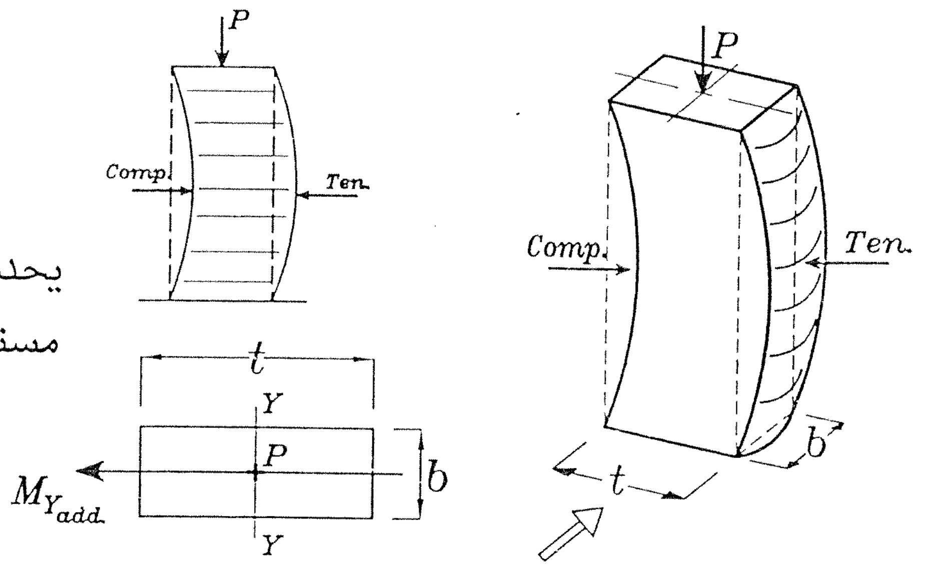
Long Columns.

For Braced Column.	IF $10 < \lambda_b < 23$	The column will be Long Column
For Unbraced Column.	IF $15 < \lambda_b < 30$	

Buckling الإنبعاج

إذا تعرض عمود إلى *Axial Force* فربما يحدث لة إنبعاج (*Buckling*)
و هذا الإنبعاج ينتج عنة إجهادات ضغط و شد مثل العزوم بالضبط.
فنعتبر أن العمود يؤثر علية عزم إضافى *additional moment* $(M_{add.})$

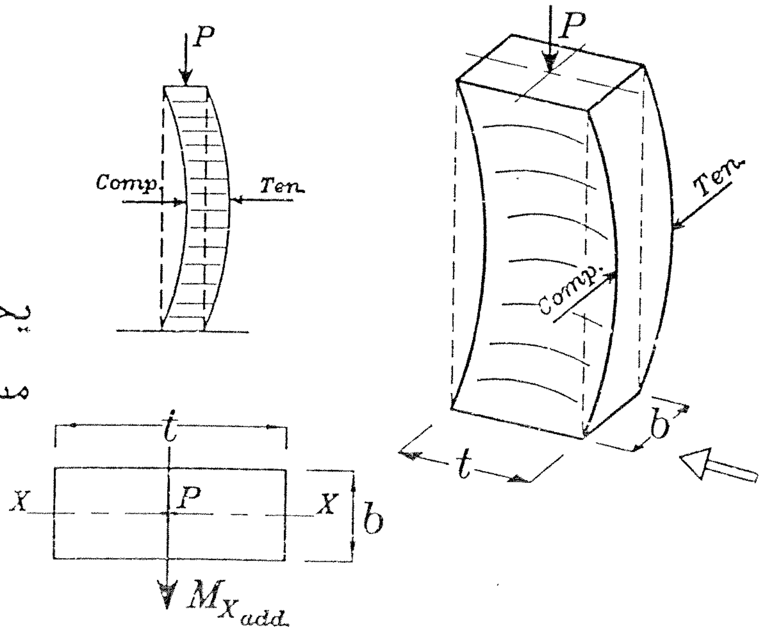
Buckling In side Plan.



يحدث الإنبعاج فى نفس مستوى الورقة فيمكن رؤيتة.

نسألكم الدعاء

Buckling Out side plan.

