LAST CHAPTER

Plastic Moment.

Plastic : a condition when a material no longer resist the force.

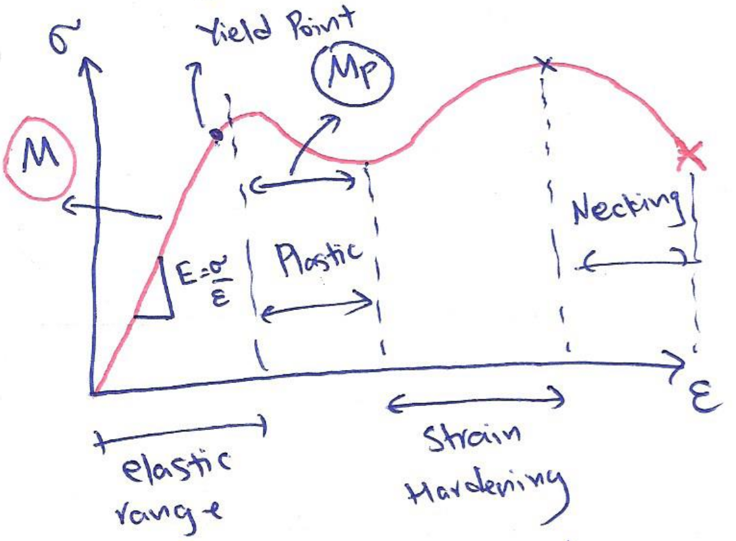
For steel structure, it is not good!

↳ elastic, Obey the Hooke law

Yield Moment

M_y

$$E = \frac{\sigma}{\varepsilon}$$



$M < M_y \rightarrow$ OK!

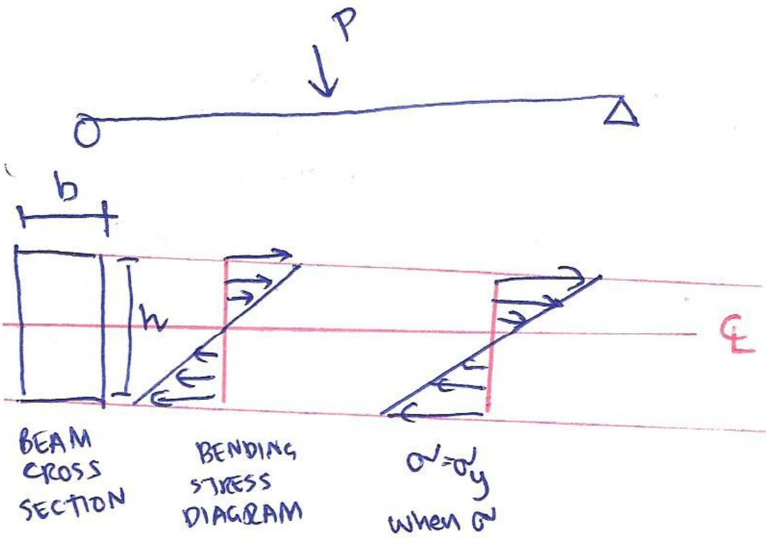
$M_p < M_y \rightarrow$ No...NO...NO

The objective :

1) To know the ultimate moment a structure can handle.
2) To lower the risk of ~~fai~~ failure.

Method to analyze:
1) Graphical Method
2) Virtual Work Method.

Let say, there is a ~~ted~~ load on a beam.



$$\underbrace{\sigma < \sigma_y}_{\text{elastic range}}$$, but

$$\sigma_y = \frac{M_y \cdot y}{I} = \frac{M_y \cdot \frac{h}{2}}{I}$$

Yield stress $\sigma_y = \frac{M_y h}{2I}$

Yield Moment $M_y = \frac{\sigma_y 2I}{h}$

$$M_y = \frac{\sigma_y \cdot \cancel{2} \times \left(\frac{bh^{\cancel{3}\,2}}{\cancel{12}\,6}\right)}{\cancel{h}} = \sigma_y \cdot \frac{bh^2}{6}$$

