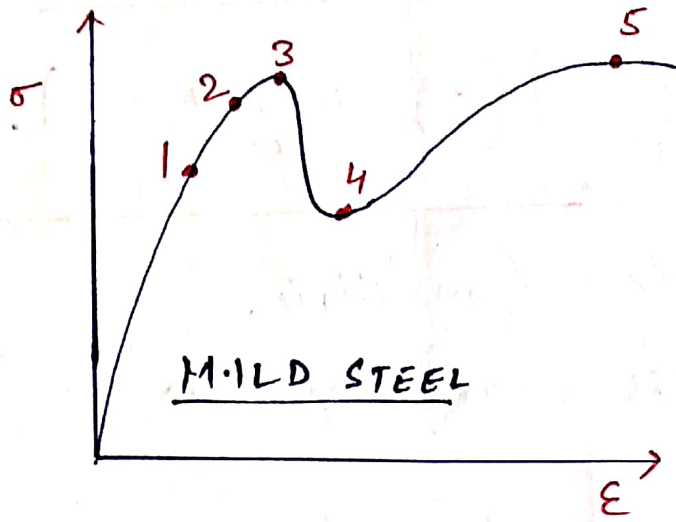
Stress Strain Curve



1 = PROPOTIONAL LIMIT 2 = Elastic Limit

3 = Upper yield point 4 = LOWER yield point

5 = Ultimate tensile strength 6 = Failure

LOADS IN BARS - SERIES & Parallel

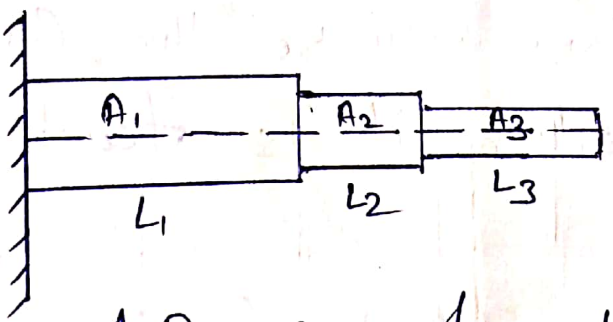
① Bars in Series Conditions

(1) Bar should be Premistic.

(2) Pure Axial loading.

(3) Bar is made up of same material.

Case I



A Bar is shown having three different

(22)

Areas Component. A load P is applied at the end of the bar. So

Elongation $\delta_{Total} = \delta_{Bar1} + \delta_{Bar2} + \delta_{Bar3}$.

& $$\delta_{Total} = \frac{P L_3}{A_3 E_3} + \frac{P L_2}{A_2 E_2} + \frac{P L_1}{A_1 E_1}$$

$$\delta_{Total} = P \sum_{i=1}^{n} \left[\frac{L_i}{A_i E_i}\right]$$ [Generalised fourmula for Total deformation].

Now

$\sigma_{maximum}$ = Will be at the section that have minimum Area.

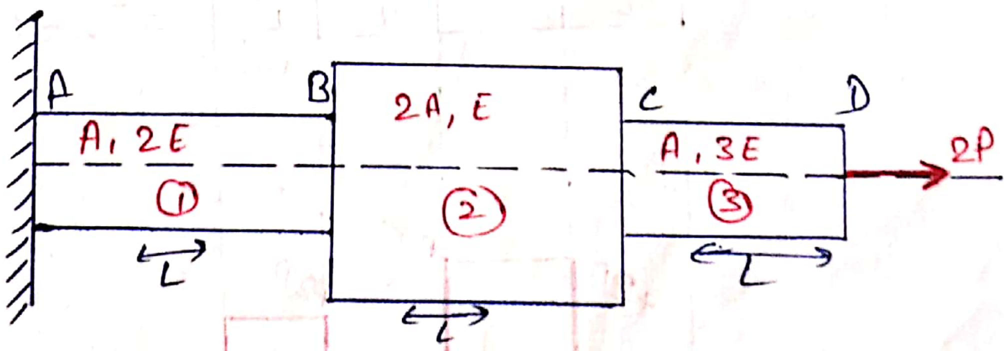
$$\sigma_{maximum} = \frac{P}{A_3}$$

$$\sigma_{minimum} = \frac{P}{A_1}$$

So $$\frac{\sigma_{max}}{\sigma_{min}} = \frac{A_1}{A_3} \Rightarrow \boxed{\left[\frac{d_1}{d_3}\right]^2}.$$

Question For the stepped bar as shown in figure. Determine (i) $\sigma_{max}/\sigma_{min}$ (ii) Deformation at free end if deformation at B point is δ.

