

- Phases
 - phase 1:- uncracked section.
 - phase 2:- linear cracked section.
 - phase 3:- Non linear cracked section.

• Nominal strength:- the largest strength can be applied on the section.

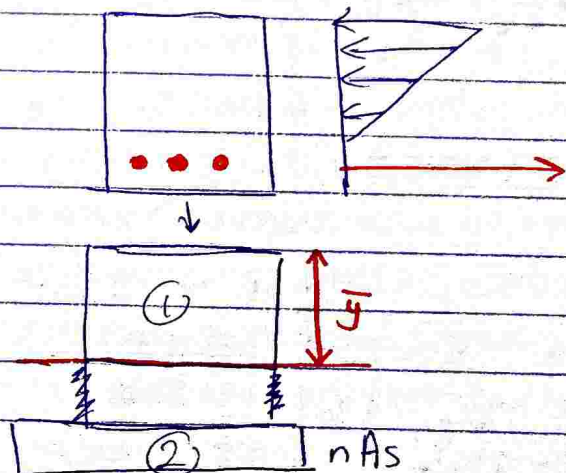
$\phi M_n \geq M_u$
 from the materials prop. $\leftarrow$ $\rightarrow$ from the structural analysis

• Example $\Rightarrow$ phase 1.
Before

$M_{cr} = 69 \text{ kN.m}$

• Example:-
Like the example Before
But $M = 120 \text{ kN.m}$

$\Rightarrow 69 < 120 \Rightarrow$ phase (2)



$\times$	A	y	Ay
1	$250\bar{y}$	$\bar{y}/2$	$125\bar{y}^2$
2	11776	600	~

$\bar{y} = \frac{\sum Ay}{\sum A} = 167.94 \text{ mm}$

$\rightarrow$ J_c of concrete
 Concrete J_c
 (Concrete) J_c

$\times$	I''	A	D	AD	$I'' + AD^2$
1	$BH^3/3$	~	~	~	~
2	0	11776	600-168	~	~

$I = 2.6 \times 10^9 \text{ mm}^4$

- In this case the stress on the concrete will Increase
- But the stress In the steel will Increase more, Because we remove the concrete.

$$\cdot \sigma_{max, c} = 120 \times 10^6 \times 168 / 2.6 \times 10^9 = 7.75 \text{ MPa}$$

$$\cdot f_s = n \sigma_c = 8 (120 \times 10^6 \times (600 - 168) / 2.6 \times 10^9) = 159.5 \text{ MPa}$$

~~XXXXXX~~

~~XXXXXX~~

~~XXXXXX~~

• Phase 3: Nominal Strength.

Reinforced

1- under reinforced:-

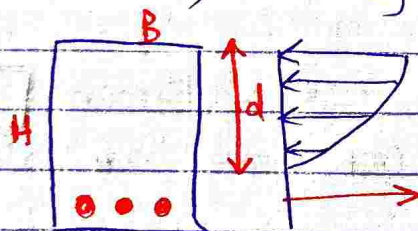
Steel fails Before.

2- Balanced:-

Steel and the concrete fails in the same time

3- Over-reinforced:-

Concrete fails Before, economically



من تصميم خرسانية
مساواة، يتحول إلى أنه
الفيل يكون بالستيل أد
لأنه الكونكريت
Warning
بصيرته فيلر ليدون

