Chapter 4: Axial load

δ: displacement of a point relative to the other.

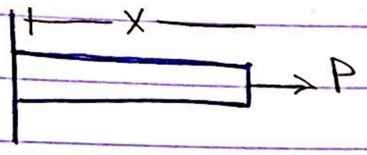
$$\delta = \frac{PL}{AE}$$

P: Internal force located at x distance from one end.

L: Length of bar

A: cross sectional Area of bar

E: modulus of elasticity.



- if P is Tensile
  ↳ It's Positive → Elongation

- if P is Compression
  ↳ It's negative → Contraction

Statically indeterminant :-

Compatibility Equation

Force Method (Flexibility Method)

→ We assume one of the supports is redundant and remove It's effect and we find the effect of one support and the external load.

Thermal stress:

$$\delta_T = \alpha \Delta T L$$

α: linear Coefficient of thermal expansion
ΔT: Temprecture
L: original length
δ_T: Change in the length of the member

Examples Solved on Chapter 4:

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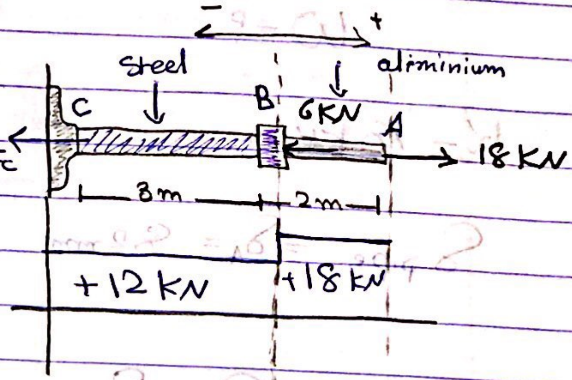
$d_{CB} = d_{BA} = 12\,mm$

δ_B , δ_A = ?

$E_{st} = 200$ Gpa

$E_{al} = 70$ Gpa



First: find the reaction at c

$\sum F_x = 0 \quad 18 - 6 + -F_c = 0$

$\boxed{F_c = 12\,KN}$

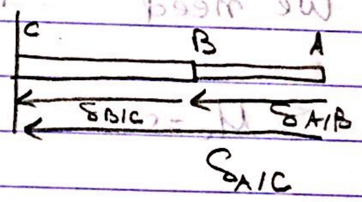
Second: Draw the axial load diagram

Third: find displacement

$$\delta_{B/C} = \delta_B = \frac{(12K)(3)}{(0.012)^2\frac{\pi}{4}(200\times10^9)} = 1.59\,mm$$

$$\delta_{A/C} = \delta_{A/B} + \delta_{B/C}$$

$$= \frac{(18K)(1000)(2)}{\frac{\pi}{4}(0.012)^2(70)\times10^9} + 1.59 = 6.14\,mm$$



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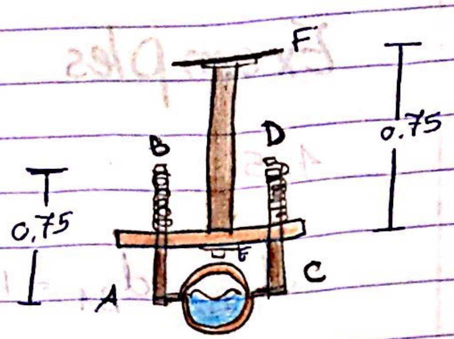
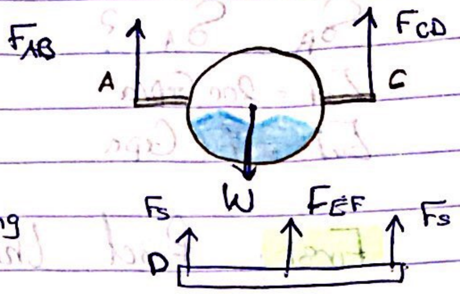


