Design of sections of Columns.

نسألكم الدعاء

Design of sections of Columns. Table of Contents.

قطاعات الاعمده ممكن أن تكون معرضه ل :

1- Axial Compression Force. قوى ضغط محوريه

2- Axial Compression Force & Bending moment.
قوى ضغط محوريه و عزم انحناء

3- Biaxial moment. قوى ضغط محوريه و عزوم انحناء فى اتجاهين

Design of sections subjected to Axial Compression Force.

$$P_{U.L.} = 0.35\, A_c\, F_{cu} + 0.67\, A_s\, F_y$$

$P_{U.L.} = 1.4\,(D.L.) + 1.6\,(L.L.) = \checkmark \quad N$

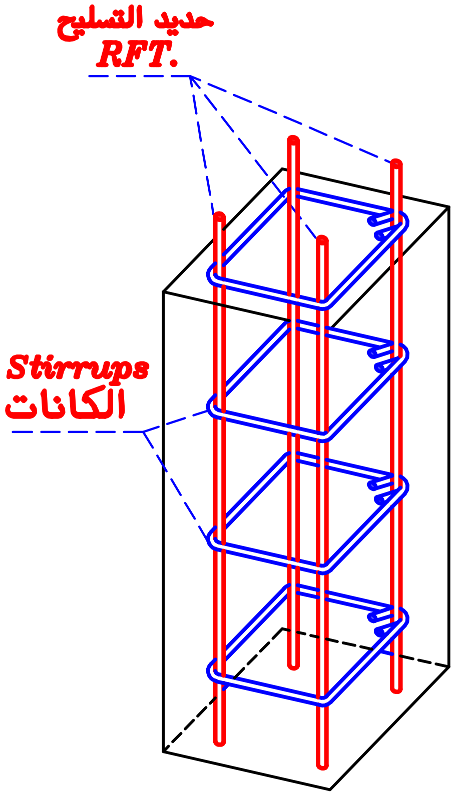
A_c = Area of Concrete $= \checkmark \quad mm^2$

A_s = Area of Steel $= \checkmark \quad mm^2$

$F_{cu} = \checkmark \quad N\backslash mm^2$

$F_y = \checkmark \quad N\backslash mm^2$

Details of Reinforcement. RFT. تفاصيل التسليح



فائده الحديد الرأسى فى الأعمده :

١- تتحمل جزء من الحمل الرأسى .

٢- تقاوم العزوم الناتجه عن الإنبعاج *Buckling*.

٣- تقاوم العزوم الناتجه عن الرياح أو الزلازل .

٤- تقاوم الإجهادات الناتجه عن الإنكماش .

٥- تعمل على تقليل مساحه القطاع .

٦- تحمى أركان العمود من الكسر .

٧- تعمل على زياده المطولية للعمود.

تفاصيل التسليح

- أقل نسبه تسليح فى الأعمده تساوى μ_{min}

٠,٨ ٪ من مساحه الخرسانه المطلوبه

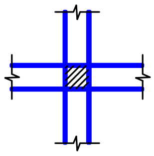
$$\mu_{min} = \frac{A_{s\,min}}{A_{c\,(required)}} = 0.8\,\%$$

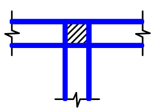
٠,٦ ٪ من مساحه الخرسانه المعطاه

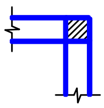
$$\mu_{min} = \frac{A_{s\,min}}{A_{c\,(chosen)}} = 0.6\,\%$$

- أكبر نسبه تسليح فى الأعمده تساوى

$$\mu_{max} = \frac{A_{s\,max}}{A_c}$$

Interior col. $\mu_{max} = 4\,\%$  عمود وسطى

Edge col. $\mu_{max} = 5\,\%$  عمود طرفى

Corner col. $\mu_{max} = 6\,\%$  عمود ركنى

Steps of Design of axially Loaded Columns.

Type ① **Given :** $P_{D.L.}$, $P_{L.L.}$, F_{cu} , F_y

Req : Design The Sec. (Get A_c , A_s)

Solution :

$$P_{U.L.} = 0.35\, A_c\, F_{cu} + 0.67\, A_s\, F_y$$

$P_{U.L.} = 1.4\,(D.L.) + 1.6\,(L.L.) = \checkmark\ N$

Take $\mu = \frac{A_s}{A_c} = 1.0\ \%$ $\longrightarrow$ $A_s = \frac{A_c}{100}$

$\therefore P_{U.L.} = 0.35\, A_c\, F_{cu} + 0.67 \left(\frac{A_c}{100}\right) F_y$ $\longrightarrow$ Get $A_c = \checkmark\ mm^2$

, Get $A_s = \frac{A_c}{100} = \checkmark\ mm^2$

– IF the column section is a square (b*b)

$A_c = b^2$ $\quad\therefore b = \sqrt{A_c}$

b لا تقل عن ٢٥٠ مم و تقرب لأقرب ٥٠ مم بالزياده .

– IF the column section is a rectangle (b*t)

$A_c = b * t$ $\quad$ Choose $b = 250\ mm$ $\xrightarrow{Get}$ $t = \frac{A_c}{b}$

t لا تقل عن ٢٥٠ مم و تقرب لأقرب ٥٠ مم بالزياده.

يفضل أخذ b تساوى ٢٥٠ مم حتى يكون سُمك العمود هو نفس سُمك الحائط .

IF $t > 5\,b$ $\longrightarrow$ Increase b (take $t = 4\,b$)

and then get $b * t = b * 4\,b = A_c$ $\xrightarrow{get}$ $b = \checkmark\ mm$

$t = \frac{A_c}{b} = \checkmark\ mm$

– IF the column section is a circle.

$A_c = \frac{\pi D^2}{4}$ $\xrightarrow{Get}$ $D = \sqrt{\frac{4\,A_c}{\pi}}$

D لا تقل عن ٣٠٠ مم و تقرب لأقرب ٥٠ مم بالزياده.

Example.

Data. $F_{cu} = 25 \; N\backslash mm^2$, st. 360/520

$P_{D.L.} = 2000 \; kN \quad P_{L.L.} = 1150 \; kN$

Req. Design a (Square , Rectangle , Circular & Hexagon) Section For the column.

Solution. $P_{U.L.} = 1.4\,(2000) + 1.6\,(1150) = 4640\,kN$

Take $\mu = \frac{A_s}{A_c} = 1.0\,\%$ $\longrightarrow$ $A_s = \frac{A_c}{100}$

$\therefore P_{U.L.} = 0.35\, A_c\, F_{cu} + 0.67\, \left(\frac{A_c}{100}\right) F_y$

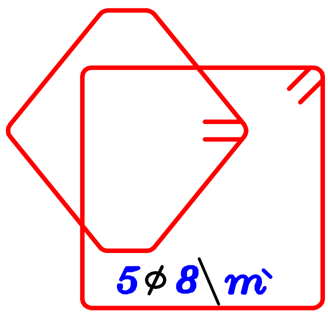
$4640 * 10^3 = 0.35\, (A_c)\,(25) + 0.67\, \left(\frac{A_c}{100}\right)(360)$

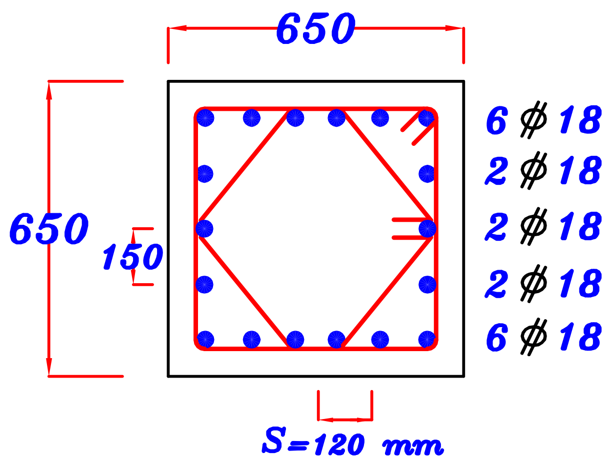
$\longrightarrow A_c = 415696.1\; mm^2 \longrightarrow A_s = \frac{415696.1}{100} = 4156.9\; mm^2$

* For Square Section.

18 ϕ 18

$b = \sqrt{A_c} = \sqrt{415696.1} = 644.7\; mm$ Take **$b = 650\; mm$**





* For Rectangular Section.

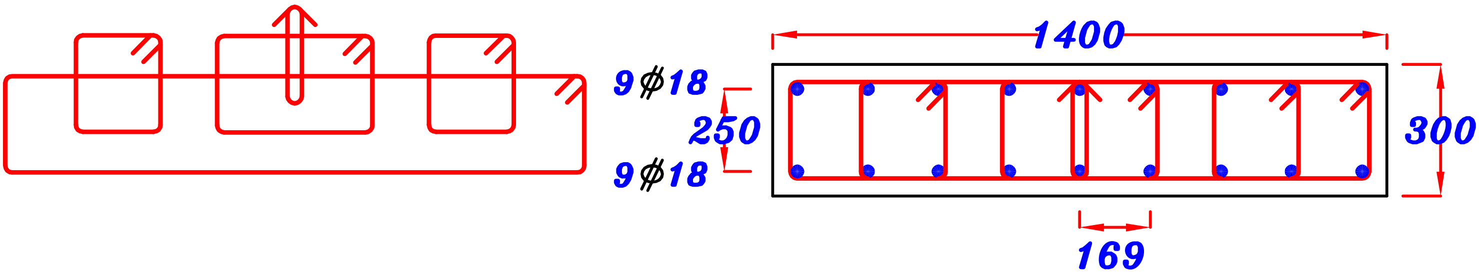
$A_c = 415696.1\; mm^2$ Take $b = 250\; mm$

$\longrightarrow t = \frac{A_c}{b} = \frac{415696.1}{250} = 1662.7\; mm$

$t > 5b \longrightarrow$ Increase b (take $t = 4b$)

$$b * t = b * 5b = 415696.1 \xrightarrow{get} b = 288 \xrightarrow{take} \boxed{b = 300\ mm}$$

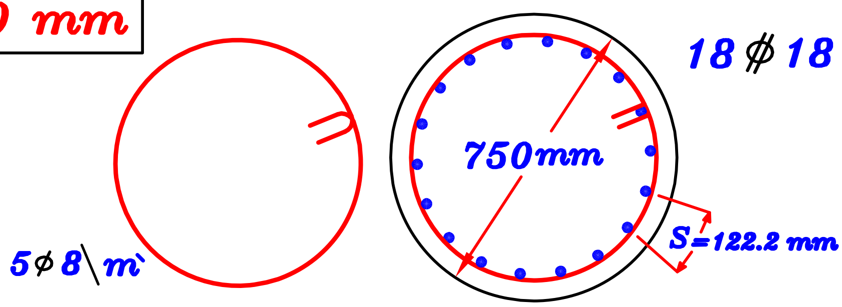
$$t = \frac{A_c}{b} = \frac{415696.1}{300} = 1385.6\ mm \quad \boxed{t = 1400\ mm}$$



*** For Circular Section.** $A_c = 415696.1\ mm^2$

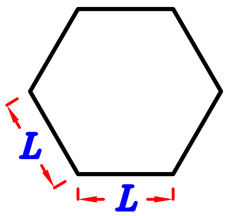
$$A_c = \frac{\pi D^2}{4} \xrightarrow{Get} D = \sqrt{\frac{4\,(415696.1)}{\pi}} = 727.5\ mm$$

Take $\boxed{D = 750\ mm}$

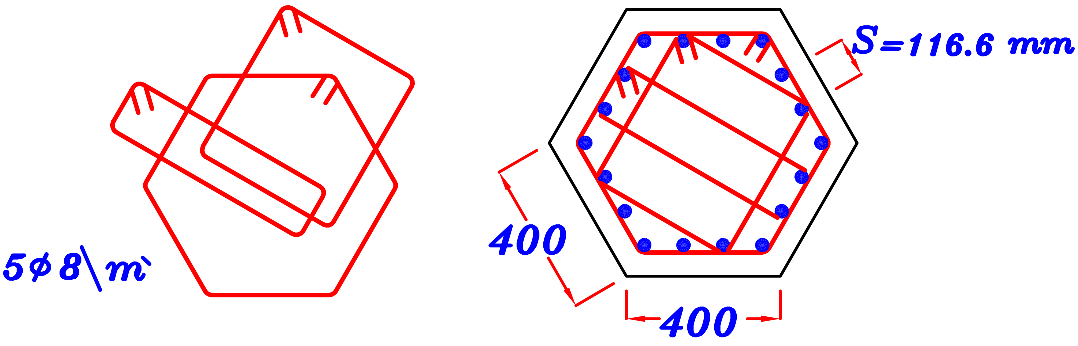


*** For Hexagon Section.**

$$\boxed{Area\ of\ hexagon = 1.5 * \sqrt{3} * L^2}$$



$$A_c = 415696.1 = 1.5 * \sqrt{3} * L^2 \longrightarrow \boxed{L = 400\ mm}$$



Type ②

Given : $P_{D.L.}$, $P_{L.L.}$, F_{cu} , F_y , A_c

Req : Design The Sec. (Get A_s)

Solution :

$$P_{U.L.} = 1.4\ (D.L.) + 1.6\ (L.L.) = \checkmark\ N$$

$$P_{U.L.} = 0.35\ A_c\ F_{cu} + 0.67\ A_s\ F_y$$

$\xrightarrow{Get}$ $A_s = \checkmark\ mm^2$ $\xrightarrow{Get}$ $\mu = \frac{A_s}{A_c}$

Check $\mu_{min} = 0.8\ \%\ A_{c\,(required)}$ OR $0.6\ \%\ A_{c\,(chosen)}$

IF	$\mu < 0.6\ \%$	Take	$\mu = 0.6\ \%$
IF	$0.6\ \% < \mu < 0.8\ \%$	Take	$\mu = 0.8\ \%$

Check μ_{max} = 4% Interior col.
5% Edge col.
6% Corner col.