• Reinforcement ratio

$$\rho = \frac{A_s}{Bd}$$

↳ effective depth

$$\rho \gg \rho_b$$

→ concrete fails Before

$$\rho = \rho_b$$

→ at the same time

$$\rho \ll \rho_b$$

→ tension Control section

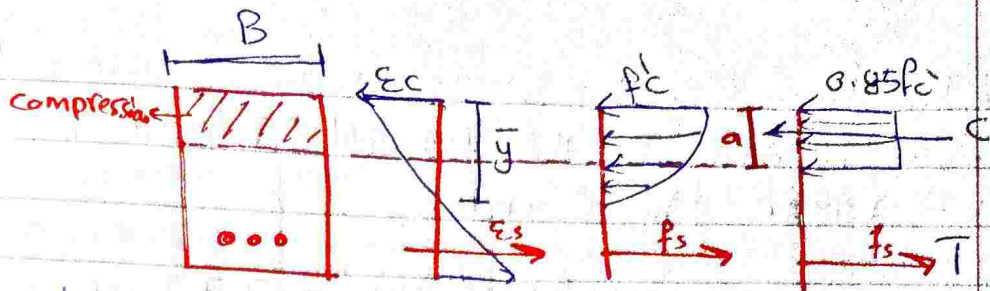
* Whitney Block distribution: -

• Example :-

Phase 3:-



[Flexural formula] ما ينطبق
 ↳ لا تنطبق
 ↳ من غير



$$a = \beta_1 \bar{y}$$

$$0.65 \leq \beta_1 \leq 0.8$$

$$\beta_1 = 0.85 - 0.05 \left[\frac{f_c' - 28}{7} \right] \Rightarrow \text{بتناقص قوة التسليح}$$

$$C = 0.85 f_c' (aB)$$

$$T = f_s \times A_s$$

$$T = C \Rightarrow \text{Equ}$$

$$a = \frac{f_s A_s}{0.85 f_c' \beta}$$

$$\rightarrow M_n = C \left(d - \frac{a}{2} \right) = f_s A_s \left(d - \frac{a}{2} \right)$$

T أو C ←

→ Failure in concrete → ultimate strain = $0.003 = \epsilon_u$
 the strain in steel must have a value = $0.004 \epsilon_s$

Hook's law ← Elastic المنطقة المرنة
 $\sigma = E \epsilon$

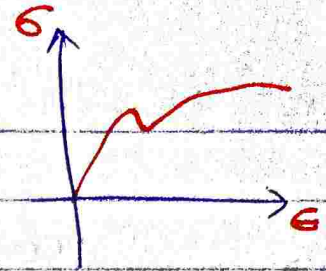
الكونكريت يفقد حال non-Elastic Region

• Suppose:-

$$f_y = 420 \text{ MPa}$$

$$\sigma_y = E \epsilon_y$$

$$\epsilon_y = 0.0021$$



~~0.004 = $\frac{\sigma_y}{E}$ stress strain~~
~~yield~~
~~stress strain~~
~~AISC~~

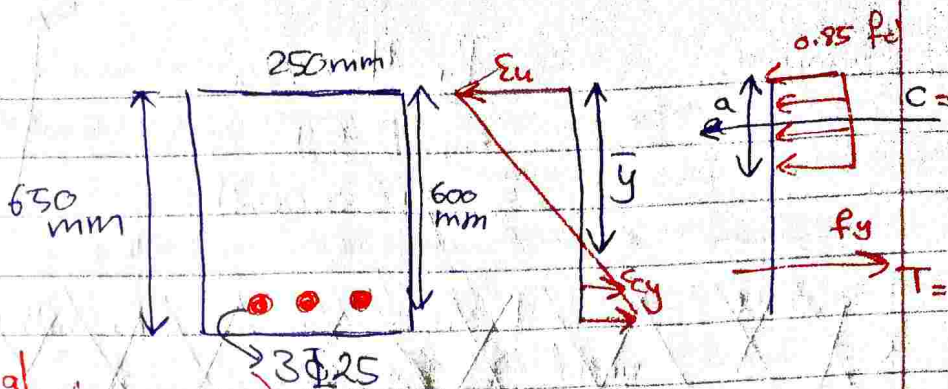
• In the AISC - code: The failure in the Beam happened when the strain in the steel reach double value of its yield strain.



That's help to determine the perfect
rain for cement.

• Example:

$$F_c = 28 \text{ MPa}$$
$$F_y = 420 \text{ MPa}$$



- Calculate (Nominal moment Capacity) $\rightarrow 38.25$
- Calculate the strain in concrete and steel at failure?

