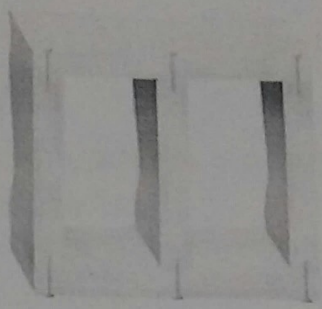
Dr. Wissam Kadhil
Dr. Luma Fadhil

Shear Flow in built up members

In engineering practice, members are "built up" from several composite parts in order to achieve a greater resistance to loads. Examples are shown in Figures below.

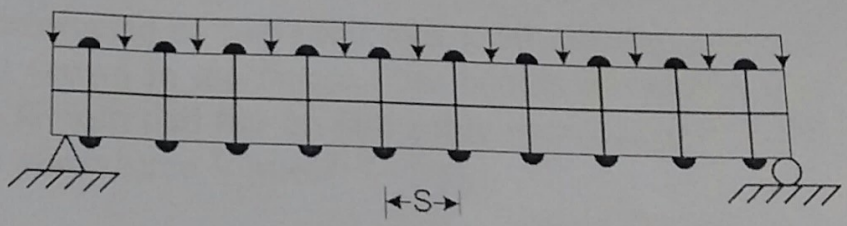


In order to design these fasteners or determine their spacing, it is necessary to know the shear force that must be resisted by the fastener. This loading, when measured as a force per unit length of beam, is referred to as shear flow (q).

$$q = \frac{VQ}{I}$$

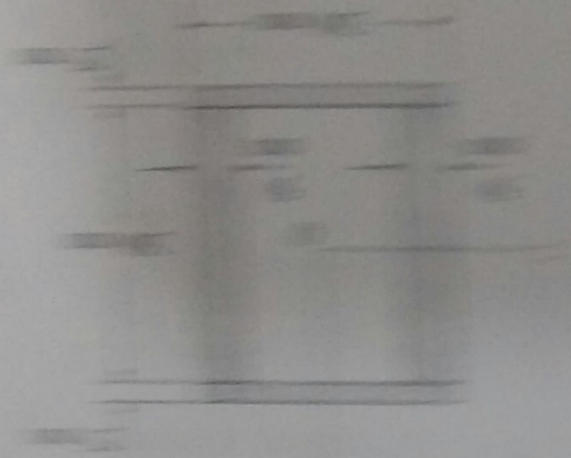
The Shear Flow (q) would help to find the spacing between bolts, as follow:
S=F/q

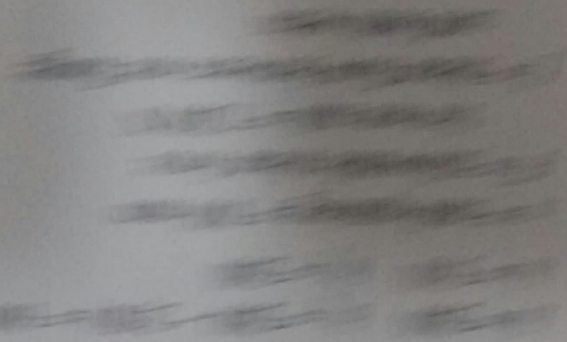
Where:
S= spacing between the bolts, and
F= allowable shearing force per bolt.



Examples:

EX 1) The beam is constructed from four boards glued together as shown in Fig. below. If it is subjected to a shear of V = 850 kN, determine the shear flow at *B* and *C* that must be resisted by the glue.