IF $\mu > \mu_{max}$ $\xrightarrow{Take}$ $\mu = \mu_{max}$ $\xrightarrow{Get}$ $A_{c_{new}}$

$$A_s = \mu_{max} * A_{c_{new}}$$

$$P_{U.L.} = 0.35\ A_{c_{new}}\ F_{cu} + 0.67\ (\mu_{max}\ A_{c_{new}})\ F_y$$

$\xrightarrow{Get}$ $A_{c_{new}} = \checkmark\ mm^2$ $\xrightarrow{Get}$ $A_s = \mu_{max} * A_{c_{new}} = \checkmark\ mm^2$

Example.

Data. $F_{cu} = 25\ N\backslash mm^2$, st. 360/520

$P_{D.L.} = 1500\ kN$, $P_{L.L.} = 1000\ kN$

Req. Design an interior Column.

IF the column, (450 * 1100)

(450 * 700)

(450 * 400)

Solution. $P_{U.L.} = 1.4\,(1500) + 1.6\,(1000) = 3700\ kN$

* For Column. (450 * 1100)

$$A_c = 450 * 1100 = 495000\ mm^2$$

$$\because\ P_{U.L.} = 0.35\ A_c\ F_{cu} + 0.67\ A_s\ F_y$$

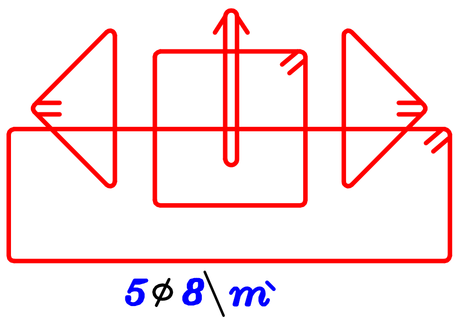
$$\therefore\ 3700 * 10^3 = 0.35\,(495000)\,(25) + 0.67\ A_s\,(360)$$

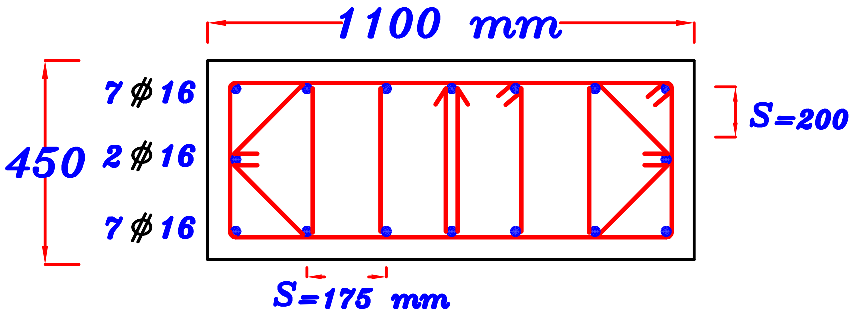
$$\therefore\ A_s = -\,2617.1\ mm^2$$

$$\therefore\ \mu = \frac{A_s}{A_c} = \frac{-2617.1}{495000} = -0.0052 = -0.52\ \% < 0.6\ \%$$

$$\therefore\ \text{Take}\ \mu = 0.6\ \% \longrightarrow A_s = \frac{0.6}{100} * 495000 = 2970\ mm^2$$

16 ϕ 16





* For Column. (450*700)

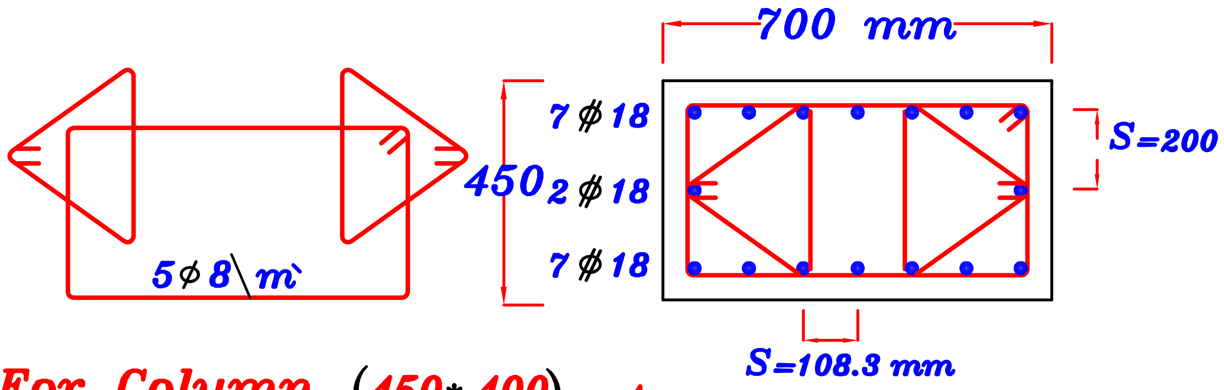
$A_c = 450 * 700 = 315000\ mm^2$

$\because P_{U.L.} = 0.35\ A_c\ F_{cu} + 0.67\ A_s\ F_y$

$\therefore 3700 * 10^3 = 0.35 (315000)(25) + 0.67\ A_s\ (360)$

$\therefore A_s = 3912.7\ mm^2$ **16 ϕ 18**

$\therefore \mu = \frac{A_s}{A_c} = \frac{3912.7}{315000} = 0.0124 = 1.24\ \%$ $\therefore \mu_{min} < \mu < \mu_{max}$



* For Column. (450*400)

$A_c = 450 * 400 = 180000\ mm^2$

$\because P_{U.L.} = 0.35\ A_c\ F_{cu} + 0.67\ A_s\ F_y$

$\therefore 3700 * 10^3 = 0.35 (180000)(25) + 0.67\ A_s\ (360)$

$\therefore A_s = 8810.1\ mm^2$ $\therefore \mu = \frac{A_s}{A_c} = \frac{8810.1}{180000} = 0.0489 = 4.89\ \%$

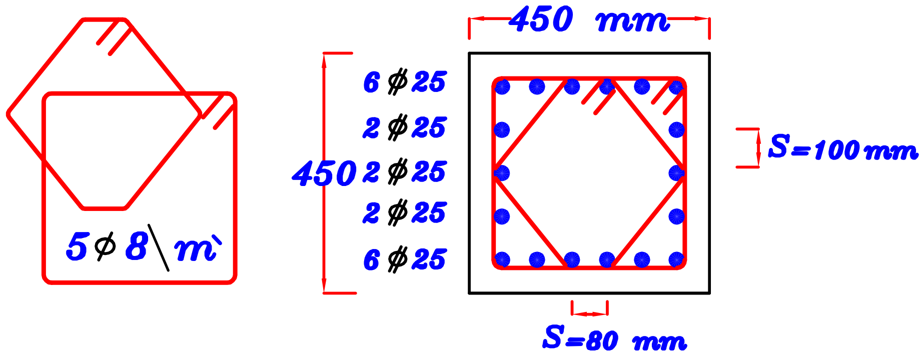
$\therefore \mu > \mu_{max}$ $\therefore$ Take $\mu = \mu_{max} = 4.0\ \%$ $\therefore A_s = \mu_{max} * A_{c_{new}} = \frac{4.0}{100} * A_{c_{new}}$

$\therefore P_{U.L.} = 0.35\ A_{c_{new}}\ F_{cu} + 0.67 \left(\frac{4.0}{100}\right) * A_{c_{new}}\ F_y$

$\therefore 3700 * 10^3 = 0.35 (A_{c_{new}})(25) + 0.67 \left(\frac{4.0}{100}\right) * A_{c_{new}} (360)$

$\therefore A_{c_{new}} = 201108.8\ mm^2 \longrightarrow (450 * 450)$

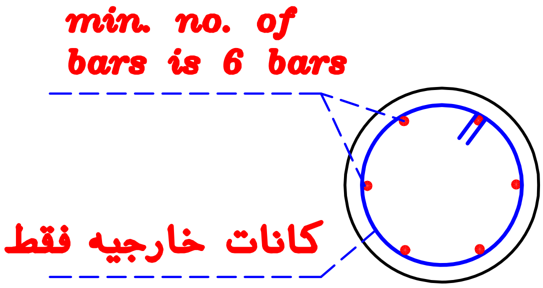
$A_s = \frac{4.0}{100} * 201108.8 = 8044.35\ mm^2$ **18 ϕ 25**



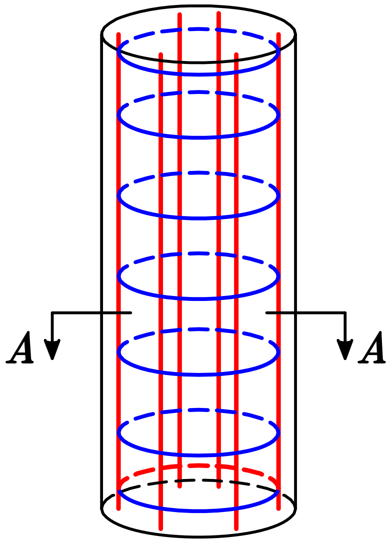
① Circular column with tied stirrups.

عمود دائرى ذو كانات دائريه منفصله

$$P_{U.L.} = 0.35\ A_c\ F_{cu} + 0.67\ A_s\ F_y$$



Sec.(A–A)



② Spiral Column. عمود دائرى ذو كانات حلزونيه

$$P_{U.L.} = 0.35\ A_k\ F_{cu} + 0.67\ A_s\ F_y + 1.38\ V_{sp}\ F_{yp}$$

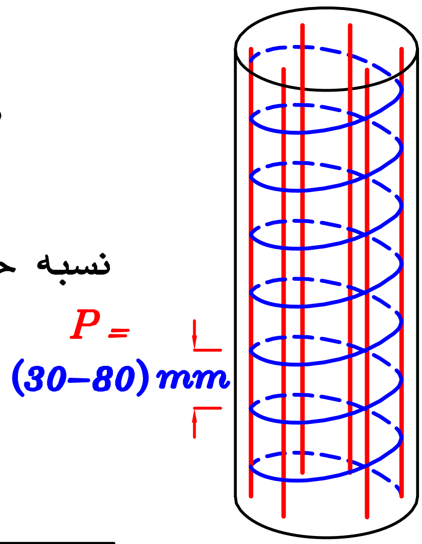
Cover = 30 mm

$A_k = \dfrac{\pi D_k^2}{4}$ مساحة قلب القطاع الخرسانى المحدد بدائره الكانه الحلزونيه

$V_{sp} = (\pi A_{sp} D_k) / P$ نسبه حجم الحديد فى الدوره الواحده

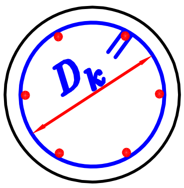
A_{sp} = مساحه مقطع الكانه الحلزونيه

$F_{yp} = 360\ N\backslash mm^2$ لحديد الكانه F_y



or

$$P_{U.L.} = 1.14\ (0.35\ A_c\ F_{cu} + 0.67\ A_s\ F_y)$$



Design of Sections Subjected to M , N

Bending Moment & Compression Force

Steps of Design :

1- Get Dimensions of the section. $(b \times t)$

2- Check IF N neglected or not.