$$T = C$$

$$\Rightarrow A_s \times f_y = 0.85 f_c' a \beta \Rightarrow a = \frac{A_s f_y}{0.85 f_c' \beta}$$

$$a = \frac{3 \times 25^2 \times \pi/4 \times 420}{0.85 \times 28 \times 250}$$

$T, C \Rightarrow$ Same

$$= 103.9 \text{ mm}$$

$$\Rightarrow M_n = \text{force} \times \text{arm} = A_s \times f_y$$

$$= 3 \times 25^2 \times \frac{\pi}{4} \times 420 \left(\frac{d-a}{2} \right) =$$

$$= 339 \times 10^6 \text{ N.mm}$$

$$= 339 \text{ KN.m}$$

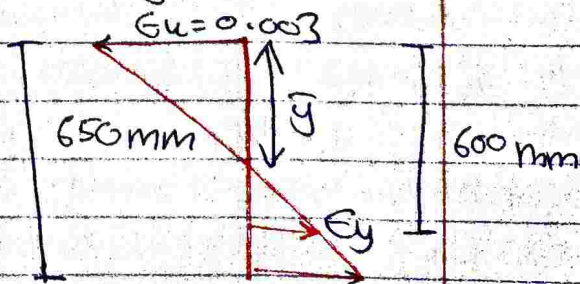
عند هاي اطوفينه
راح بصير في ضل
بالبيم

N
mm
MPa

$$\Rightarrow a = B_1 \bar{y} \Rightarrow 1039 = 0.85 \bar{y} \Rightarrow \bar{y} = 122.2 \text{ mm}$$

$$\frac{G_u}{\bar{y}} = \frac{G_s}{d-\bar{y}} \Rightarrow G_s = \frac{d-\bar{y}}{\bar{y}} G_c$$

$$G_s = 0.017$$



- يلبس الد yield بالسيل $\leftarrow 0.002$.
- يعني ~~لا يلبس الد~~ وليس السيل زلزال ~~لا يلبس الد~~ لا yield.
- لما يصير في فيلر بال concrete معناه إنه صار في الفيلر بالسيل منه مثل

◆ Balanced sections ($\epsilon_c = \epsilon_u$, $\epsilon_s = \epsilon_y$)

$$\begin{array}{ll} \epsilon_y = 0.0021 & \epsilon_u = 0.003 \\ \text{Steel} \swarrow & \searrow \text{concrete} \end{array}$$

◆ Find the Balanced steel ratio (P_b)

$$T = C \quad A_s f_y = 0.85 f'_c a b \Rightarrow a = \frac{A_s f_y}{0.85 f'_c b} \quad \text{--- (1)}$$

$$\frac{\epsilon_u}{\bar{y}} = \frac{\epsilon_y}{d - \bar{y}} \Rightarrow \bar{y} = d \frac{\epsilon_u}{\epsilon_u + \epsilon_y} \quad \text{--- (2)}$$

② in ①

$$B \cdot \bar{y} = \frac{A_s f_y}{0.85 f'_c b}$$

$$B \cdot \bar{y} = A_s f_y / 0.85 f'_c b$$

$$B \cdot d \frac{\epsilon_u}{\epsilon_u + \epsilon_y} = \frac{A_s f_y}{0.85 f'_c b} \quad \text{--- (3)}$$

Reinforcement ratio $\Rightarrow P = \frac{A_s}{Bd} \Rightarrow A_s = P B d$

Sub. In (3)

$$P_b = B \left(\frac{\epsilon_u}{\epsilon_u + \epsilon_y} \right) \times 0.85 \frac{f'_c}{f_y}$$

$\downarrow \quad \quad \quad \downarrow$
 $0.003 \quad \quad \quad 0.002$

At ACI

$P_{max} \rightarrow \epsilon_c = 0.003$
 $\epsilon_y = 0.004 \rightarrow 2 \times \epsilon_{yield} \text{ to steel.}$

$$P_{max} = B \left(\frac{\epsilon_u}{\epsilon_u + \epsilon_y} \right) \times 0.85 \frac{f'_c}{f_y}$$

$\downarrow \quad \quad \quad \downarrow$
 $0.003 \quad \quad \quad 0.004$

* ACI $\Rightarrow$ requires tension-controlled design
 crushing In Concrete yield قبل

* maximum reinforcement ratio

$$\rho_{max} = \rho_{0.004} = 0.85 \beta_1 \left(\frac{f'_c}{f_y} \right) \left(\frac{0.003}{0.003 + 0.004} \right)$$