Sol



Now (i) $\sigma_{max}/\sigma_{min} \Rightarrow \sigma_{max} = \frac{2P}{A}$ & $\sigma_{min} = \frac{2P}{2A}$

Scanned by CamScanner

So

$$\frac{\sigma_{max}}{\sigma_{min}} = \frac{2\cancel{P}\times 2\cancel{A}}{\cancel{A}\times 2\cancel{P}} = 2.$$

Now To find the deformation at any point in the bar always take fix point as refrence point & deformation is with fix point.

$$\delta_{Total} = \delta_1 + \delta_2 + \delta_3$$

$$= \frac{\cancel{2}PL}{A\times\cancel{2}E} + \frac{\cancel{2}PL}{\cancel{2}AE} + \frac{2PL}{3EA}$$

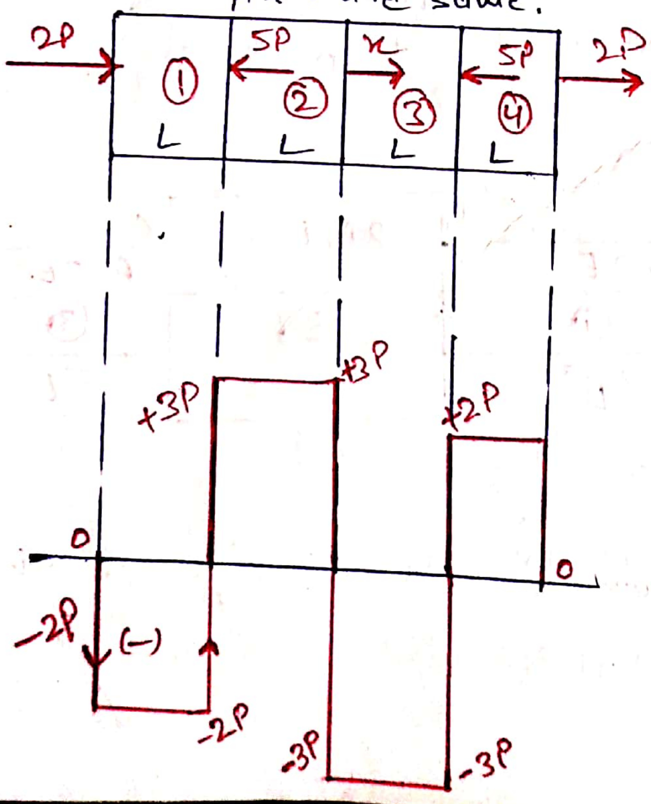
$$= \delta + \delta + \frac{2}{3}\frac{PL}{EA}$$

$$= \delta + \delta + \frac{2}{3}\delta \Rightarrow 8\delta/3.$$

<u>Now</u>

<u>Case II</u> For the bar shown Determine max stress induced, Ratio of $\sigma_{max}/\sigma_{min}$ & Deformations.

A & E are same.



Now Put Load Linearly

$-2P + 5P - x + 5P - 2P = 0$

$x = 6P.$

Obtain from the diagram.

Now

$P_1 = -2P$ [compressive].

$P_2 = +3P$ [Tensile].

$P_3 = -3P$ [Compressive]

$P_4 = +2P$ [Tensile]

So $\sigma_{max.}$ = It will be depend on Areas of bar But Areas are equal So Intensity of Loads. i.e.

σ_{max} at P_2 & or P_3 So

$$\sigma_{max} = \frac{3P}{A} \text{ \& Simillarly } \sigma_{min} = \frac{2P}{A}$$

So

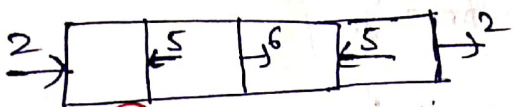
$$\frac{\sigma_{max}}{\sigma_{min}} = \frac{3}{2}$$

Now Elongation.

$$\delta_{Total} = \delta_1 + \delta_2 + \delta_3$$

$$= \frac{L}{AE}\left[P_1 + P_2 + P_3 + P_4\right] = \text{Zero}.$$

Another method of solving load.



$P_1 = -2$

So $P_2 = -2 + 5 = 3$

$P_3 = -2 + 5 - 6 = -3$

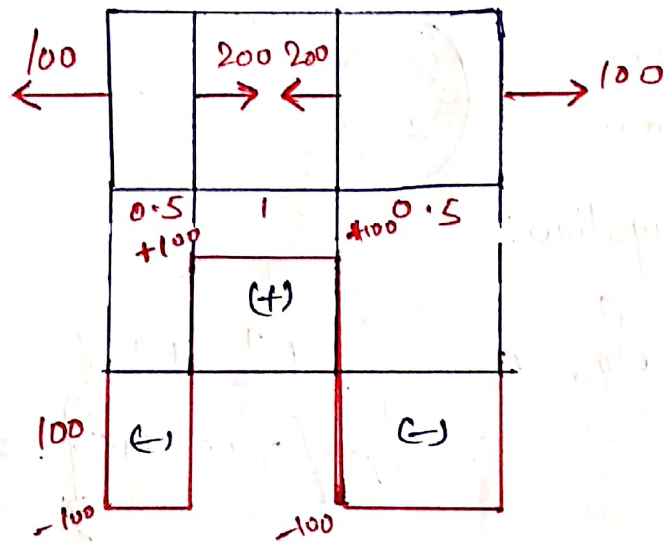
$P_4 = -2 + 5 - 6 + 5 = +2$.