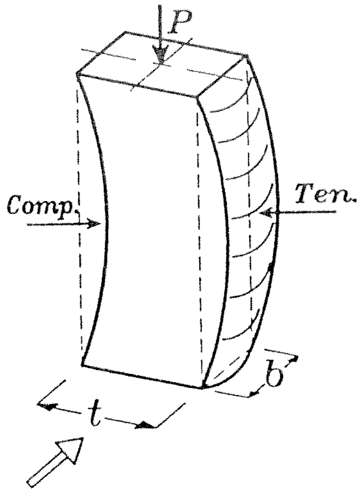


يحدث الإنبعاج عمودى على مستوى الورقة فلا يمكن رؤيتة.

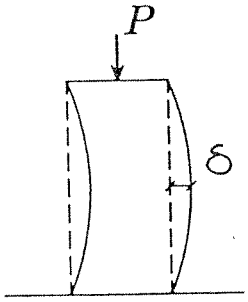
Moment due to Buckling. ($M_{add.}$)

Inside Plan.

يحدث الإنبعاج فى نفس
مستوى الورقة فيمكن رؤيتة.

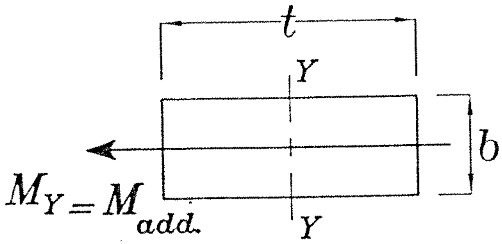


$$\boxed{\delta = \frac{(\lambda_b)^2 * t}{2000}} \quad (m)$$



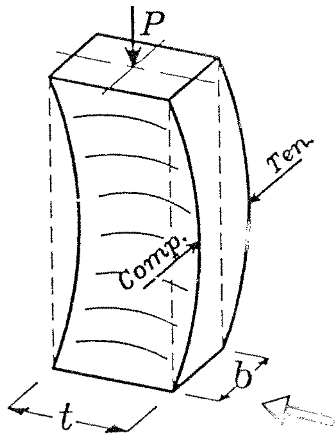
(t) هو العرض الموازى لل moment

$$\boxed{M_{add.} = P_{(t)} * \delta_{(m)}} \quad (m.t.)$$

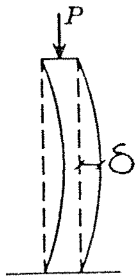


Outside plan.

يحدث الإنبعاج عمودى على
مستوى الورقة فلا يمكن رؤيتة.

