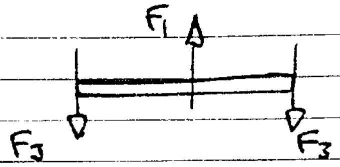
So, the three-pronged attack:



EQUILIBRIUM

F.B.D. of beam :-

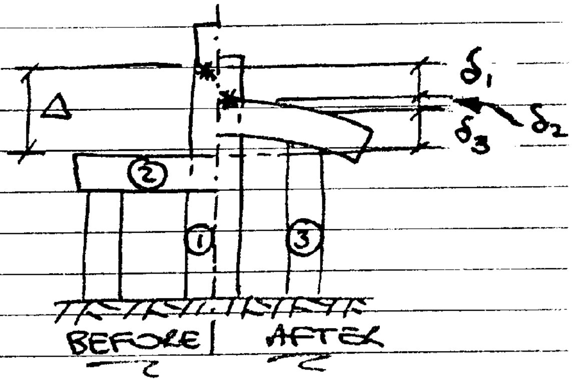
(i) $F_1 = 2F_3$

where it can be seen by reactions to these that F_1 is compressive load on (1)

F_3 is tensile load on each (3).

COMPATIBILITY

Show initial mark * on shank of screw which, after movement $\Delta = 0.75$ mm, finishes up at top of beam :-



From deformation diag

(ii) $\delta_1 + \delta_2 + \delta_3 = \Delta = 0.75$ mm

where

δ_1 = shortening of (1)

δ_2 = central deflexion of simple beam (2)

δ_3 = extension of tie rods (3)

Note how deflections tally with forces above.

CONSTITUTIVE LAWS   NOTE UNITS

Assume forces in kN, deflexions in mm.

(iii) $F_1 = k_1 \delta_1 \; ; \; k_1 = \left(\frac{AE}{L}\right)_1 = \frac{\frac{\pi}{4} \times 20^2 \times 207E3}{250} = \underline{260 \text{ kN/mm}}$

$\delta_2 = \frac{F_{central} L^3}{48EI} = F_1 L^3 / 48EI$

(iv) $\therefore F_1 = k_2 \delta_2 \; ; \; k_2 = 48EI/L^3$

$= 48 \times 207E3 \times \frac{1}{12} \times 30 \times 60^3 / 250^3$

$= \underline{343} \text{ kN/mm}$

(v) $F_3 = k_3 \delta_3 \; ; \; k_3 = \left(\frac{AE}{L}\right)_3 = \frac{\frac{\pi}{4} \times 15^2 \times 207E3}{250} = \underline{146 \text{ kN/mm}}$

SOLUTION

Solving (i) to (v) for required F_3 :

$F_3 = \frac{1}{2}\Delta / (1/k_1 + 1/k_2 + 1/2k_3) = 36.8$ kN.

$\therefore \sigma_3 = (F/A)_3 = 36.8 \times 10^3 / \frac{\pi}{4} \times 15^2 = \underline{\underline{209 \text{ MPa}}}$