3- Get Reinforcement A_s , A_s'

Solution:

1- Get Dimensions of the section. $(b \times t)$

Take $b = (300$ mm or 350 mm or 400 mm$)$

To get t get the bigger value of t_1 (Bending) , t_2 (Normal)

- Get $d_1 = C_1 \sqrt{\dfrac{M_{U.L.}}{F_{cu}\, b}}$ take $C_1 = 3.5$, $J = 0.78$ (as R-Sec.)

$t_1 = d_1 +$ cover where cover $= 50$ mm IF $t \leqslant 1000$ mm

$= 100$ mm IF $t > 1000$ mm

- Get t_2 $\xrightarrow{Take}$ $\mu = \dfrac{A_s}{b\, t_2} = 1.0\ \%$ $\longrightarrow$ $A_s = \dfrac{b\, t_2}{100}$

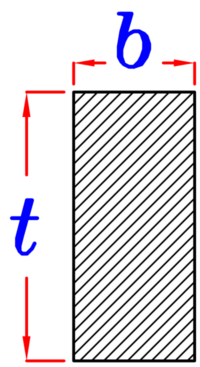
From $P_{U.L.} = 0.35\, A_c\, F_{cu} + 0.67\, A_s\, F_y$

$\therefore\ P_{U.L.} = 0.35\, b\, t_2\, F_{cu} + 0.67\, \dfrac{b\, t_2}{100}\, F_y$

$$\therefore\ \boxed{P_{U.L.} = \left(0.35\, b\, F_{cu} + 0.67\, \frac{b}{100}\, F_y\right) t_2}$$

- t_o = The bigger value of t_1 & t_2

- $t = (1.1 \rightarrow 1.3)\, t_o$



2- Check:

✓✓ 1- IF $K = \frac{N_{U.L.}}{F_{cu}\, b\, t} \leq 0.04 \longrightarrow$ neglect $N_{U.L.}$

and Design the Sec. on B.M. only as Beams.

$$\therefore\ d = d_1 = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\, b}}$$

take $C_1 = 3.5$, $J = 0.78$ (R-Sec.)

take $C_1 = 6.0$, $J = 0.826$ (T-Sec. , L-Sec.)

ملحوظه هامه :

فى بدايه التصميم نعمل تصميم على M, N على أن القطاع R-sec.

و لكن اذا أهملنا ال N فنعمل تصميم على M فقط فيجب مراعاه

اذا كان القطاع R-sec. or T-sec.

Get $e = \frac{M_{U.L.}}{N_{U.L.}}$

IF $\frac{e}{t} \leq 0.05 \longrightarrow$ neglect $M_{U.L.}$

and Design the Sec. on N.F. only as Columns.

$$P_{U.L.} = 0.35\, A_c\, F_{cu} + 0.67\, A_s\, F_y$$

Take $\mu = 1.0\ \%$

$$\therefore\ P_{U.L.} = 0.35\, A_c\, F_{cu} + 0.67\, \frac{A_c}{100}\, F_y$$

Get A_c , A_s

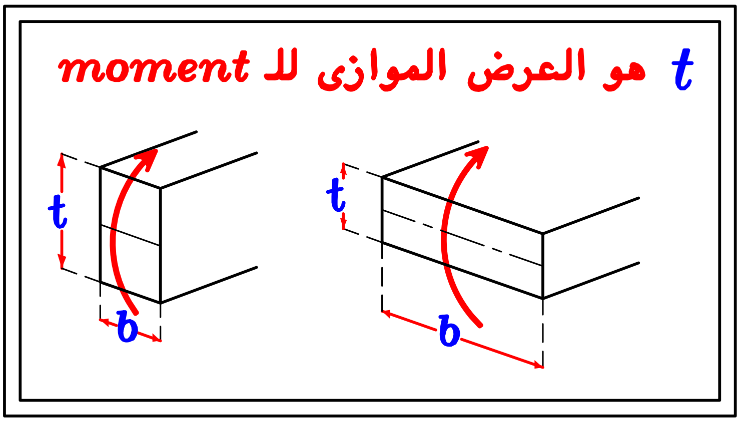
ممكن إهمال هذه الخطوه

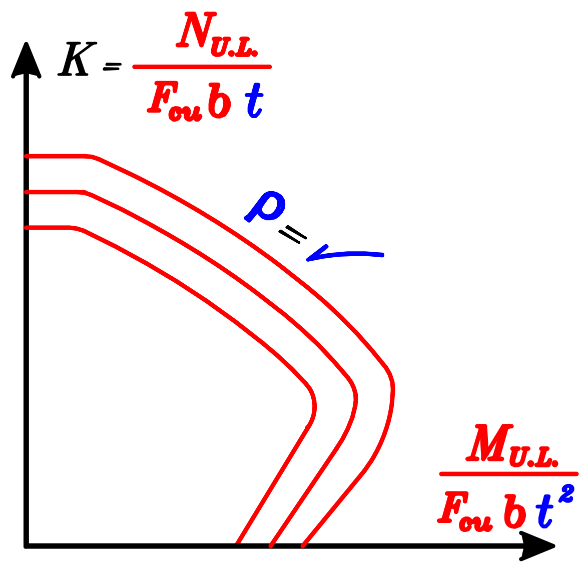
IF $K = \frac{N_{U.L.}}{F_{cu}\, b\, t} > 0.04$ **Design the Sec. on both N.F. , B.M.**

3 – Get Reinforcement $A_s, A_s`$

Use Interaction Diagram	ECCS Page (4–20) ⟶ (4–63)

Interaction Diagram. (I.D.)





لتحديد الصفحه المطلوبه نحدد ثلاثه قيم . F_y, α, ζ

Chart Key

F_y	= ✓
ζ	= ✓
$\alpha = \frac{A_s`}{A_s}$	= 1

Chart Key مفتاح الجدول

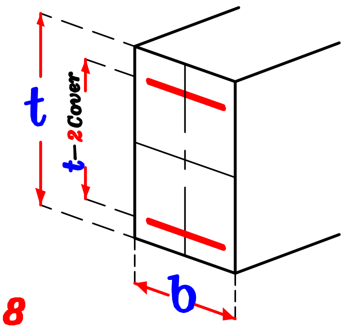
يوجد فى كل صفحه من صفحات ال I.D. فى الجداول مفتاح للجدول لتحديد أى جدول سوف نستخدمه

– F_y = Type of Steel:
- 240
- 280
- 360 ✓✓
- 400 ✓✓

– $\alpha = \frac{A_s`}{A_s}$:
- 0.8
- 1.0 ✓✓

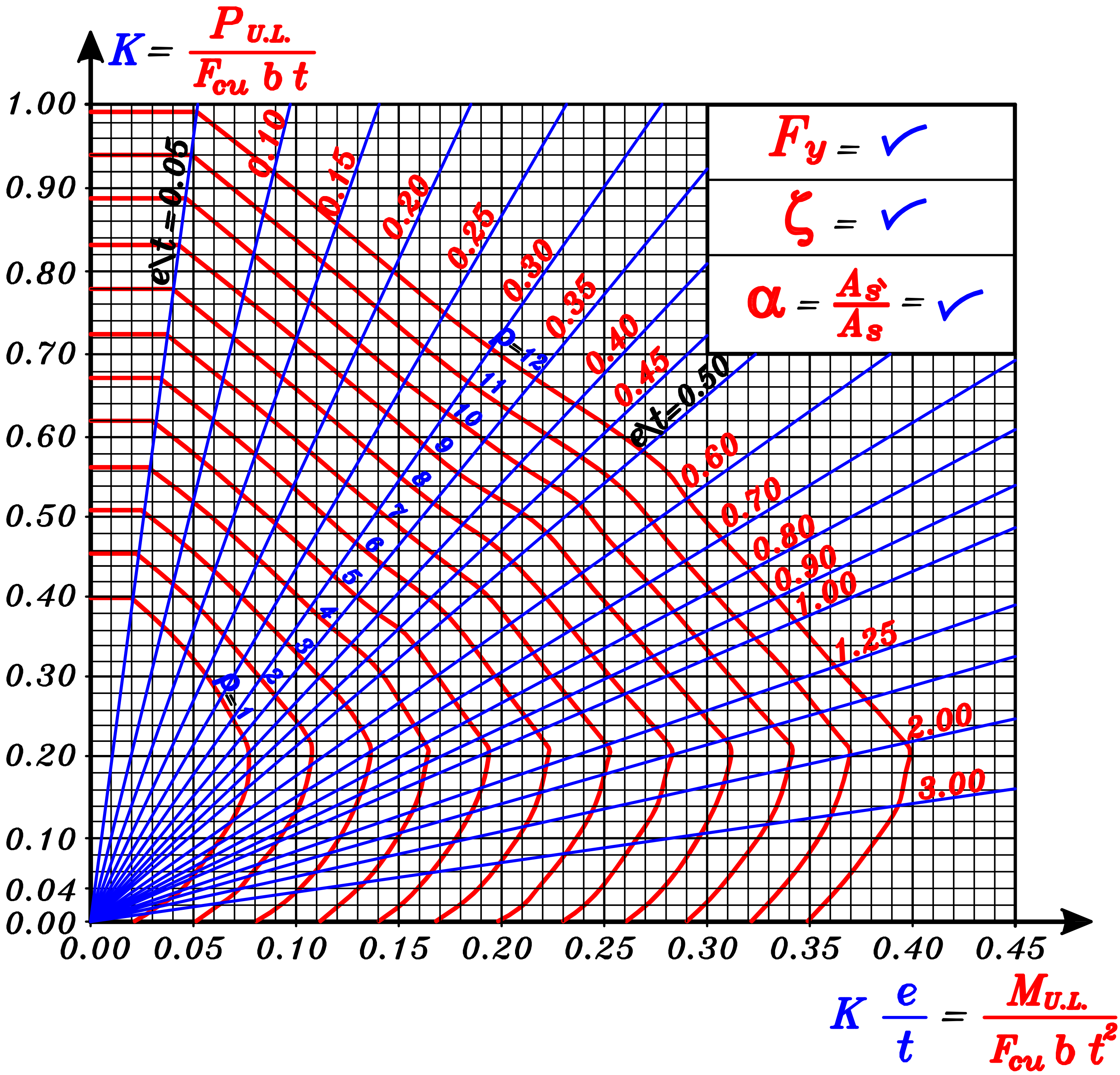
نسبة تحدد قبل بدء ال Design و تؤخذ عاده تساوى ١

– $\zeta = \frac{t - 2\,Cover}{t} = \frac{\text{المسافه بين الحديد}}{\text{التخانه الكليه}}$ و تقرب للرقم الأصغر



Example: $t = 800\ mm$

$\therefore \zeta = \frac{800 - 100}{800} = \frac{700}{800} = 0.875 \xrightarrow{Take} \zeta = 0.8$



$$\mu = \rho * F_{cu} * 10^{-4}$$

$$A_s = \mu * b * t$$

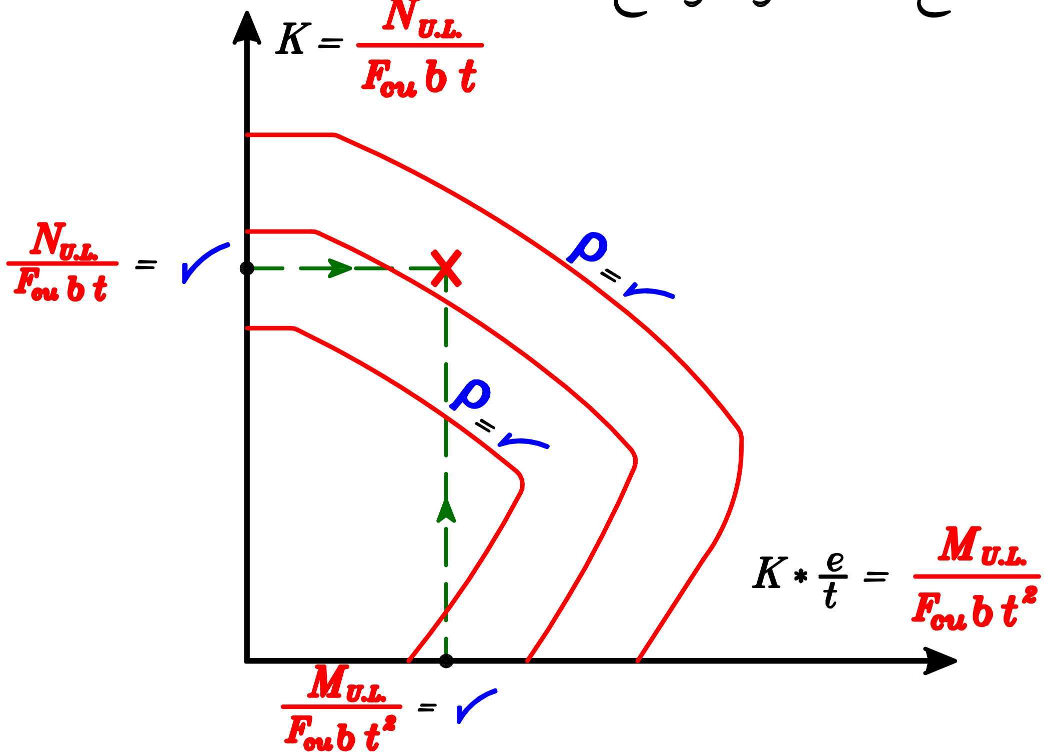
$$A_s` = \alpha * A_s$$

How to determine the design Method by using I.D.??