* minimum reinforcement ratio: إذا امكنه من الاعتبار إنه
 فعل تليج بالمثل وراح يصير
 ضيق الكونكريت بدون أي
 كثر من نسبة

$$\max \left[\frac{1.4}{f_y}, \frac{0.25 \sqrt{f'_c}}{f_y} \right]$$

$$\rho_{max} < \rho < \rho_{min}$$

← بتعين ال strain
 بالمثل ما قبل عنه
 0.004
 أي هيصرفه نيل

Which I will
 use it In
 design

تبين إنه في
 Tension failure
 In steel
 $\Rightarrow$ warning

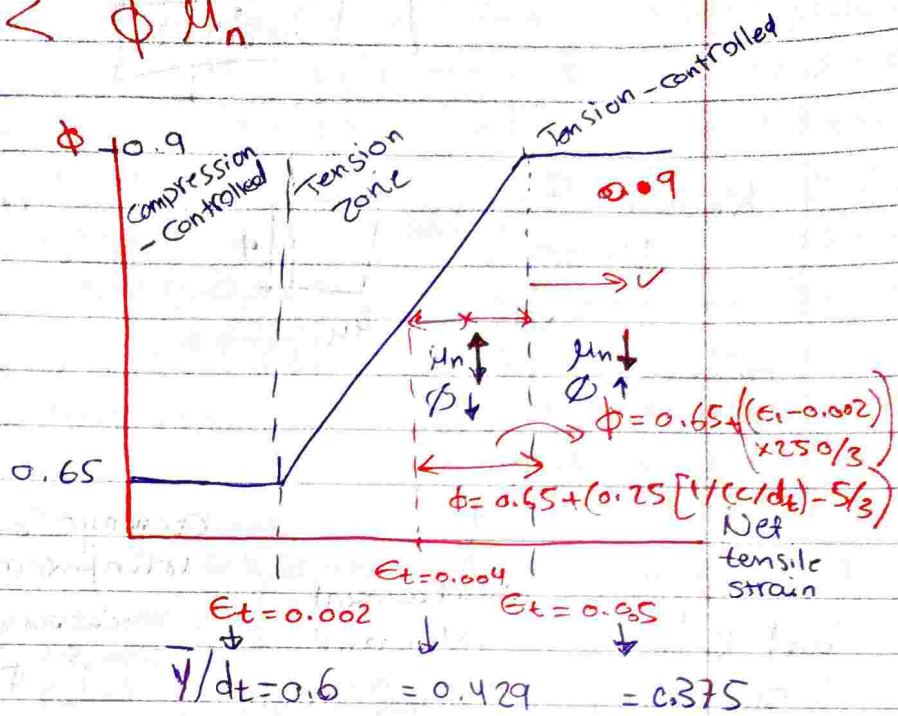
$\Rightarrow \frac{\bar{\epsilon}}{d} = \frac{\epsilon_u}{\epsilon_u + \epsilon_t} \Rightarrow$ good indication to determine
 If we exceed reinforcement
 limit.

CH9 + H22 لازم نعرف نطوع المحاللات هاي من الكود

In ACI code 2019

رقم التبيد ...

~~St.~~ Mu
St. Analysis $\leftarrow$



* serviceability requirements:-

- ACI $\rightarrow$ limit for the min. depth of the beam depend on span continuity Table 9.3.1.1

- depend on span continuity Table 9.3.1.1
- | Support Condition | Diagram | Factor |
|--------------------|---|----------|
| Simply |  | $l/16$ |
| one end continuity |  | $l/18.5$ |
| Cantilever |  | $l/8$ |
- ← إذا ما بنائنا
في الحايير لدرج
نسب ديفليكشن ويكون لها حد (maximum deflection).

- distance between bars : $\rightarrow$ diameter of the bar

المحطة بتعلق فوقهم أو يتلاقى بينهم. $\rightarrow$ diameter of the bar

$S_{min} = \max \left[25 \text{ mm}, d_b, \frac{4}{3} d_{agg} \right]$

من لازم تكون المسافات بعيدة كثير

In general $\rightarrow$ 19 mm $\rightarrow$ 80 mm

→ إذا كان عنا أكبر صغار لعدم ثبات ولهم ما ينجوا الذين ليس بنخيار أكبر عدد ممكن

- Concrete clear cover $\rightarrow 40 \text{ mm}$, But if there $\left\{ \begin{array}{l} \text{Weather} \rightarrow 50 \text{ mm} \\ \text{Soil} \rightarrow 75 \text{ mm} \end{array} \right.$