المحاضرة الأولى

Direct Design Methods

Moments in two-way slabs can be found using the semie-mperical direct design method, subject to the following restrictions:

1- There must be a minimum of three continuous spans in each direction.

2- The panels must be rectangular, with the ratio of the longer to the shorter spans within a panel not greater than 2.

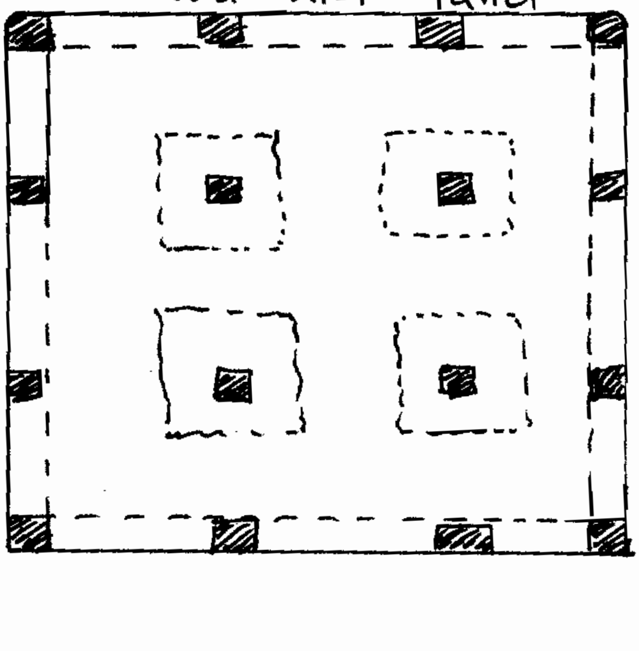
3- The successive span lengths in each direction must not differ by more than one third of the longer span

4- Columns may be offset a maximum of 10 percent of the span in the direction of the offset from either axis between centerlines of successive columns

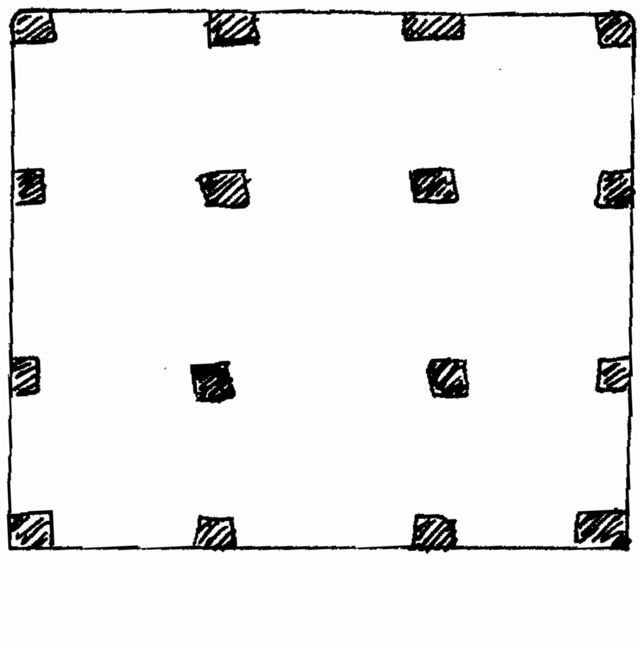
5- loads must be due to gravity only and the live load must not exceed 3 times the dead load.

6- If beams are used on the column lines, the relative stiffness of the beams in the two perpendicular directions, given by the ratio $\alpha_1 l_2^2/\alpha_2 l_1^2$ must be between 0.2 and 5.0.

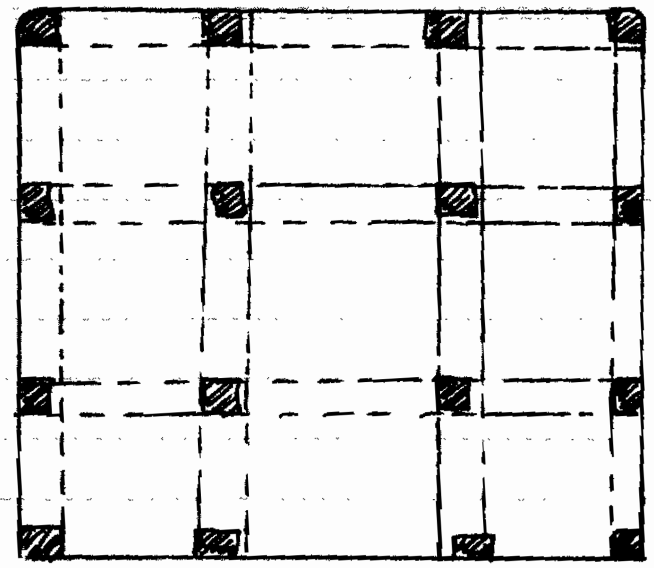
flat slab with edge beams and drop panel