* Individual members have non-zero deformations. But total deformation is zero.

* Load acting on any member = Load acting at non-junction point of the member.

* Junction load is devided into members hence not real load.

Question A cylindar Bar of Area = $100\,mm^2$ is subjected to loading & $E = 200\,GPa$. Find $\delta L = ?$



Sol.

So

$P_1 = -100$ [compressive]

$P_2 = +100$ [Tensile]

$P_3 = -100$ [compressive].

So $\delta_{Total} = \frac{P_1 L_1}{AE} + \frac{P_2 L_2}{AE} + \frac{P_3 L_3}{AE}$

$\delta_{Total} = \frac{1}{AE}\left[P_1 L_1 + P_2 L_2 + P_3 L_3\right].$

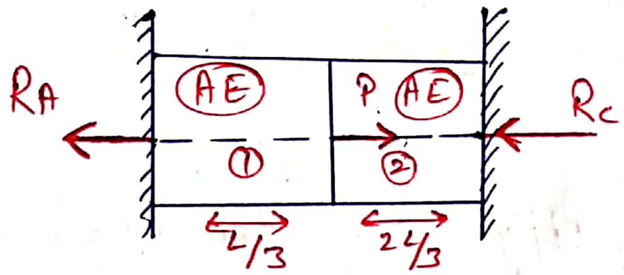
$$\delta_T = \frac{1}{AE}\left[-100\times 0.5 + 100\times 1 - 100\times 0.5\right]$$

$$\delta_T = \frac{1}{AE}[0] \Rightarrow \boxed{\delta_T = 0}$$

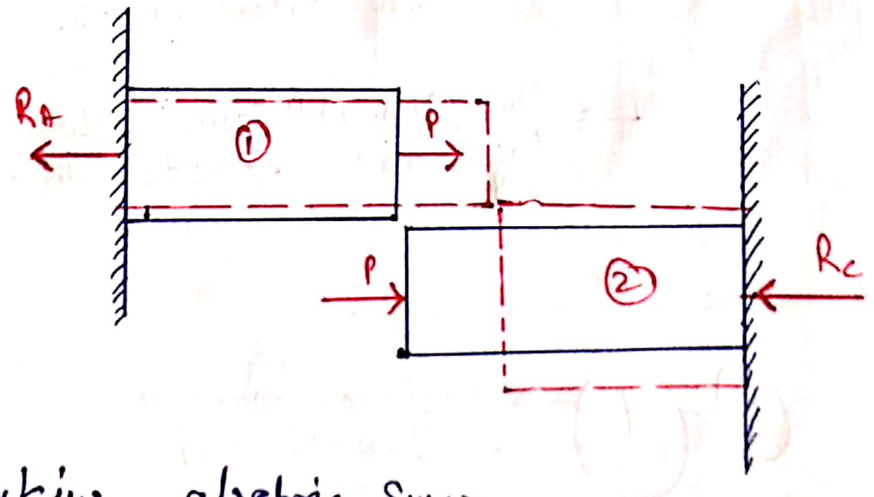
Case III Bar Fixed at both ends [Statically indetermined Bar.]

| No. of Rxn in the Bar | > | No. of Usefull Static equilibrium equation i.e $\Sigma V = \Sigma H = \Sigma M = 0$ |

Solution



Initially take rxn at ends at the opposite directions of acting loads.



Taking algebric Sum

$$R_A - P + R_C = 0$$

$$R_A + R_C = P$$

&

$\delta_1 + \delta_2$ will be equal to zero.

So

$$\frac{P_1 L_1}{AE} = -\frac{P_2 L_2}{AE}$$

$$\Rightarrow P_1 L_1 = -P_2 L_2$$

$$R_A L_1 = -(R_A - P) L_2 \quad [P = R_A \text{ opposite}].$$

$$R_A \frac{\cancel{L}}{\cancel{3}} = -(R_A - P)\frac{2\cancel{L}}{\cancel{3}}$$

$$R_A = -2R_A + 2P$$

$$R_A = 2P/3$$

$$\text{So } R_C = P/3$$

<u>Second Method</u> Applyed only when $A, E =$ Constant for all.

$$R_{xn} \text{ at fix end} = \begin{matrix} + \\ - \end{matrix} \left[\frac{\Sigma[\text{Load acting} \times \text{Distance from the opposite end}]}{\text{Total length}}\right]$$

Plus sign will come when Rxn & Load are opposite direction other wise −ve.

For the above case:-

$$R_A = \frac{P \times \frac{2L}{3}}{L}$$

Distance from the opposite end

Total length.

Only one Load is acting

$$R_A = \frac{2P}{3} = P_1$$