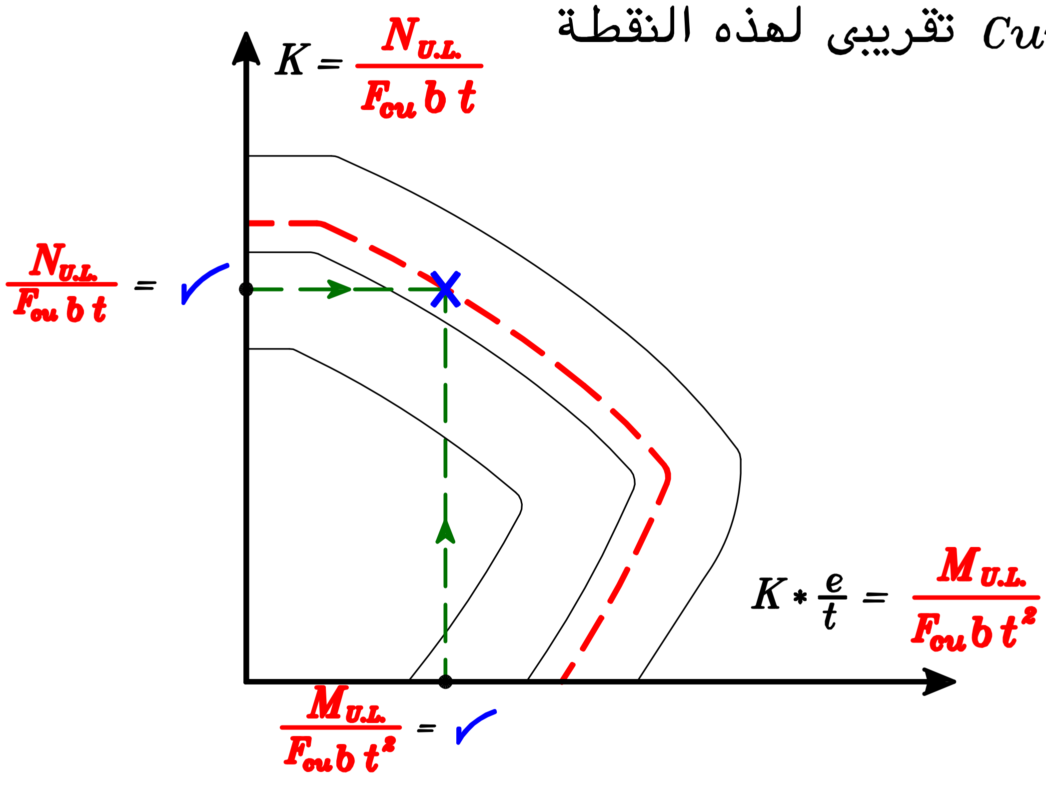
١- بعد تحديد الـ Curve بمعرفة كل من F_y , α , ζ

٢- نحدد قيمة كل من $K*\frac{e}{t}=\frac{M_{U.L.}}{F_{cu}\,b\,t^2}$, $K=\frac{N_{U.L.}}{F_{cu}\,b\,t}$

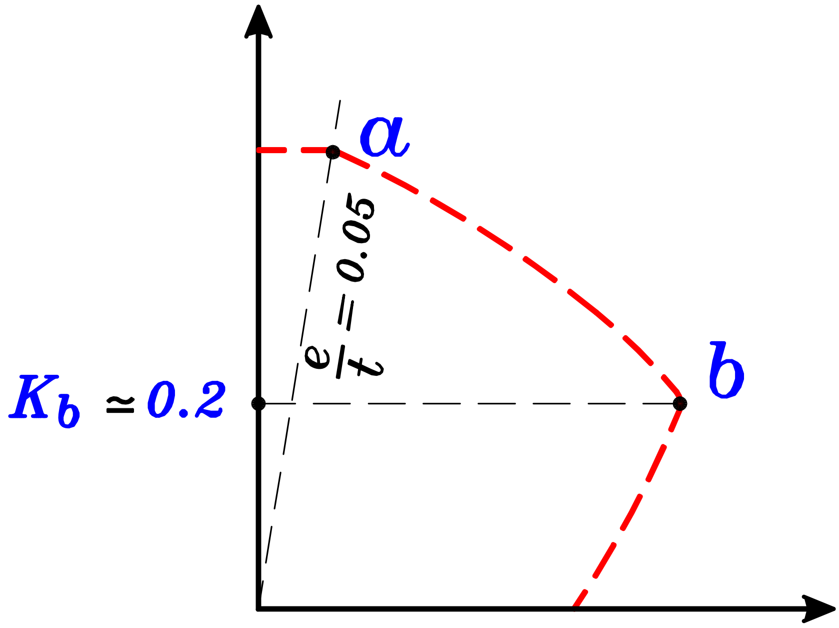
ثم نحدد نقطة التقاطع كما هو موضح



٣- ثم نرسم Curve تقريبى لهذه النقطة



٤- نحدد النقطتين a , b على هذا ال Curve
كما هو موضح بالشكل

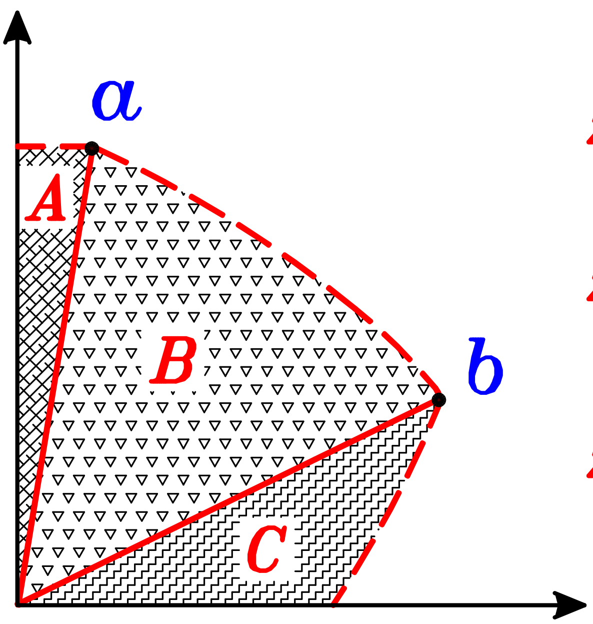


$$K_b = K_{balanced}$$

$$K_b = \frac{N_b}{F_{cu}\, b\, t} \simeq 0.2$$

حيث a هى نقطة min eccentricity
و عند هذه النقطة تكون $\frac{e}{t} = 0.05$
و نقطة b هى نقطة ال Balanced Failure

٥- من النقطتين a , b نوصل خطين الى نقطة ال origin (0,0)
و نقسم المساحة الى Zones
و نحدد طريقة ال Design

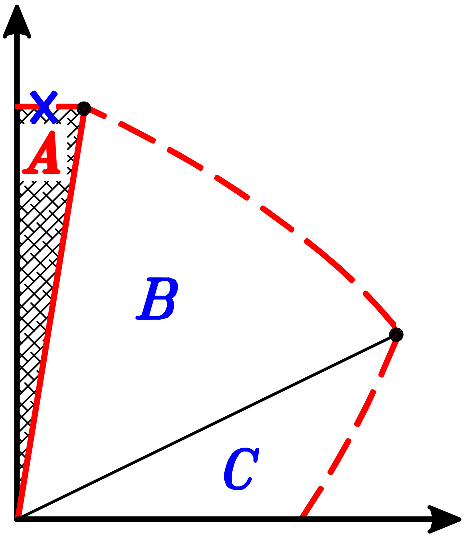


Zone A → Design as Short Column

Zone B → Design as Compression Failure

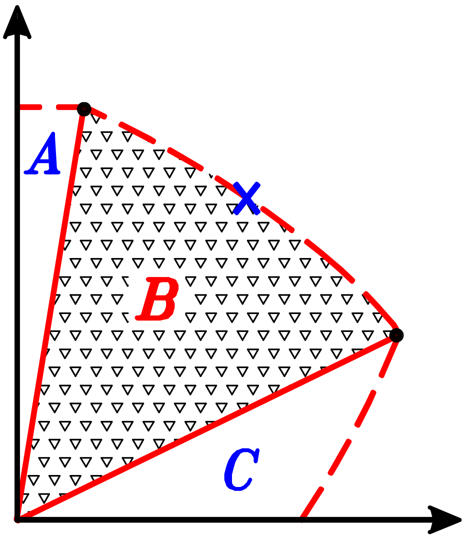
Zone C → Design as Tension Failure

بعد تحديد نقطة تقاطع $K * \frac{e}{t} = \frac{M_{U.L.}}{F_{cu}\, b\, t^2}$, $K = \frac{N_{U.L.}}{F_{cu}\, b\, t}$



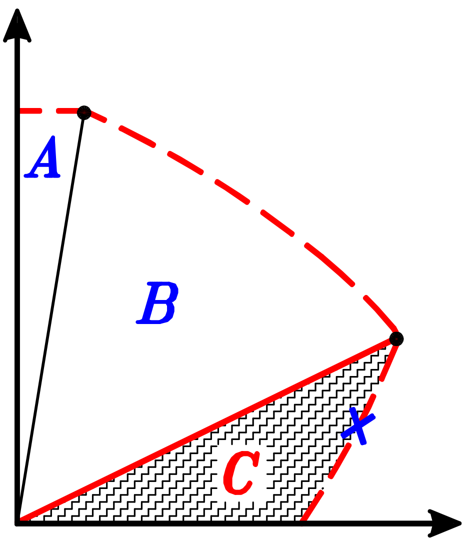
عند وجود نقطة التقاطع عند **Zone A**
نهمل وجود الـ moment و نصمم على
الـ Normal فقط

Design as Short Column using $P_{U.L.}$



عند وجود نقطة التقاطع عند **Zone B**
يكون أغلب القطاع علية Compression

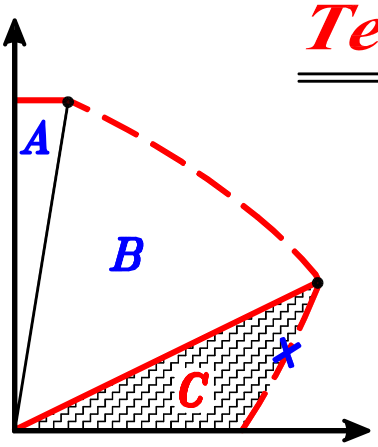
Design as Compression Failure using Interaction Diagram



عند وجود نقطة التقاطع عند **Zone C**
يكون أغلب القطاع علية Tension

Design as Tension Failure using e_s

Tension Failure (as Beams)