or $M_y = \sigma_y \cdot Z$

where Z = section modulus

Also, Z can be represented as

$Z = \frac{I}{y}$

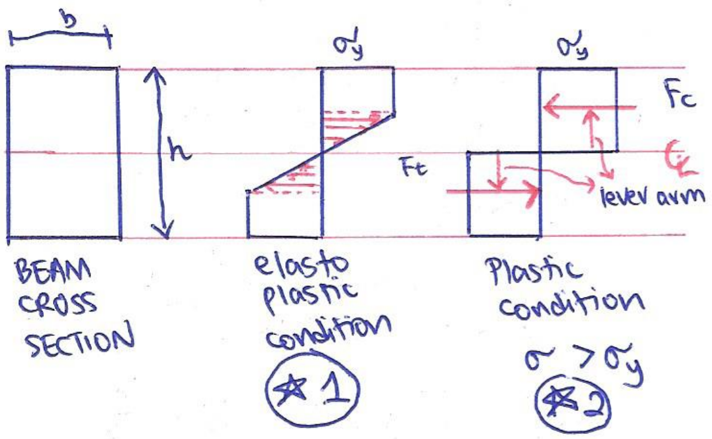
shape

Rectangular $Z = \frac{bh^2}{6}$

Circular $Z = \frac{\pi d^3}{32}$

※ Note that until now, it is only applicable for elastic range, as you already learned in BFC 20903 : Stress In Beam . From now on.....

IF !!! the load continues to be loaded, the beam will exceed the yield point and the beam will transform from elastic condition to PLASTIC condition! Consider again :



★1 In this condition, the material is consider half-elastic and half-plastic (elasto-plastic). Notice the stress distribution, which is different from the elastic condition (half-triangle)

★2 In this condition, the material is already in plastic stage. In this condition, the stress distribution is the same througout the section! So, we assume one (1) concernrated load is applied in each section, and the distance is in the middle of each section. For compression part, it is written as F_c (in the middle, the distance is $h/4$), and for tension part, it is F_t (also in the middle, the distance is $h/4$), from the centre of the block ! The distance is called LEVER ARM !

Shape factor (S) and load factor (λ)

Shape factor (S)

- the ratio of $S = \dfrac{M_p \text{ (Plastic Moment)}}{M_y \text{ (Yield Moment)}}$
- always greater than 1. ($S > 1$)
- For rectangular section, ratio = 1.5
- For circular section, ratio = 1.7
- For thin walled section, ratio = 1.1 ~ 1.2
- For I section, ratio : 1.15

Load Factor (λ)

- The ratio of collapse load to the maximum applied load
- Based on the cross sectional SHAPE.
- The equation for Load Factor (λ)

$$\boxed{\lambda = \frac{\sigma_y}{\sigma_b} \times S} \quad \text{or} \quad \boxed{\lambda = \frac{\text{Collapse Load}}{\text{Work Load}}}$$

where ;

λ = load factor

σ_y = yield stress

σ_b = permissible stress

S = shape factor

In structural analysis, it is used to determine the design strength and compare it with maximum load.

Theories in Plastic Analysis

In collapse state, the requirement;

1) Must be in equilibrium

$$\left.\begin{array}{l}\Sigma F_x = 0 \\ \Sigma F_y = 0 \\ \Sigma M = 0\end{array}\right\}\ \text{must be balance!}$$

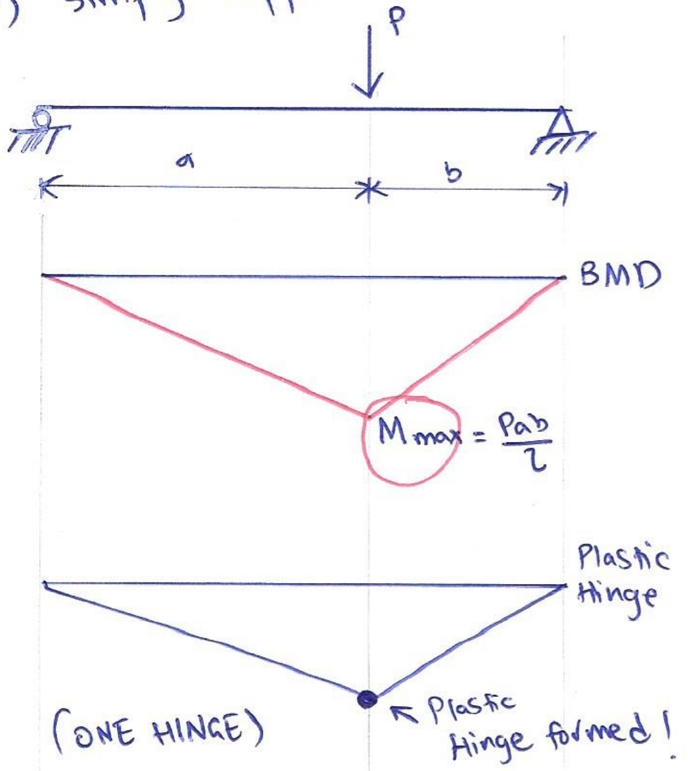
2) The moment value must not exeeed the Moment Plastic (M_p) value
3) Sufficient hinges must have formed to ensure the collapse