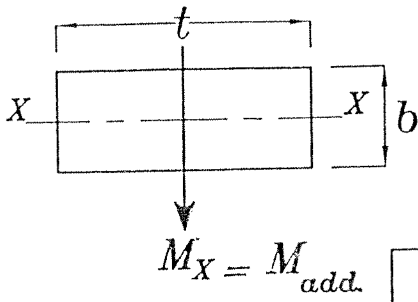


$$\boxed{\delta = \frac{(\lambda_b)^2 * b}{2000}} \quad (m)$$



(b) هو العرض الموازى لل moment

$$\boxed{M_{add.} = P_{(t)} * \delta_{(m)}} \quad (m.t.)$$



ملحوظة

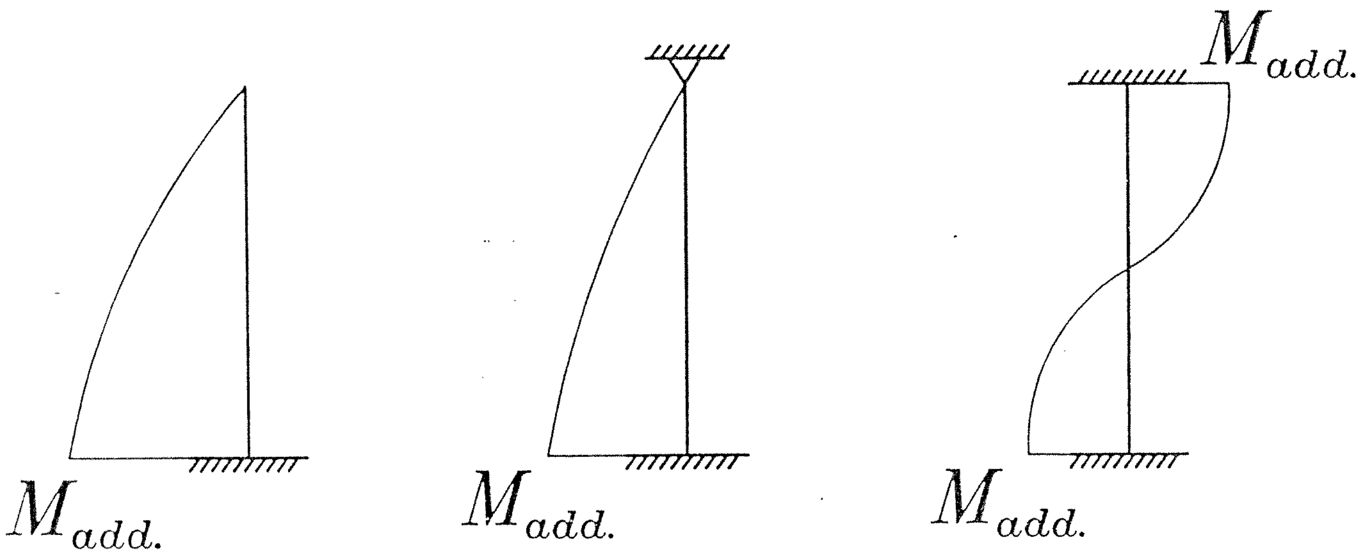
لا يمكن حدوث Buckling للعمود فى الإتجاهين
لذا إذا وجدّ فى العمود الإتجاهان Long Column
نأخذ فقط الإتجاه الذى ثية λ أكبر.

IF $M_{ext.}$ & $M_{add.}$ at the same direction.

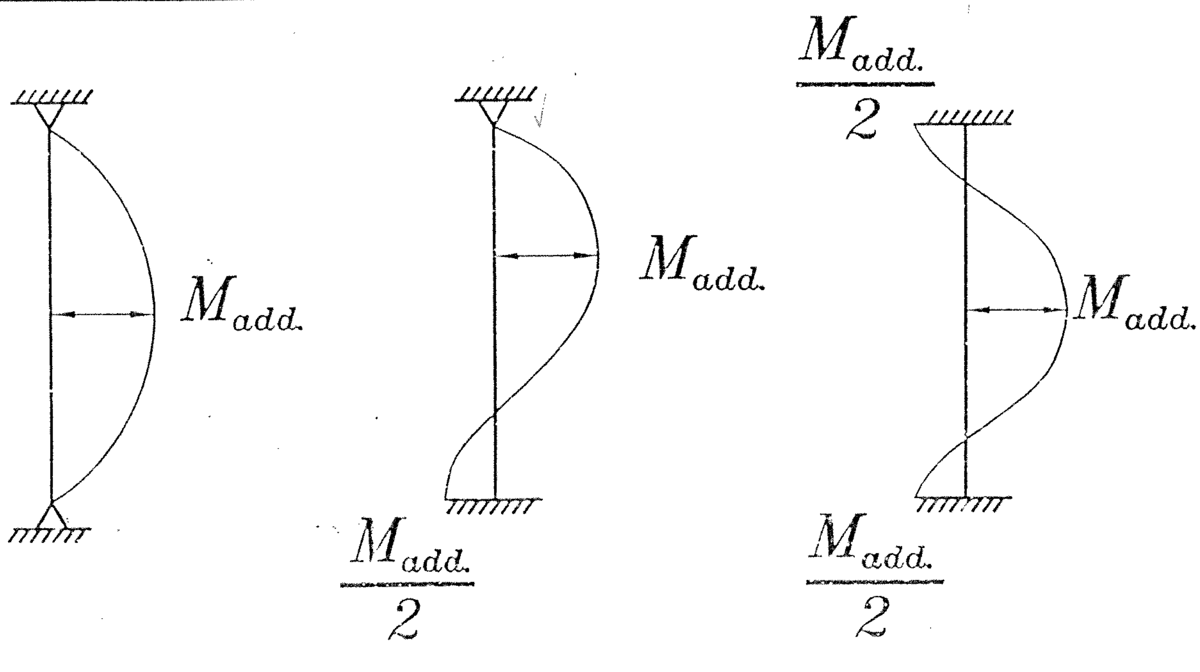
$$\boxed{M_{des.} = M_{ext.} + M_{add.}}$$

Where $M_{ext.}$ & $M_{add.}$ depends on the column end conditions.