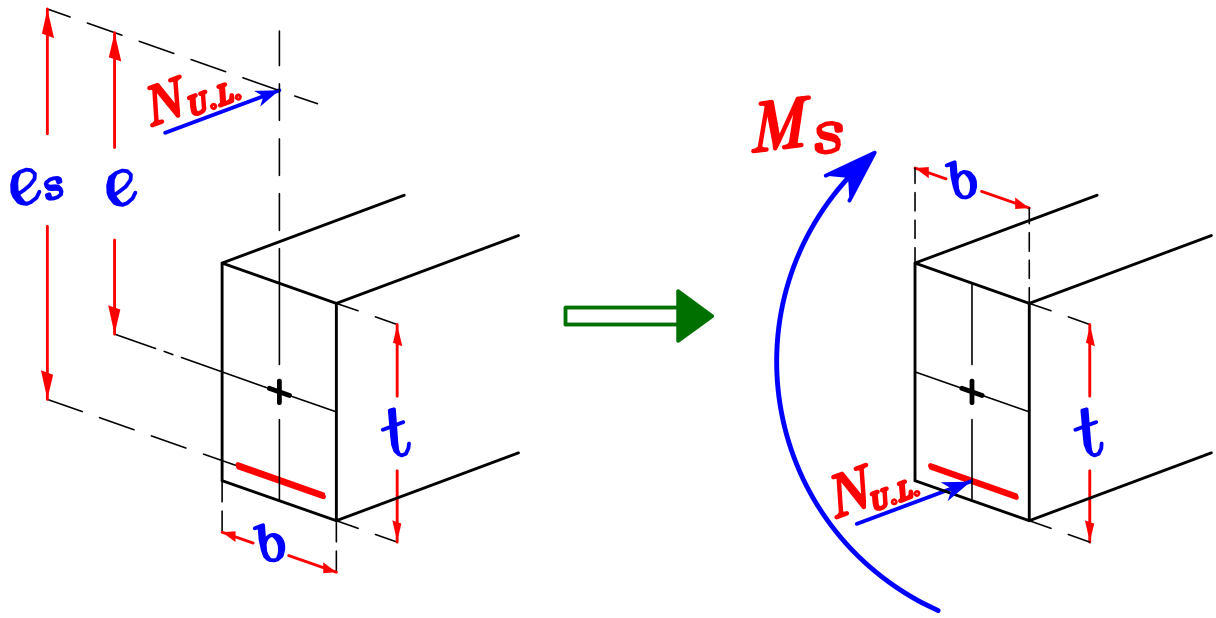
Zone C عند وجود نقطة التقاطع عند

يكون أغلب القطاع علية Tension

Design as Tension Failure

القطاع أقرب لقطاع الكمره منة لقطاع العمود .

أى أن جهة من الخرسانة عليها Compression و جهة عليها Tension.



Get $$e = \frac{M_{U.L.}}{N_{U.L.}}$$

Get $$e_s = e + \frac{t}{2} - c$$

حيث e هى بعد المحصله عن ال **C.G.**

حيث e_s هى بعد المحصله عن ال **steel**

Where: C is the Cover
- $= 50\ mm$ IF $t \leqslant 1000\ mm$
- $= 100\ mm$ IF $t > 1000\ mm$

- Get the moment about Tension steel

$$M_s = N_{U.L.} * e_s$$

- From $d = C_1 \sqrt{\frac{M_s}{F_{cu}\, b}}$ Get $C_1 = \checkmark \xrightarrow{get} J = \checkmark$

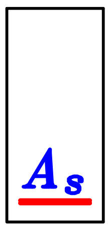
- Get A_s From

$$A_s = \frac{M_s}{J\, F_y\, d} - \frac{N_{U.L.}}{(F_y/\gamma_s)}$$

- **Check $A_{s_{min.}}$**

Compare with tension steel only

$A_{s_{min.}} =$ الأكبر من:
- الأقل من: $\frac{1.1}{F_y}\, b\, d$ و $1.3\, A_{s\, req.}$
- st. 360/520: $\frac{0.15}{100}\, b\, d$
- st. 240/350: $\frac{0.25}{100}\, b\, d$



Stirrup Hangers.

Stirrup Hangers = الأكبر من:
- $(0.1 \rightarrow 0.2)\, A_s$
- $2 \phi 12$ Frames

ملحوظه :

سواء كان الـ member أفقى أو رأسى يعامل معامله الكمره
ولكن **يفضل** أن لا يقل الـ stirrup hangers فى الـ members
الرأسيه عن $0.4\, A_s$ و هذا ليس شرط.

Shrinkage Bars. (IF the sec. in Beam.)

- توضع ال Shrinkage Bars عندما تكون $t > 700$ mm
- و قيمة ال Shrinkage Bars = $2\phi10$ at every 300 mm

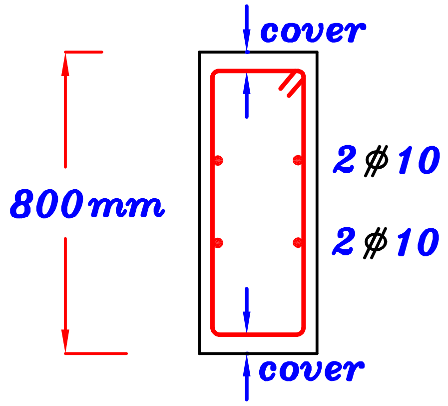
Example.

IF $t = 800$ mm

$\therefore$ No. of Spacings =

$$= \frac{800-100}{300} = 2.33 = 3.0 \text{ Spacing}$$

$$= 2.0 \text{ Bars}$$



Buckling Bars. (Longitudinal Bars)

(IF the sec. in Column.)

- فى الأعمده التى يؤثر عليها M & N.
يجب وضع أسياخ جانبيه تسمى Buckling Bars.
- و توضع أيضاً عندما تكون $t < 700$ mm (ليس مثل ال Shrinkage Bars)
- و قيمة ال Buckling Bars = $2\phi12$ at every 250 mm
- و توضع كانات داخليه
بحيث لا تزيد المسافه بين كل فرع كانه و الفرع الذى يليه عن ٣٠٠ مم

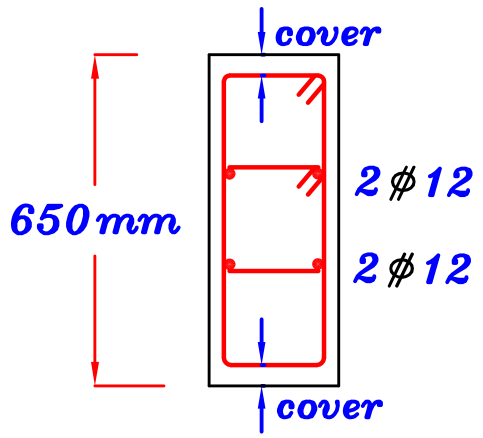
Example.

IF $t = 650$ mm

$\therefore$ No. of Spacings =

$$= \frac{650-100}{250} = 2.20 = 3.0 \text{ Spacing}$$

$$= 2.0 \text{ Bars}$$



هام جدا جدا

ممكن للتقريب لمعرفه اذا كان القطاع سوف يصمم على انه

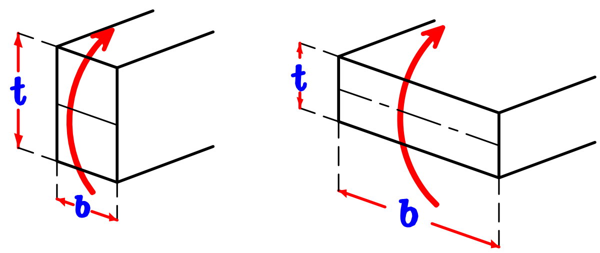
Compression Failure or Tension Failure

حساب الاتى

- Get $e = \dfrac{M_{U.L.}}{N_{U.L.}}$

- Get $\dfrac{e}{t}$

t هو العرض الموازى لل moment



- IF $\dfrac{e}{t}$

$\dfrac{e}{t} \geqslant 0.5$

Big Eccentricity

Tension Failure

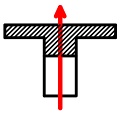
$\dfrac{e}{t} < 0.5$

Small Eccentricity

Compression Failure

Example.

$F_{cu} = 25 \ N\backslash mm^2$ st. $360/520$

$M_{U.L.} = 300 \ kN.m$  , $N_{U.L.} = 400 \ kN$, $b = 300 \ mm$

Req. Design the Sec. (Beam.)

Solution.

$$- \ d_1 = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\, b}} = 3.5 \sqrt{\frac{300 * 10^6}{25 * 300}} = 700 \ mm \ \text{(as R-Sec.)}$$

$$\therefore \ t_1 = 700 + 50 = 750 \ mm$$

$$- \ P_{U.L.} = \left(0.35 \ b \ F_{cu} + 0.67 \frac{b}{100} F_y\right) t_2$$

$$\therefore 400 * 10^3 = \left(0.35 * 300 * 25 + 0.67 * \frac{300}{100} * 360\right) t_2 \rightarrow t_2 = 119 \ mm$$

$$\therefore \ t_o = 750 \ mm \longrightarrow t = (1.1 \rightarrow 1.3) \ t_o$$

$$= (825 \rightarrow 975) \ mm \qquad \boxed{t = 850 \ mm}$$

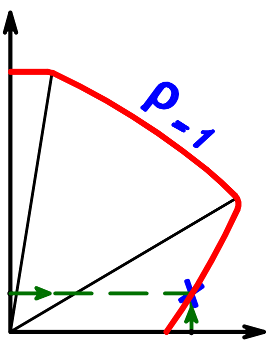
Check $\frac{N}{F_{cu}\, b\, t} = \frac{400 * 10^3}{25 * 300 * 850} = 0.063 > 0.04$ (Don't neglect N)

$\therefore$ Design the Sec. on both N.F. , B.M.

$\therefore$ Use Interaction Diagram

$\zeta = \frac{850 - 100}{850} = 0.88 = 0.80 \xrightarrow{use}$ ECCS Design Aids Page 4—24

$$\left.\begin{aligned} \frac{N_U}{F_{cu}\, b\, t} &= \frac{400 * 10^3}{25 * 300 * 850} = 0.063 \\ \frac{M_U}{F_{cu}\, b\, t^2} &= \frac{300 * 10^6}{25 * 300 * 850^2} = 0.055 \end{aligned}\right\} \rho = 1.0$$



Tension Zone $\therefore$ Use e_s

$e = \frac{M}{N} = \frac{300}{400} = 0.75\ m$ طريقه تقريبيه لتحديد نوع القطاع

$\frac{e}{t} = \frac{0.75}{0.85} = 0.88 > 0.50 \rightarrow$ **Tension Failure** $\xrightarrow{use} e_s$

$$e = \frac{M}{N} = \frac{300}{400} = 0.75\ m$$

$$e_s = e + \frac{t}{2} - c = 0.75 + \frac{0.85}{2} - 0.05 = 1.125\ m$$

$$M_s = N * e_s = 400 * 1.125 = 450\ kN.m$$

$$\therefore d = C_1\sqrt{\frac{M_s}{F_{cu}\, b}} \quad \therefore 800 = C_1\sqrt{\frac{450*10^6}{25*300}} \rightarrow C_1 = 3.265 \rightarrow J = 0.766$$

$$\therefore A_s = \frac{M_s}{J\, F_y\, d} - \frac{N_{U.L.}}{(F_y \backslash \delta_s)}$$

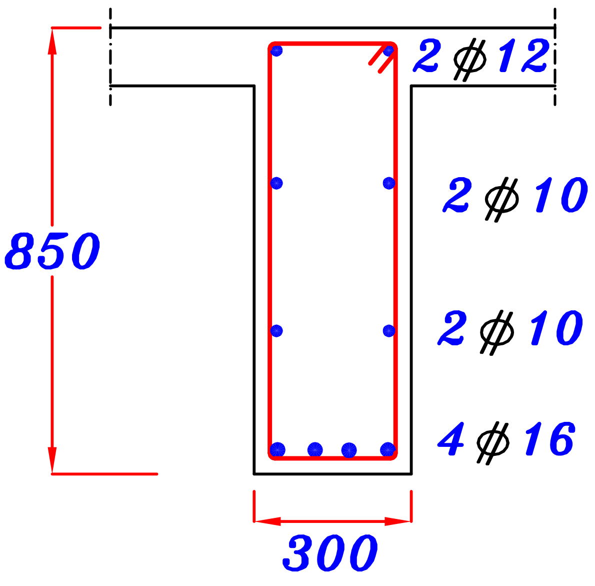
$$= \frac{450*10^6}{0.766*360*800} - \frac{400*10^3}{(360 \backslash 1.15)} = 762\ mm^2 \quad 4\phi 16$$

$$-\text{Check } A_{s_{min.}} = \frac{1.1}{F_y} b\, d = \frac{1.1}{360}(300)(800) = 733\ mm^2$$

$$\therefore A_s > A_{s_{min.}} \quad \therefore o.k.$$

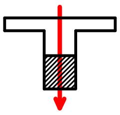
$$\therefore n = \frac{b-25}{\phi+25} = \frac{300-25}{16+25} = 6.70 = 6.0$$

Stirrup Hangers $= (0.1 \rightarrow 0.2)\, A_s = (0.1 \rightarrow 0.2)\ 762$ $2\phi 12$



Example.