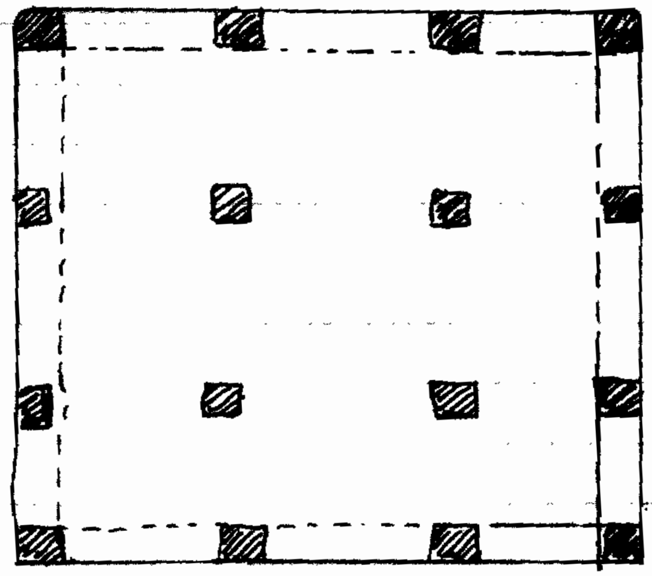
flat-Plate Slab

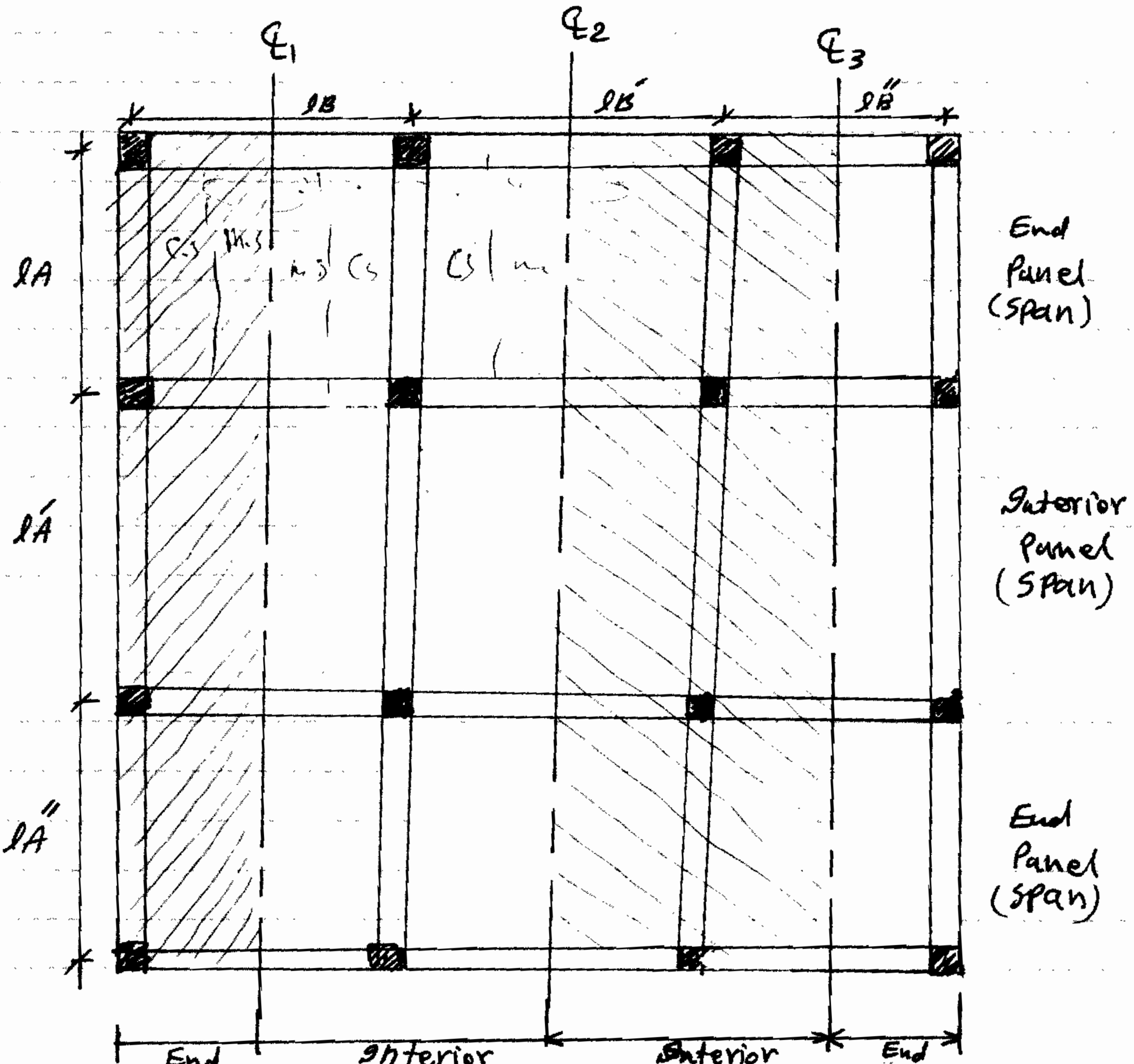


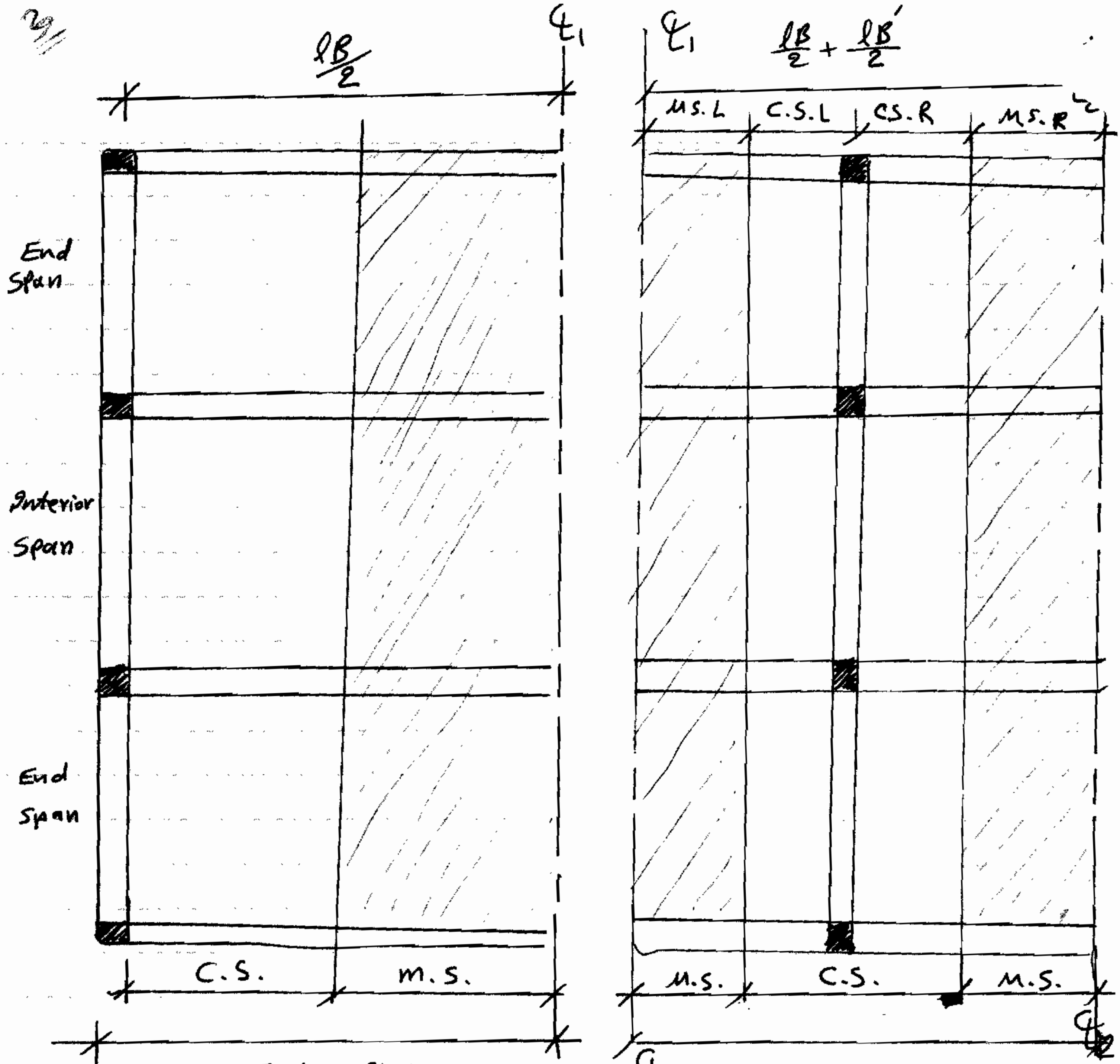
slab with beam between all supports



flat slab with edge beams







End Strip　　　　Interior Strip

$$\text{End strip width} = \frac{\text{طول الفضاء العمودي}}{2} + \frac{\text{beam width (العوارض)}}{2}$$

$$\text{width C.S.} = \min\left\{\frac{lB}{4} \text{ or } \frac{lA}{4} \text{ or } \frac{lA'}{4} \text{ or } \frac{lA''}{4}\right\}$$