UnBraced Columns.



Braced Columns.



Steps of design For Columns. (P_U, $M_{ext.}$) Given

1- Determine, IF the column is braced or unbraced.

2- Determine, the end conditions at top and bottom of the column. (i.e. Fixed, partially Fixed, hinged or Free) to get the Factor (K).

3- Get the clear height of the column (H_o) and then calculate the effective height $= K * H_o$

4- Calculate the slenderness ratio (λ_b) For the two directions (Inside plan & Outside plan) To get, IF the Column is short or Long.

5- For short column, $M_{add.} = Zero$

and Designed under P_U & $M_{ext.}$

6- For Long column, calculate $M_{add.}$

* IF $M_{ext.}$ & $M_{add.}$ at the same direction.

  $\therefore M_{des.} = M_{ext.} + M_{add.}$

  Design the Column under P_U & $M_{des.}$

* IF $M_{ext.}$ & $M_{add.}$ are perpendicular to each other

  $\therefore$ Design the Column under double moment P_U, $M_{ext.}$ & $M_{add.}$

7- Check the code requirements For concrete dimensions and steel bars.

Example.

Data.

$F_{cu} = 250 \ kg\backslash cm^2$

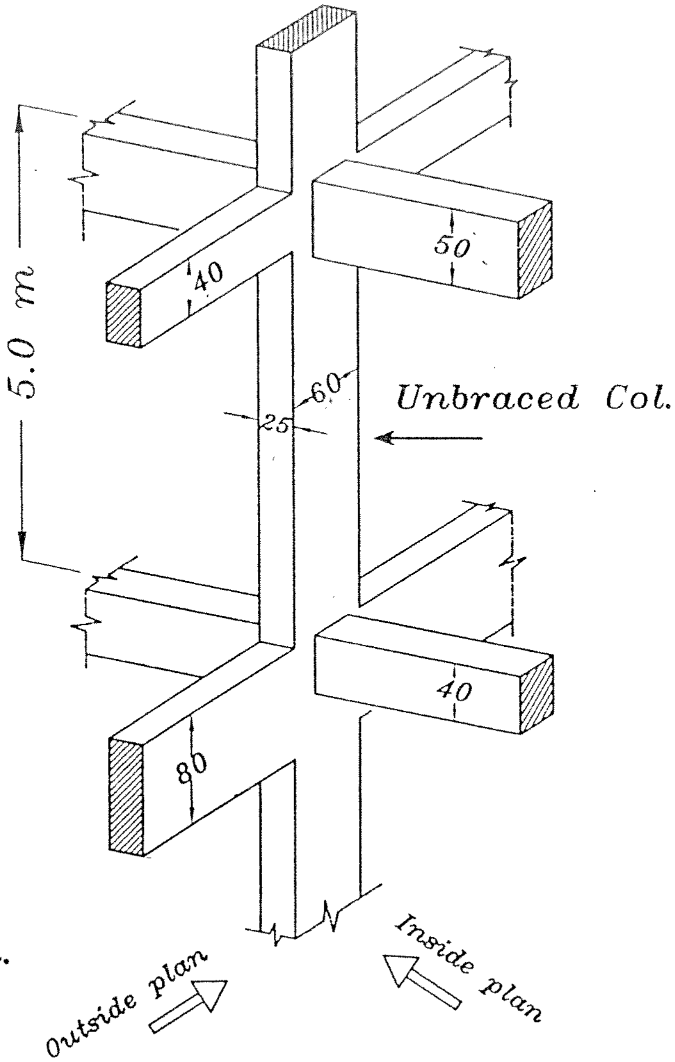
$F_y = 3600 \ kg\backslash cm^2$

$P_{U.L.} = 180 \ t$

Unbraced Col.

Req.

Design the column.