$F_{cu} = 30 \ N\backslash mm^2$ st. 360/520

$M_{U.L.} = 500$ kN.m  , $N_{U.L.} = 200$ kN , $b = 300$ mm

Req. Design the Sec. (**Beam.**)

Solution.

$$\therefore d_1 = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\, b}} = 3.5 \sqrt{\frac{500 * 10^6}{30 * 300}} = 824.9 \ mm$$

$$= 850 \ mm$$

$$\therefore t_1 = 850 + 50 = 900 \ mm$$

$$- P_{U.L.} = \left(0.35\, b\, F_{cu} + 0.67 \frac{b}{100} F_y\right) t_2$$

$$\therefore 200 * 10^3 = \left(0.35 * 300 * 30 + 0.67 * \frac{300}{100} * 360\right) t_2 \rightarrow t_2 = 51.6 \ mm$$

$$\therefore t_o = 900 \ mm \rightarrow t = (1.1 \rightarrow 1.3)\, t_o = (990 \rightarrow 1170) \ mm \qquad \boxed{t = 1000 \ mm}$$

Check $\frac{N}{F_{cu}\, b\, t} = \frac{200 * 10^3}{30 * 300 * 1000} = 0.022 < 0.04 \quad \therefore$ (**neglect N**)

$$\therefore \text{Take } d = d_1 = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\, b}} \qquad \text{take } C_1 = 3.5 , J = 0.78$$

$$\therefore d = 824.9 \ mm \qquad \therefore \text{Take } \boxed{d = 850 \ mm} , \boxed{t = 900 \ mm}$$

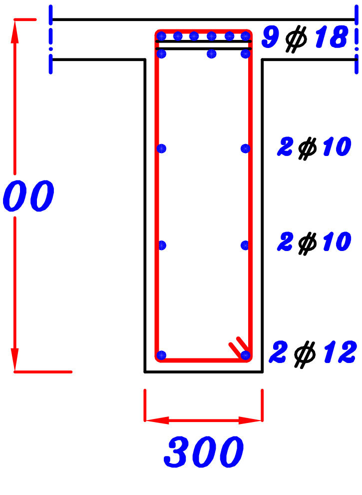
$$\therefore A_s = \frac{M_{U.L.}}{J\, F_y\, d} = \frac{500 * 10^6}{0.78 * 360 * 824.9} = 2160 \ mm^2 \qquad 9 \phi 18$$

$$- \text{Check } A_{s\,min.} = \frac{1.1}{F_y}\, b\, d = \frac{1.1}{360} (300)(850) = 779 \ mm^2$$

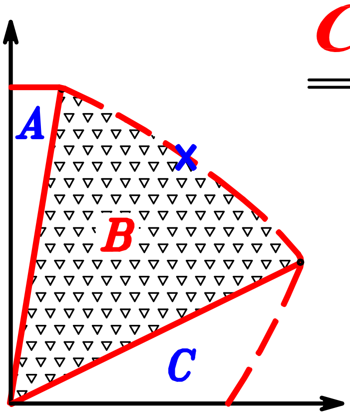
$$\therefore n = \frac{b - 25}{\phi + 25} = \frac{300 - 25}{18 + 25} = 6.39 = 6.0$$

Stirrup Hangers $= (0.1 \rightarrow 0.2)\, A_s$

$$= (0.1 \rightarrow 0.2)\ 2160 \qquad 2 \phi 12$$



Compression Failure



عند وجود نقطه التقاطع عند **Zone B**

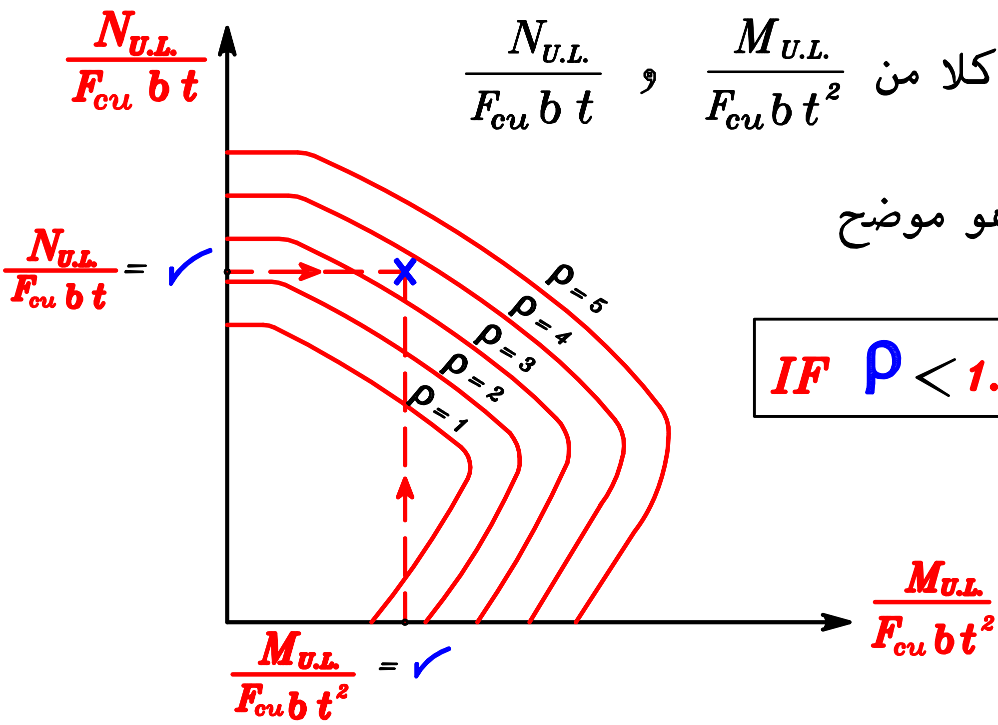
يكون أغلب القطاع عليه **Compression**

Design as Compression Failure

How to Design by using I.D. ??

بعد تحديد نقطه تقاطع كلا من $\frac{M_{U.L.}}{F_{cu}\, b\, t^2}$ و $\frac{N_{U.L.}}{F_{cu}\, b\, t}$

نحدد قيمة ρ كما هو موضح



IF $\rho < 1.0 \xrightarrow{Take} \rho = 1.0$

ثم نعوض فى المعادلات الأتيه لتحديد قيمة A_s $A_s`$

$$\mu = \rho * F_{cu} * 10^{-4}$$

$$A_s = \mu * b * t$$

$$A_s` = \alpha * A_s$$

ملحوظه :

ممكن التصميم بال I.D. فى الحالتين **Comp. & Ten. Failure**

و لكن القيم تكون غير دقيقه عندما تكون **Ten. Failure**

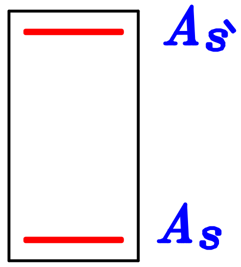
– Check $As_{min.}$

Calculate $As_{Total} = As + As\grave{}$

Calculate $As_{min.} = \frac{0.6}{100} * b * t$

IF $As_{Total} \geqslant As_{min.}$ $\therefore$ o.k.

IF $As_{Total} < As_{min.}$ $\xrightarrow{take}$ $As = As\grave{} = \frac{As_{min.}}{2}$



Shrinkage Bars. (IF the sec. in Beam.)

– توضع الـ Shrinkage Bars عندما تكون $t > 700$ mm

– و قيمة الـ Shrinkage Bars = $2 \phi 10$ at every 300 mm

Buckling Bars. (Longitudinal Bars)

(IF the sec. in Column.)

– فى الأعمده التى يؤثر عليها M & N .
يجب وضع أسياخ جانبيه تسمى Buckling Bars .

– و توضع أيضاً عندما تكون $t < 700$ mm (ليس مثل الـ Shrinkage Bars)

– و قيمة الـ Buckling Bars = $2 \phi 12$ at every 250 mm

– و توضع كانات داخليه
بحيث لا تزيد المسافه بين كل فرع كانه و الفرع الذى يليه عن ٣٠٠ مم

Example.

$F_{cu} = 25 \; N\backslash mm^2$ st. 360/520

$M_{U.L.} = 300 \; kN.m$, $N_{U.L.} = 3000 \; kN$, $b = 300 \; mm$

Req. Design the Sec. (Column)

Solution.

$$- \; d_1 = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\, b}} = 3.5 \sqrt{\frac{300 * 10^6}{25 * 300}} = 700 \; mm$$

$$\therefore \; t_1 = 700 + 50 = 750 \; mm$$

$$- \; P_{U.L.} = \left(0.35 \, b \, F_{cu} + 0.67 \frac{b}{100} F_y\right) t_2$$

$$\therefore \; 3000 * 10^3 = \left(0.35 * 300 * 25 + 0.67 * \frac{300}{100} * 360\right) t_2 \rightarrow t_2 = 896 \; mm$$

$$\therefore \; t_o = 900 \; mm \longrightarrow t = (1.1 \rightarrow 1.3) \, t_o$$

$$= (990 \rightarrow 1170) \; mm \qquad \boxed{t = 1000 mm}$$

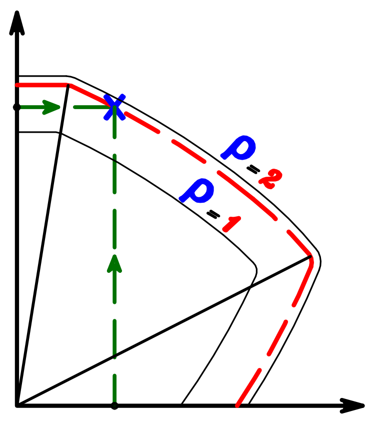
Check $\frac{N}{F_{cu}\, b\, t} = \frac{3000 * 10^3}{25 * 300 * 1000} = 0.40 > 0.04$ (**Don't neglect N**)

$\therefore$ **Design the Sec. on both N.F. , B.M.**

$\therefore$ **Use Interaction Diagram**

$\zeta = \frac{1000 - 100}{1000} = 0.90 \xrightarrow{use}$ ECCS Design Aids Page 4−23

$$\left.\begin{aligned} \frac{N_U}{F_{cu}\, b\, t} &= \frac{3000 * 10^3}{25 * 300 * 1000} = 0.40 \\ \frac{M_U}{F_{cu}\, b\, t^2} &= \frac{300 * 10^6}{25 * 300 * 1000^2} = 0.04 \end{aligned}\right\} \; \rho = 1.90$$



Compression Zone

$\therefore$ **Use Interaction Diagram**

$e = \frac{M}{N} = \frac{300}{3000} = 0.10\ m$ طريقه تقريبيه لتحديد نوع القطاع

$\frac{e}{t} = \frac{0.10}{1.0} = 0.10 < 0.50 \rightarrow$ Compresion Failure $\xrightarrow{use}$ I.D.

$\mu = \rho * F_{cu} * 10^{-4} = 1.9 * 25 * 10^{-4} = 4.75 * 10^{-3}$

$As = As` = \mu * b * t = 4.75 * 10^{-3} * 300 * 1000$

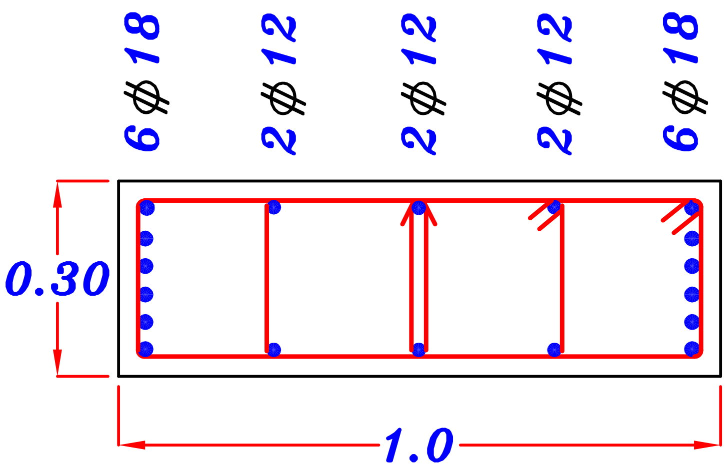
$= 1425\ mm^2$ ($6 \phi 18$)

$As_{Total} = As + As` = 2 * 1425 = 2850\ mm^2$

– Check $As_{min.} = \frac{0.6}{100} * b * t = \frac{0.6}{100} * 300 * 1000 = 1800$

$\therefore As_{Total} > As_{min.}$ $\therefore$ o.k.