$$f_{allow} = \frac{2F}{s} = \frac{2(1200\ \text{N})}{100\ \text{mm}} = 24\ \text{kN/m}$$

$$f = \frac{VQ}{I} \qquad V_{max} = \frac{f_{allow} I}{Q}$$

$$I = \frac{1}{12}(bh^3 - b_i h_i^3) = 411.125 \times 10^6\ \text{mm}^4$$

$$Q = Q_{flange} = A_f d_f = (260)(25)(142.5) = 926.25 \times 10^3\ \text{mm}^3$$

$$V_{max} = \frac{f_{allow} I}{Q} = \frac{(24\ \text{kN/m})(411.125 \times 10^6\ \text{mm}^4)}{926.25 \times 10^3\ \text{mm}^2}$$

$$= 10.7\ \text{kN}$$

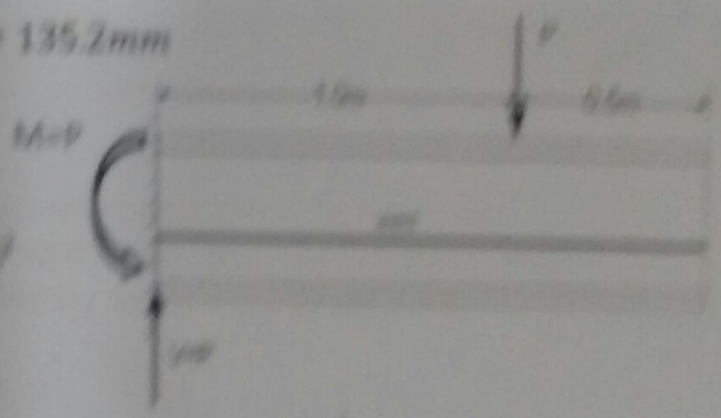
EX 3- A steel cantilever beam is made of two structural tee- section beams welded together as shown in the figure below. Determine the allowable safe load (P) that the beam can carry. The allowable stresses are: σ=150MPa in tension and compression, τ=100MPa in shear, and q=2000N/mm on the welded joint.

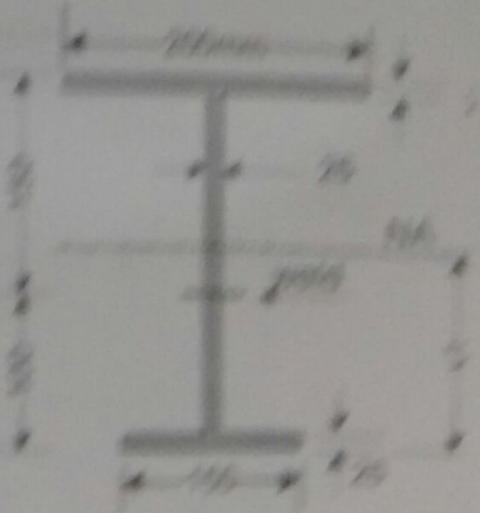
Sol:

$$y1 = \frac{150(25)(12.5) + 25(200)(125) + 200(25)(237.5)}{150(25) + 25(200) + 200(25)} = 135.2mm$$

$$I_{NA} = \frac{150(25)^3}{12} + 150(25)(135.2 - 12.5)^2 + \frac{25(200)^3}{12} + 25(200)(135.2 - 125)^2$$

$$+ \frac{200(25)^3}{12} + 200(25)(237.5 - 135.2)^2 = 126 \times 10^6\ mm^4$$





- The allowable force (P) based on the bending stresses:

$$\sigma = \frac{M\,C}{I_{NA}}$$

$$\sigma_{allow} = 150MPa, for\ both\ tension\ and\ compression$$

$$150MPa = \frac{1000P * 135.2}{1.26 * 10^8} => P = 140kN$$

- The allowable force (P) based on the shearing stresses:

V=P;

$$\tau = \frac{VQ}{I_{NA}b}$$

$$\tau_{NA} = \frac{P * [200 * 25 * 102.3 + 25 * 89.8 * 44.9]}{1.26 * 10^8 * 25} = 100MPa => P = 514.5kN$$

- The allowable force (P) based on the shear flow in the welding joint:

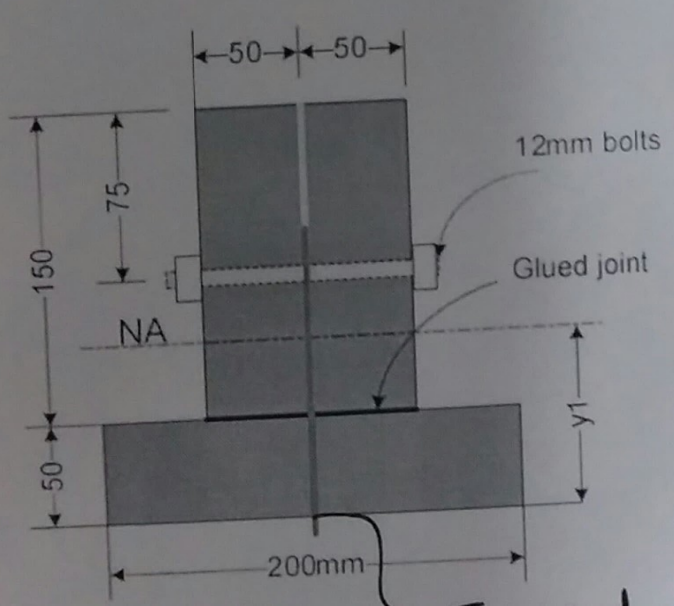
$$q = \frac{VQ}{I_{NA}}$$

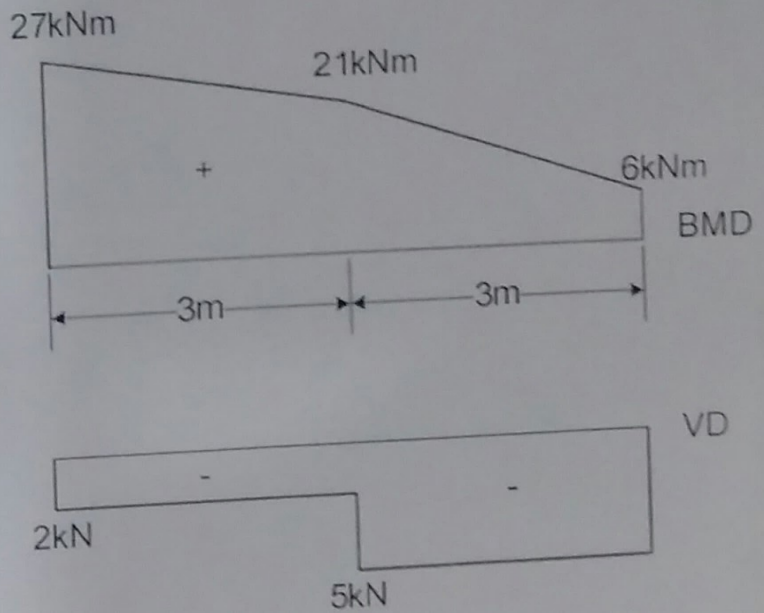
$$Q=200(25)(102.3)+25(125)(27.3)= 5.97*10^{5}mm^{3}$$

$$q_{weld} = \frac{P * 5.97 * 10^5}{1.26 * 10^8} = 2000 => P = 422.2kN$$

The safe allowable load P_{safe}= 140kN

EX 4- A beam is loaded so that the moment diagram of it varies as shown in the figure. a) Find the maximum longitudinal shearing force in the 12mm diameter bolts spaced 300mm apart. b) Find the maximum shearing stress in the glued joint.





$$y1 = \frac{200(50)(25) + 100(150)(125)}{200(50) + 100(150)} = 85mm$$

$$I_{NA} = \frac{200(50)^3}{12} + 200(50)(85-25)^2 + \frac{100(150)^3}{12} + 100(150)(125-85)^2$$

$$I_{NA} = 9 * 10^7 mm^4$$

a) Find Q @ the red fiber, which represents Q for the bolt

Q= 100(50) (-60) +150(50) (40) =-300000+300000=0

q=0

b) Find Q @ the glued joint

Q=200(50) (60) =600000mm^3

Or: Q=100(150) (40) =600000mm^3

$$\tau = \frac{VQ}{I_{NA}b}$$

$$\tau_{glue} = \frac{5000 * 600000}{9 * 10^7 * 100} = 0.333MPa$$