Solution.

Choose one direction to be In Side Plan, then the other direction will be Out Side Plan.

InSide Plan.

Upper Condition Case ②

Lower Condition Case ①

Egyptian Code Pages **(6–50,51)** $K = 1.3$

$H_o = 4.6 \ m$

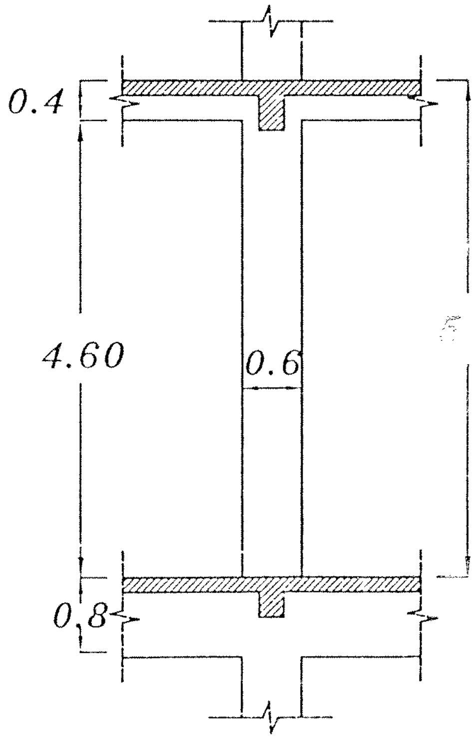
$t = 0.60 \ m$

$$\lambda_b = \frac{K * H_o}{t}$$

$$= \frac{1.3 * 4.6}{0.60} = 9.96 < 10$$

$\therefore$ InSide Plan $\longrightarrow$ Short Column.

$\therefore$ No Buckling $\longrightarrow$ No Additional Moment



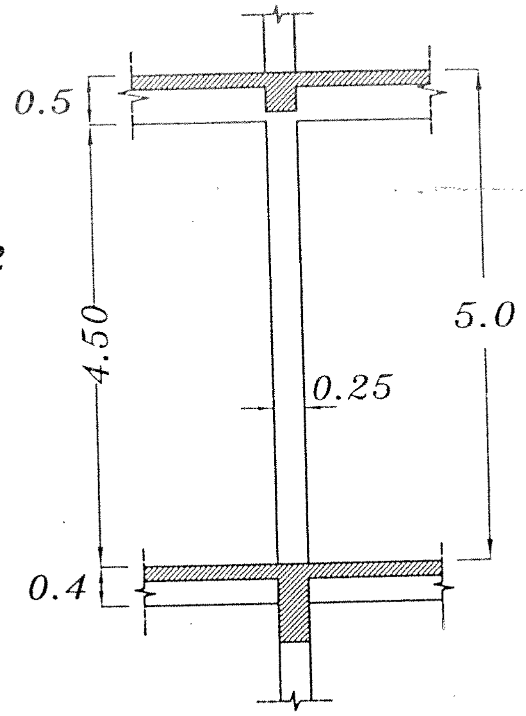
Inside plan

Out Side Plan.

Upper Condition   Case 1

Lower Condition   Case 1

Egyptian Code Pages (6-50,51) $K = 1.2$



Outside plan

$H_\circ = 4.5\ m$

$b = 0.25\ m$

$$\lambda_b = \frac{K * H_\circ}{b}$$

$$= \frac{1.2 * 4.5}{0.25} = 21.6 > 10$$

$$\delta = \frac{(\lambda_b)^2 * b}{2000} = \frac{21.6^2 * 0.25}{2000} = 0.0583\ m$$

$$M_{add.} = P * \delta = 180 * 0.0583 = 10.497\ m.t.$$

Design the Sec. (25 * 60)

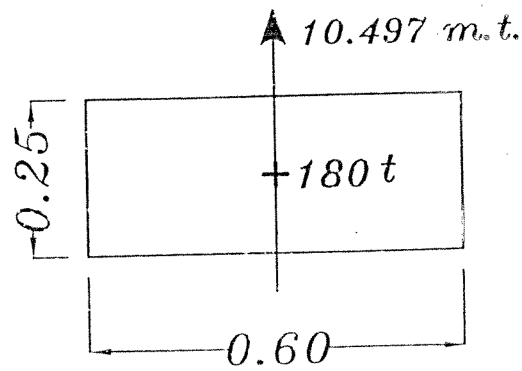
$\boxed{t \text{ هو العرض الموازى للـ moment}}$ ملحوظة

