000 = 2263.5\ kN$$

Staggered Bolts



Staggered Bolts

- For a bolted tension member, the connecting bolts can be staggered for several reasons:
  - To get more capacity by increasing the effective net area
  - To achieve a smaller connection length
  - To fit the geometry of the tension connection itself.

- For a tension member with staggered bolt holes (see example figure above), the relationship f = P/A does not apply & the stresses are a combination of tensile & shearing stresses on the inclined portion *b-c*.
- Net section fracture can occur along any zig-zag or straight line. For ex., fracture can occur along the inclined path *a-b-c-d* in the figure above. However, all possibilities must be examined.

Staggered Bolts

- Empirical methods have been developed to calculate the net section fracture strength.
  - net width = gross width - $\sum d + \sum \frac{s^2}{4g}$

d - the diameter of hole to be deducted (d_b + 3.2 mm)

$s^2/4g$ - added for each gage space in the chain being considered

s - the longitudinal spacing (pitch) of the bolt holes in the direction of loading

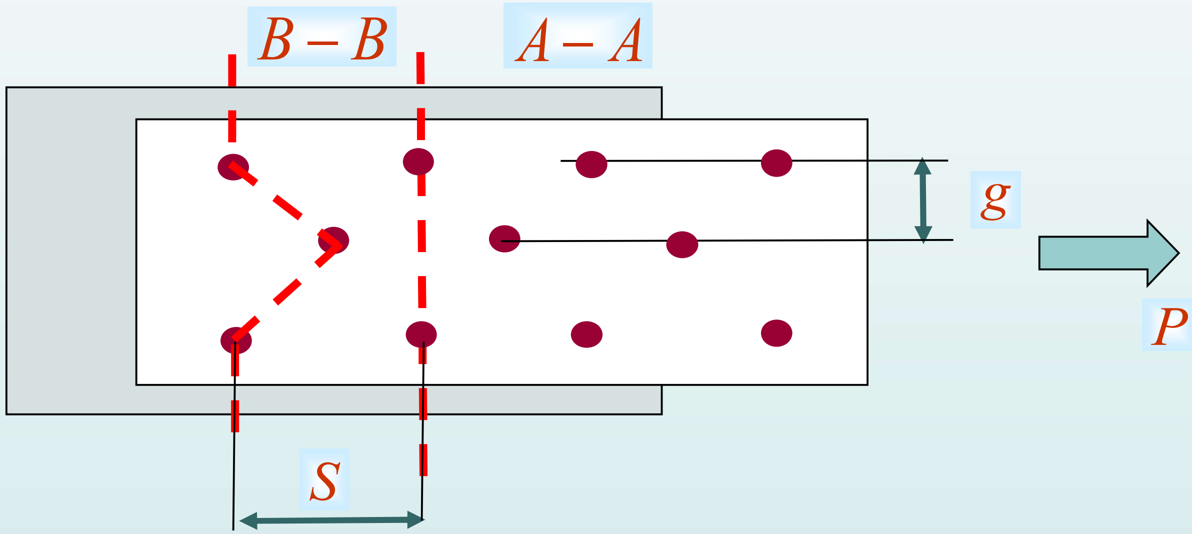
g - the transverse spacing (gage) of the bolt holes perpendicular to loading direction.

net area (A_n) = net width x plate thickness

effective net area (A_e) = U A_n ***where*** $U = 1 - \frac{\bar{x}}{L}$

net fracture design strength = $\phi_t A_e F_u$ (ϕ_t = 0.75)

Staggered Bolted Connections



- Stresses on inclined planes are a mix of tension and shear and thus a correction is needed.

$$W_n = W_g - \sum d + \sum \frac{S^2}{4g} \qquad A_n = W_n\, t$$

- All possible failure paths passes shall be examined. The path that yields the smallest area governs.