$W = ?$

$K = 60\ kN/m$

$\delta_{pipe} = \delta_A = 82mm$



$82mm = \delta_{A/B} + \delta_{E/F} + \delta_{spring}$

$$\delta_{A/B} = \frac{(F_{AB})(0.75)}{(0.005)^2\frac{\pi}{4}(193\times10^9)} = 1.979\times10^{-7} F_{AB}$$

$$\delta_{E/F} = \delta_E = \frac{(F_{EF})(0.75)}{(0.012)^2\frac{\pi}{4}(193\times10^9)} = 3.43\times10^{-9} F_{EF}$$

$$\delta_{spring} = \frac{F_{sp}}{k} = (F_S)\,1.667\times10^{-5} \qquad F_S = F_{AB} = \frac{W}{2}$$

we need to get F_{AB} in terms of W:

$$\Sigma M_c = 0 : \quad (W)(0.25) - (F_{AB})(0.5) = 0$$

$$\boxed{F_{AB} = \frac{W}{2}}$$

we need to get F_{EF} in terms of W

$\Sigma M = 0$

$$(F_{EF})(0.25) + (F_S)(0.5) = 0 \Rightarrow F_{EF} = \frac{(\frac{W}{2})(0.5)}{0.25} = W$$

$$\boxed{F_{EF} = W}$$

$$82\,mm = 1.979\times10^{-4}\, F_{AB} + 3.43\times10^{-6}\, F_{EF} + F_S\, 1.667\times10^{-2}$$

$$= (1.979\times10^{-4})\left(\frac{W}{2}\right) + (3.43)\times10^{-6}\, W + \frac{W}{2}(1.667\times10^{-2})$$

$$W = 9718.82\ N$$

النتيجة فيها تقريب كاش

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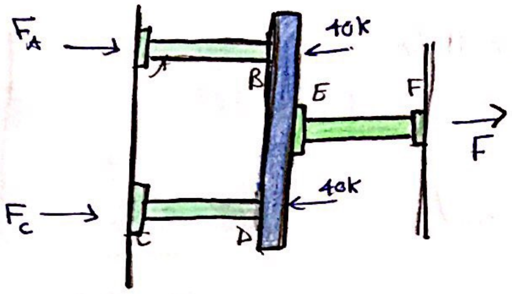
$d_{AB} = d_{CD} = 30mm$

$d_{EF} = 40mm$



σ_{AB}, σ_{CD}, σ_{EF}

We need to find the forces in each rod

Method of superposition is used.

$F_1 = F_A = F_C$ Due to symmetry

$$2F_1 + F - 80K = 0$$

▶ Considering A and C are redundant:-

$$\delta_p = \delta_{2 \times 40K} = \frac{(40)(10^3)(0.3)}{\frac{\pi}{4}(0.03)^2(101)\times10^9} = 0.168\ mm$$

$$\delta_{FE} = (\delta_{FE})_{E\to F} + (\delta_{FE})_{A\to B}$$

$$= \frac{(F)(0.450)}{(\frac{\pi}{4})(0.040)^2(193\times10^9)} + \frac{(F/2)(0.3)}{\frac{\pi}{4}(0.030)^2(101\times10^9)}$$

$$0 = \delta_p + \delta_{FE}$$

$$F = 42483.23 = 42.48\ KN$$

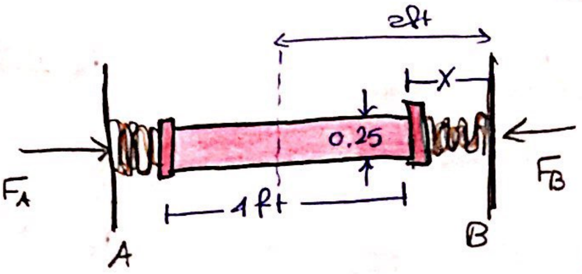
So $F_1 = 18.758\ KN$

To find σ apply $\sigma = \frac{F}{A}$

4-70

$K = 1000 \text{ lb/in}$

$\Delta T = 160 - 40 = 120°$



F in rod

Assume : spring length is X

$$X = \delta_T - \delta_{F_B}$$

$$X = (6.6 \times 10^{-6})(120°)(2)(12) - \frac{(F_B)(2)(12)}{\frac{\pi}{4}(0.25)^2 \, 29 \times 10^3}$$

Now $F_B = F_{sp} = (X + 0.5)(1000)$

$X = 0.0104$

and so $F = 0.510$ kip