$\therefore\ t = 25\ cm.$

$b = 60\ cm.$

$P_{U.L.} = 180\ t$

$M_{add.} = M_Y = 10.497\ m.t.$



$$e = \delta = \frac{M}{N} = \frac{10.497}{180} = 0.0583\ m$$

$$\therefore\ \frac{e}{t} = \frac{0.0583}{0.25} = 0.2332 < 0.5 \xrightarrow{use} I.D.$$

$$\xi = \frac{25-10}{25} = 0.6 \xrightarrow{Take} \xi = 0.7 \xrightarrow{use} \text{Tables Page 21}$$

$$\left.\begin{aligned} \frac{N_U}{F_{cu}\, b\, t} &= \frac{180 * 10^3}{250*60*25} = 0.48 \\ \frac{M_U}{F_{cu}\, b\, t^2} &= \frac{10.497 * 10^5}{250*60*25^2} = 0.112 \end{aligned}\right\} \rho = 6.90$$

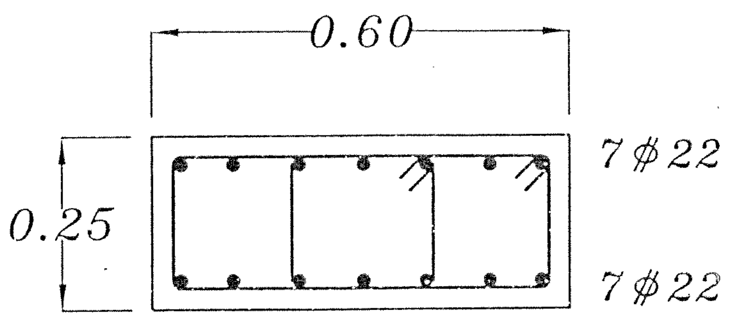
$$A_S = A_{S`} = \mu * b * t = \rho * F_{cu} * 10^{-5} * b * t = 6.9 * 250 * 10^{-5} * 60 * 25 = 25.875 cm^2$$

$$A_{S\,total} = A_S + A_{S`} = 51.75 \; cm^2$$

$$A_{S_{min}} = \frac{0.25 + 0.052\, \lambda_{max}}{100} * b * t$$

$$= \frac{0.25 + 0.052\,(21.6)}{100} * 60 * 25 = 20.65 \; cm^2 < A_{S\,total} \quad \therefore O.K.$$

$$A_S = A_{S`} = 25.875 \; cm^2 \qquad 7\phi22$$



Example.

Data.

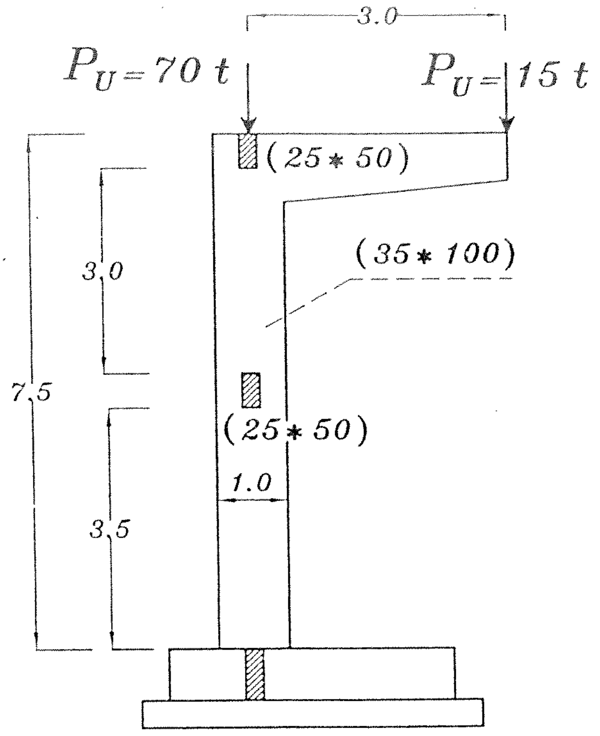
$F_{cu} = 250 \ kg\backslash cm^2$

$F_y = 3600 \ kg\backslash cm2$

Unbraced Col.