Hinges (Engsel (BM))

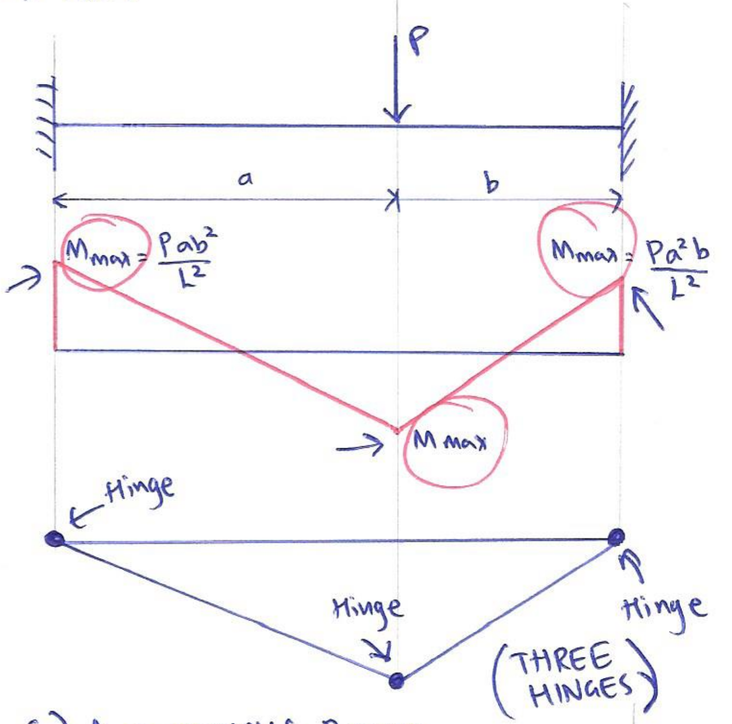
- In Plastic analysis, when a structure is overloaded, hinge(s) will appear!
- Hinge will appear at the point where maximum bending moment is detected in Bending Moment Diagram!

Consider:

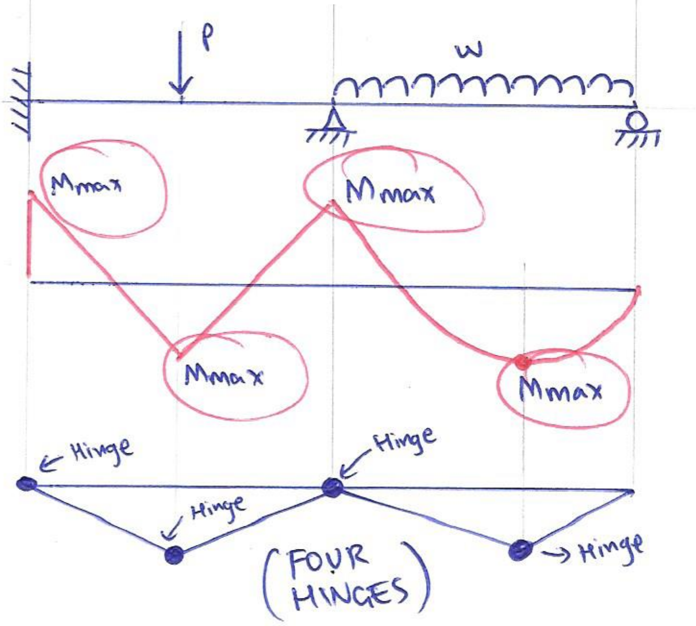
a) Simply supported beam



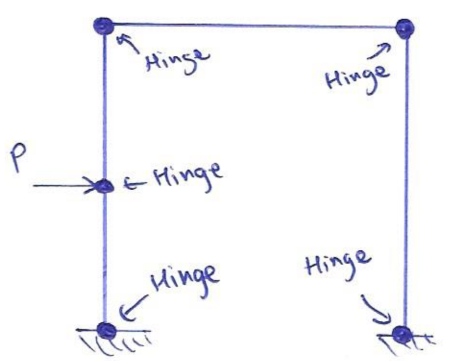
b) Fixed connection at both ends



c) A continuous Beam



d) Frame



※ Hinges will occur at

1) Intermediate support
2) Joint (for frame)
3) Points where loads are applied
4) Maximum moment in BMD!