– $n = \frac{b - 25}{\phi + 25} = \frac{300 - 25}{19 + 25} = 6.25 = 6.0$



Example.

$F_{cu} = 25 \; N \backslash mm^2$ st. 360/520

$M_{U.L.} = 200 \; kN.m$, $N_{U.L.} = 1200 \; kN$, $b = 300 mm$, $d = 750 mm$

Req. Design the Sec. (Column)

Solution.

Check $\frac{N}{F_{cu}\, b\, t} = \frac{1200 * 10^3}{25 * 300 * 800} = 0.20 > 0.04$ (Don't neglect N)

∴ Design the Sec. on both N.F. , B.M.

$e = \frac{M}{N} = \frac{200}{1200} = 0.167 \; m$ طريقه تقريبيه لتحديد نوع القطاع

$\frac{e}{t} = \frac{0.167}{0.80} = 0.21 < 0.50 \longrightarrow$ Compression Failure $\xrightarrow{use}$ I.D.

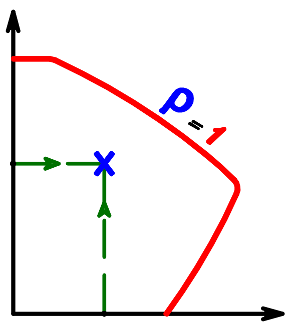
∴ Use Interaction Diagram

$\zeta = \frac{800 - 100}{800} = 0.875 \xrightarrow{Take} \zeta = 0.8 \xrightarrow{use}$ ECCS Design Aids Page 4–24

$\frac{N_U}{F_{cu}\, b\, t} = \frac{1200 * 10^3}{25*300*800} = 0.20$

$\frac{M_U}{F_{cu}\, b\, t^2} = \frac{200 * 10^6}{25*300*800^2} = 0.0416$

} $\rho < 1.0$



∵ $\rho < 1.0$ ∴ Take $\rho = 1.0$

$\mu = \rho * F_{cu} * 10^{-4} = 1.0 * 25 * 10^{-4} = 2.5 * 10^{-3}$

$A_s = A_s' = \mu * b * t = 2.5 * 10^{-3} * 300 * 800 = 600 \; mm^2$

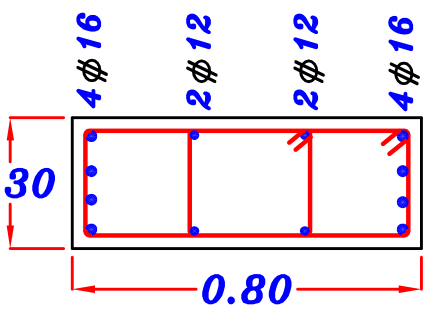
$A_{s\,Total} = A_s + A_s' = 2 * 600 = 1200 \; mm^2$

– Check $A_{s\,min.} = \frac{0.6}{100} * b * t = \frac{0.6}{100} * 300 * 800 = 1440 \; mm^2$

∴ $A_{s\,Total} < A_{s\,min.}$

∴ take $A_s = A_s' = \frac{A_{s\,min.}}{2} = \frac{1440}{2} = 720 \; mm^2$

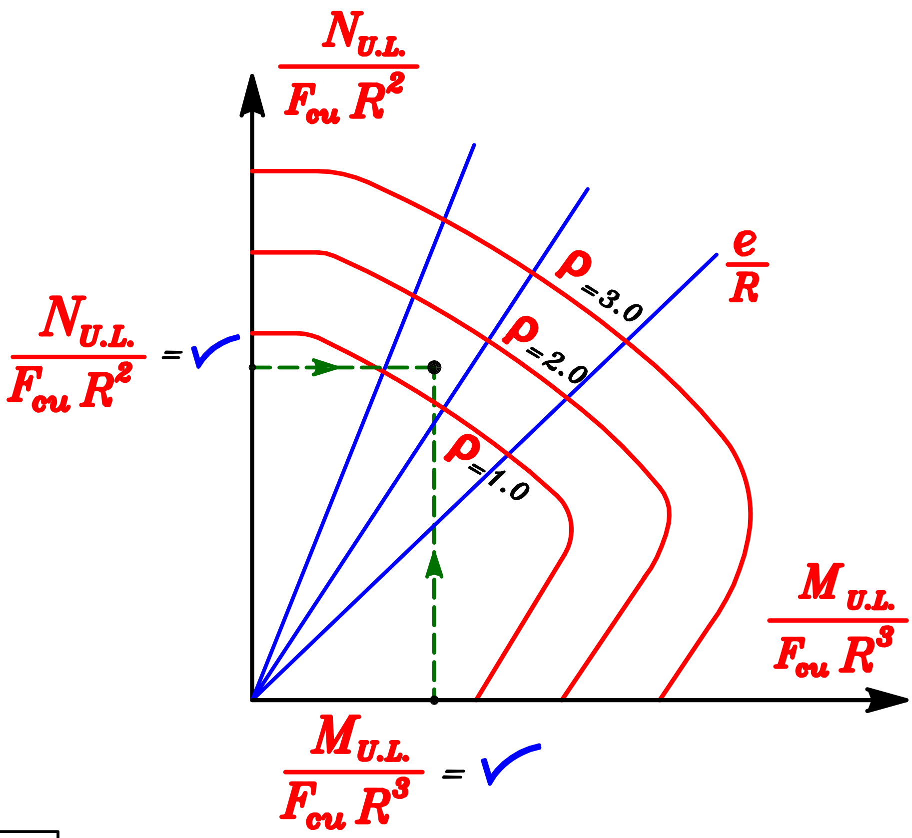
(4ϕ16)



– $n = \frac{b - 25}{\phi + 25} = \frac{300 - 25}{16 + 25} = 6.70 = 6.0$

Design of Circular Sections subjected to (M,N).

Use I.D. | ECCS Page (4–52) ⟶ (4–63) |



$$\zeta = \frac{R - 30\ mm}{R}$$

بعد تحديد الـ $Curve$ بمعرفه كل من F_y , ζ

نحدد قيمه كل من $\frac{N_{U.L.}}{F_{cu} R^2}$ و $\frac{M_{U.L.}}{F_{cu} R^3}$

حيث الـ R هو نصف قطر العمود ثم نحدد قيمه ρ كما هو موضح

$$IF \quad \rho < 1.0 \xrightarrow{Take} \rho = 1.0$$

ثم نعوض فى المعادلات الأتيه لتحديد قيمه As_{Total}

$$\mu = \rho * F_{cu} * 10^{-4}$$

$$As_{Total} = \mu * \pi * R^2$$

Design of Sec. Subjected to (Bi-Axial Moment).

Double moments & Compression Force. (M_x, M_Y, N)

Design using (Biaxial Bending Interaction Diagram)
(Symmetrical arrangement of reinforcement)

Use ECCS Page (5-9) ⟶ (5-24)

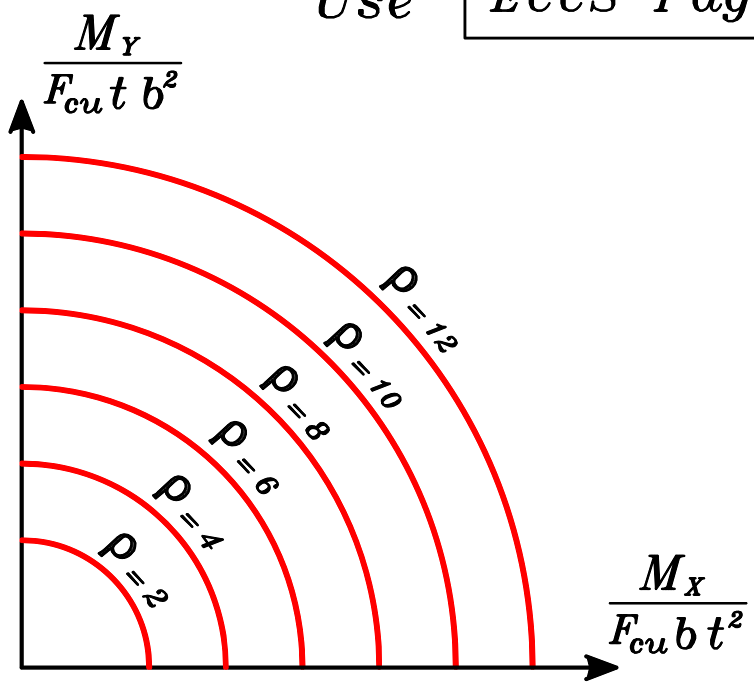
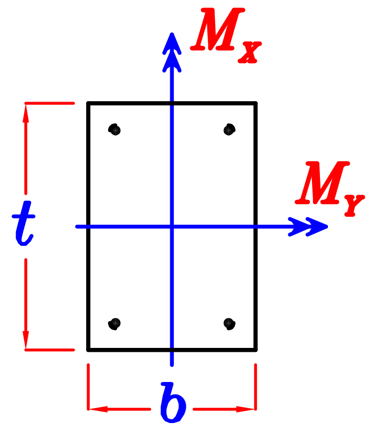


Chart Key
$F_y = \checkmark$
$R_b = \frac{P}{F_{cu}\,b\,t}$
$\zeta = \checkmark$

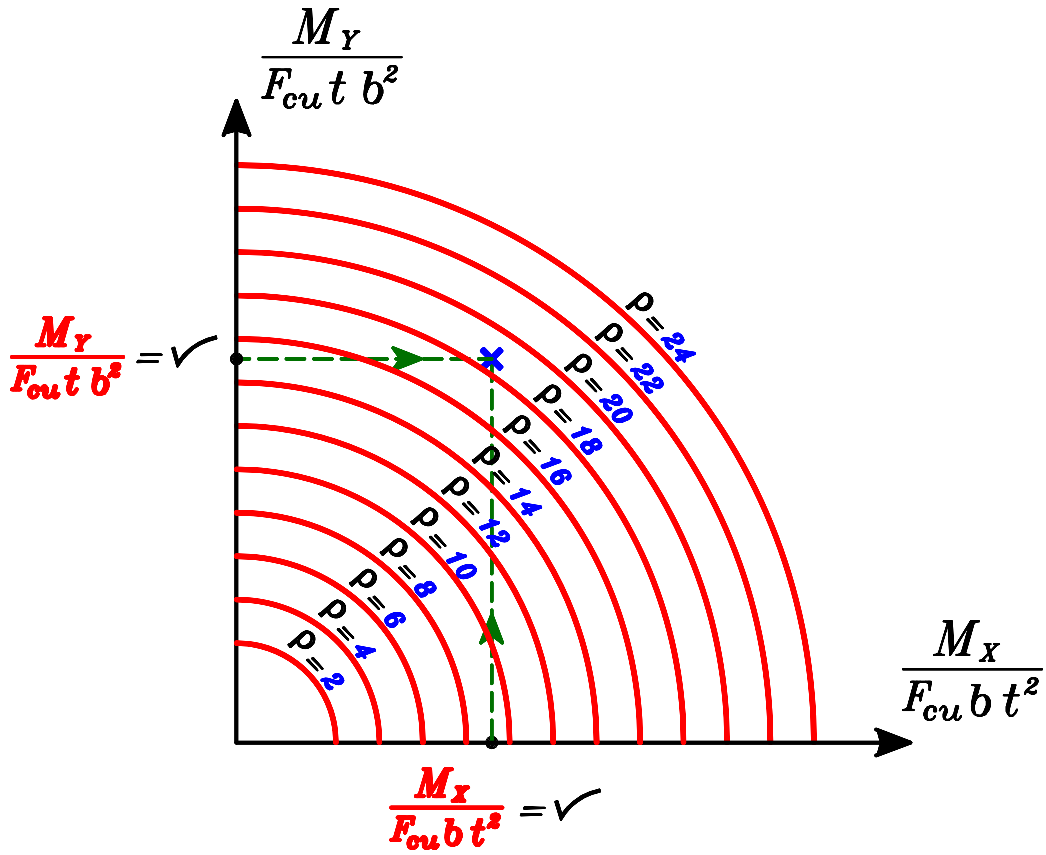
Calculate $R_b = \frac{P}{F_{cu}\,b\,t}$