Req.

Design the column.



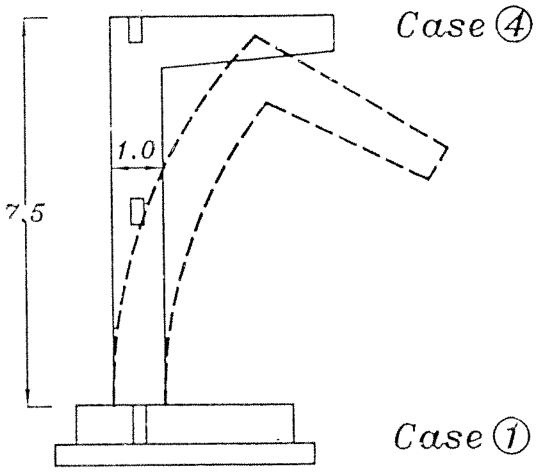
Solution.

$P_U = 70 + 15 = 85\ t$

$M_U = M_{ext.} = 15 * 3.0 = 45\ m.t.$

Check Buckling.

① Inside Plan.

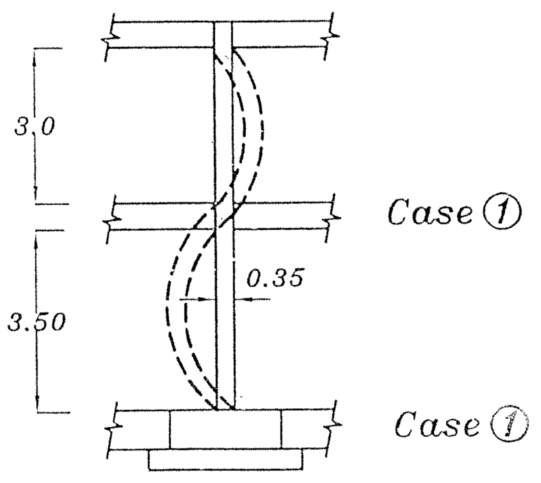


Upper Condition Case ④
Lower Condition Case ① } $k = 2.2$

$H_o = 7.5\ m$

$$\lambda_b = \frac{2.2 * 7.5}{1.0} = 16.5 > 10$$

② Outside Plan.



Upper Condition Case ①
Lower Condition Case ① } $k = 1.2$

$H_o = 3.5\ m$

$$\lambda_b = \frac{1.2 * 3.5}{0.35} = 12 > 10$$

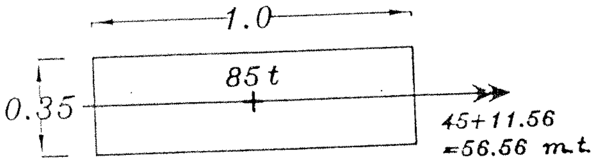
Take the bigger value of $\lambda_b = 16.5$ (Inside Plan)

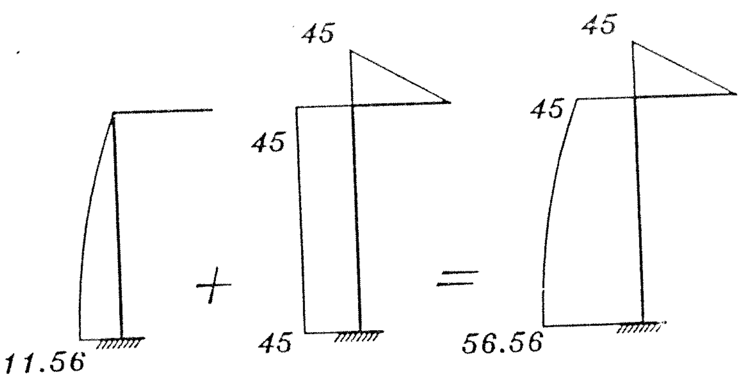
$$\delta = \frac{(\lambda_b)^2 * t}{2000} = \frac{16.5^2 * 1.0}{2000} = 0.136 \quad m$$

$$M_{add.} = P * \delta = 85 * 0.136 = 11.56 \; m.t.$$

$$\because M_{des.} = M_{ext.} + M_{add.}$$

$$\therefore M_{des.} = 45 + 11.56 = 56.56 \quad m.t.$$





Design the Sec.