$\zeta = \frac{t - 2\,Cover}{t} = \frac{\text{المسافة بين الحديد}}{\text{التخانة الكلية}}$ و تقرب للرقم الأصغر

بعد تحديد الـ $Curve$ بمعرفه كل من F_y, ζ, R_b



نحدد قيمه كل من $\frac{M_Y}{F_{cu}\,t\,b^2}$, $\frac{M_X}{F_{cu}\,b\,t^2}$



ثم نحدد قيمة ρ كما هو موضح

ثم نعوض فى المعادلات الأتيه لتحديد قيمه $A_{S\,total}$

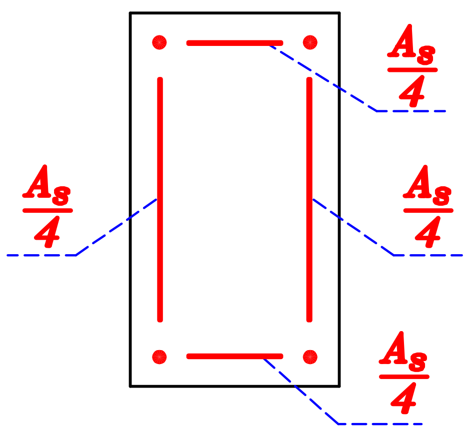
$$\mu = \rho * F_{cu} * 10^{-4}$$

$$A_{S\,total} = \mu * b * t$$

و يجب أن يكون عدد الاسياخ يقبل القسمه على ٤

نضع أربع أسياخ فى الاركان

ثم يقسم باقى الحديد بالتساوى على الاربع جهات



Example.

Data:

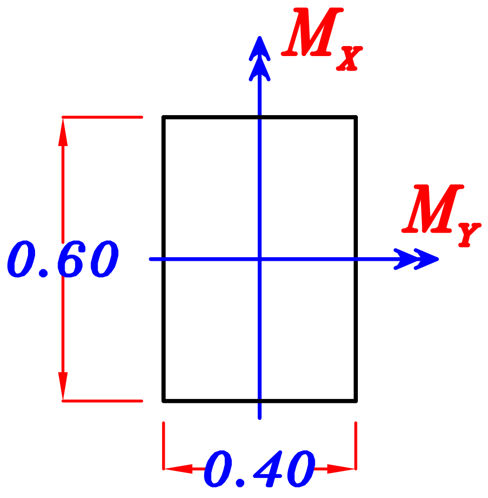
$F_{cu} = 25 \ N\backslash mm^2$

$F_y = 360 \ N\backslash mm^2$

$P_{U.L.} = 2200 \ kN$

$M_{X (U.L.)} = 400 \ kN.m$

$M_{Y (U.L.)} = 200 \ kN.m$



Req:

Design the Section.

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assume $\zeta = 0.90$

$$R_b = \frac{P}{F_{cu}\, b\, t} = \frac{2200 * 10^3}{25 * 400 * 600} = 0.366 \longrightarrow \text{Not in ECCS}$$

∴ Since the biaxial interaction diagrams don't have value of $R_b = 0.366$

Interpolation will be performed between $R_b = 0.30$, $R_b = 0.40$

For $R_b = 0.30 \longrightarrow$ **ECCS Page (5–13)**

$$\frac{M_X}{F_{cu}\, b\, t^2} = \frac{400 * 10^6}{25 * 400 * 600^2} = 0.111$$

$$\frac{M_Y}{F_{cu}\, t\, b^2} = \frac{200 * 10^6}{25 * 600 * 400^2} = 0.083$$

$\Big\} \quad \rho = 11.8$

For $R_b = 0.40 \longrightarrow$ **ECCS Page (5–14)**

$$\frac{M_X}{F_{cu}\, b\, t^2} = \frac{400 * 10^6}{25 * 400 * 600^2} = 0.111$$

$$\frac{M_Y}{F_{cu}\, t\, b^2} = \frac{200 * 10^6}{25 * 600 * 400^2} = 0.083$$

$\Big\} \quad \rho = 15$

To get value of ρ For $R_b = 0.366$

$R_b = 0.30 \longrightarrow \rho = 11.8$

$R_b = 0.40 \longrightarrow \rho = 15$

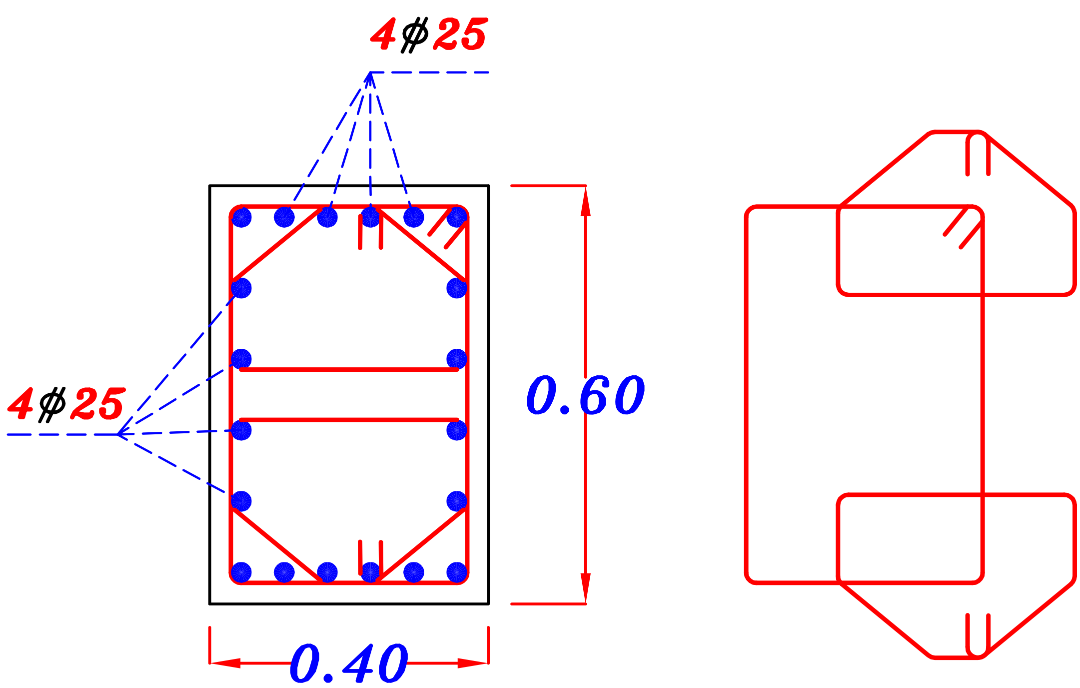
$$R_b = 0.366 \longrightarrow \rho = \left(\frac{0.366 - 0.30}{0.40 - 0.30}\right)(15 - 11.8) + 11.8 = 13.9$$

$$\mu = \rho * F_{cu} * 10^{-4} = 13.9 * 25 * 10^{-4} = 0.0347$$

$$A_{s_{total}} = \mu * b * t = 0.0347 * 400 * 600 = 8328 \ mm^2$$

20 ∅25

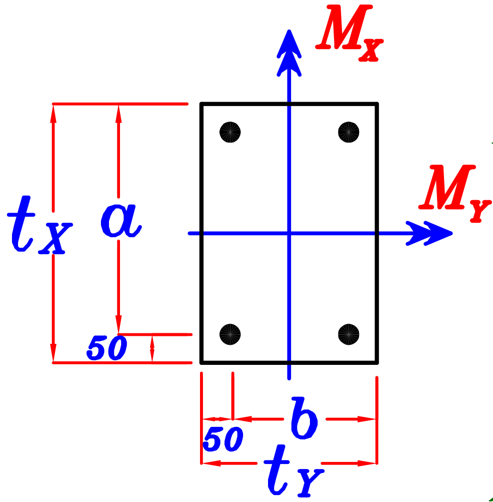
$$- \text{ Check } A_{s_{min.}} = \frac{0.6}{100} * b * t = \frac{0.6}{100} * 400 * 600 = 1440 \ mm^2$$



Design using (Uniaxial Bending Interaction Diagram)

(Symmetrical arrangement of reinforcement)

$\because d = t - 50$ mm $\therefore$ $a = t_X - 50$ mm, $b = t_Y - 50$ mm



Get $\dfrac{M_X}{a}$, $\dfrac{M_Y}{b}$

① IF $\dfrac{M_X}{a} > \dfrac{M_Y}{b}$

Neglect M_Y and design the Sec. on $N, M_X`$

Where: $$M_{X`} = M_X + \beta \, \frac{a}{b} \, M_Y$$

β = Factor ⟶ Use Code Page (6–57)

$R_b = N_U/(F_{cu}\, b\, t)$	$\leqslant 0.2$	0.3	0.4	0.5	$\geqslant 0.6$
β	0.80	0.75	0.70	0.65	0.60

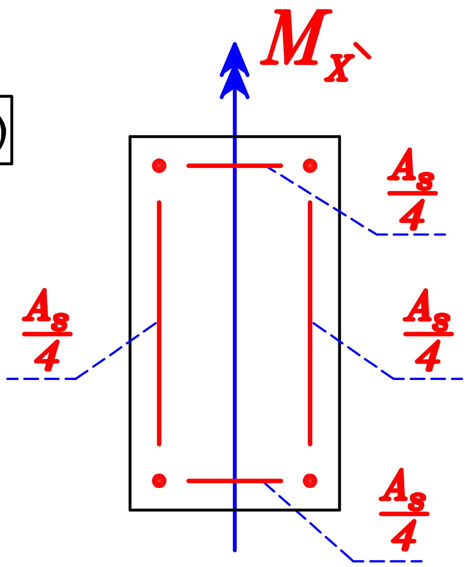
then design the sec. on $N, M_{X`}$

* Use I.D. ECCS Page (4–20) ⟶ (4–51)

Then get $A_s = A_{s`}$ , $A_{st} = A_s + A_{s`}$

نضع أربع أسياخ فى الاركان

ثم يقسم باقى الحديد بالتساوى على الاربع جهات



نضع أربع أسياخ فى الاركان

ثم يقسم باقى الحديد بالتساوى على الاربع جهات

② IF $\frac{M_Y}{b} > \frac{M_X}{a}$

Neglect M_X *and design the Sec. on* $M_{Y`}$

Where:

$$M_{Y`} = M_Y + \beta \frac{b}{a} M_X$$

then design the sec. on $N, M_{Y`}$

* *Use I.D.* ECCS Page (4–20) ⟶ (4–51)

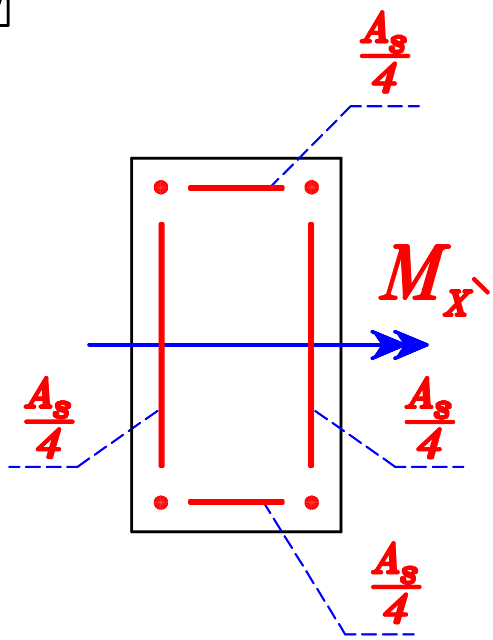
Then get $A_s = A_{s`}$ , $A_{st} = A_s + A_{s`}$

نضع أربع أسياخ فى الاركان

ثم يقسم باقى الحديد بالتساوى على الاربع جهات

نضع أربع أسياخ فى الاركان

ثم يقسم باقى الحديد بالتساوى على الاربع جهات



3–(Unsymmetrical arrangement of reinforcement)

Use Code Page (6–59)