$$e = \frac{M}{N} = \frac{56.56}{85} = 0.665 \; m \qquad \therefore \frac{e}{t} = \frac{0.665}{1.0} = 0.665 > 0.5 \xrightarrow{use} e_s$$

$$e_s = e + \frac{t}{2} - c = 0.665 + \frac{1.0}{2} - 0.05 = 1.115 \; m$$

$$M_s = N * e_s = 85 * 1.115 = 94.775 \quad m.t.$$

$$\therefore 95 = C_1 \sqrt{\frac{94.775 * 10^5}{250 * 35}} \longrightarrow C_1 = 2.886 \longrightarrow J = 0.728$$

$$\therefore A_s = \frac{M_s}{J F_y d} - \frac{N_{U.L.}}{(F_y \backslash \delta_s)} = \frac{94.775 * 10^5}{0.728 * 3600 * 95} - \frac{85 * 10^3}{(3600 \backslash 1.15)} = 10.913 \; cm^2$$

$$\text{Take } A_s' = A_s = 10.913 \; cm^2$$

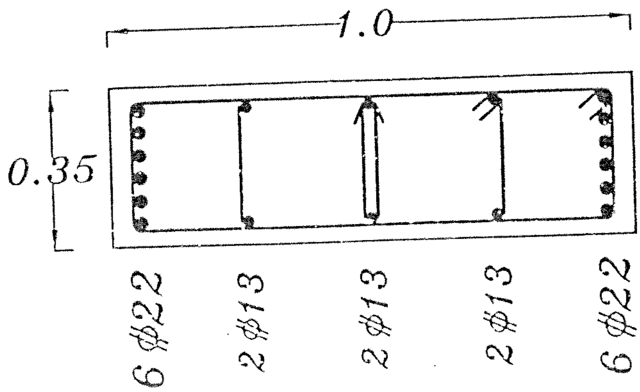
$$A_{s\,total} = A_s + A_s' = 21.826 \, cm^2$$

$$A_{s_{min}} = \frac{0.25 + 0.052 \lambda_{max}}{100} * b * t$$

$$= \frac{0.25 + 0.052 \; (16.5)}{100} * 35 * 100 = 38.78 \; cm^2 > A_{s\,total}$$

$$A_s' = A_s = \frac{A_{s\,min}}{2} = 19.39 \; cm^2$$

6 ϕ 22



Circular Columns. الاعمده الدائرية

Buckling in Circular Columns.

Unbraced col.

Short Col.

$\lambda_b \leqslant 8$

Buckling لا يوجد

Long Col.

$8 < \lambda_b \leqslant 18$

Buckling يوجد

IF $\lambda_b > 18 \xrightarrow[\text{Buckling}]{\text{Unsafe}}$ Increase D

Braced col.

Short Col.

$\lambda_b \leqslant 12$

Buckling لا يوجد

Long Col.

$12 < \lambda_b \leqslant 25$

Buckling يوجد

IF $\lambda_b > 25 \xrightarrow[\text{Buckling}]{\text{Unsafe}}$ Increase D

Where :

λ_b is the slenderness ratio

$$\boxed{\lambda_b = \frac{K * H_o}{D}}$$

* H_o = Clear height of the column.

* K = Constant depends on the upper & Lower Conditions of the Column.

Egyptian Code Pages (6-50,51)

Upper End Conditions	Braced Columns			Unbraced Columns		
	Lower End Conditions			Lower End Conditions		
	Case (1)	Case (2)	Case (3)	Case (1)	Case (2)	Case (3)
Case (1)	0.75	0.80	0.90	1.20	1.30	1.60
Case (2)	0.80	0.85	0.95	1.30	1.50	1.80
Case (3)	0.90	0.95	1.0	1.60	1.80	——
Case (4)	——	——	——	2.20	——	——