$b = b_{m.s} =$

$$\text{width M.S.} = \frac{lB}{2} - (\text{width C.S.})$$ (⇐ Ru تستخدم في قانون)

$$b = b_{c.s} = \text{width C.S} - \frac{\text{beam width [illegible]}}{2}$$ (⇐ Ru تستخدم في قانون)

ACI 13.6.2.2

Panel Moment
M_o 100% static Moment

For internal spans

- ACI 13.6.3.3 — **Negative Moment**: Neg $M_u = 0.65\, M_o$
  - ACI 13.6.4 — Mid. Strip Moment
  - Col. Strip Moment
    - ACI 13.6.5 — Beam Moment
    - Slab Moment
- **Positive Moment**: Pos $M_u = 0.35\, M_o$
  - Col. Strip Mom.
    - Beam Moment
    - Slab Moment
  - Mid. Strip Mom.

First: End Strip / Interior span:

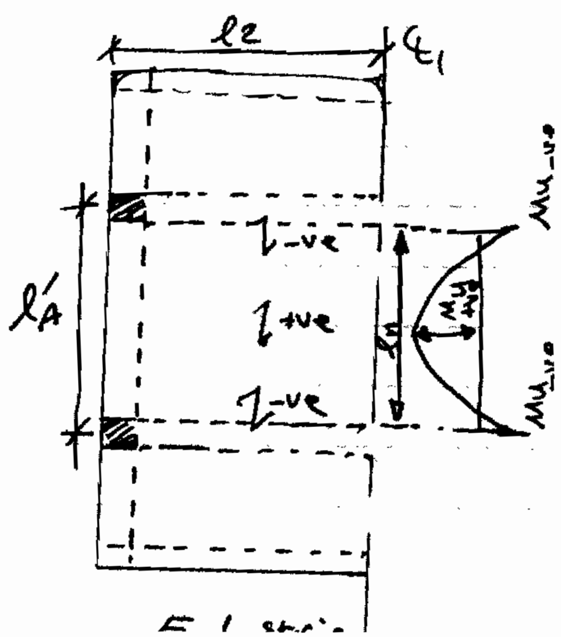
$$W_u = 1.2\,D + 1.6\,L$$

$$l_2 = \frac{l_B}{2} + \frac{\text{beam width}}{2}$$
عمودي على الشريحة

موازي للشريحة $l_n = l_A' -$ Col. width

check $l_n \geq 0.65\, l$

$$\therefore \boxed{M_o = \frac{W_u \times l_2 \times (l_n)^2}{8}}$$

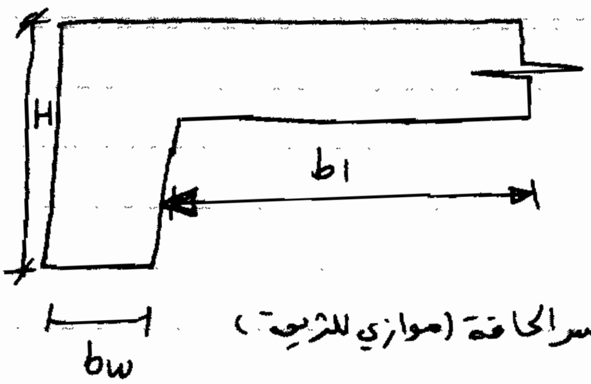


ملاحظة: في حالة كون العمود بمقطع دائري
فانا نعوض عن ذلك بمربع:

D ⇨ d

$\therefore d = 0.886\, D$

A) $M_{-ve} = 0.65\, M_o$



$$b_1 = \min\{H-h,\ 4h\}$$

$$\bar{y} = \frac{b_w * \frac{H^2}{2} + b_1 * \frac{h^2}{2}}{b_w * H + b_1 * h}$$

لجسر الحافة (موازي للزيت)
$$I_b = \frac{(b_w + b_1) * (y')^3}{3} + \frac{b_w (H - y')^3}{3} - \frac{b_1 * (\bar{y} - h)^3}{3}$$

$$l_2 = \frac{l_B}{2} + \frac{b_w}{2}$$

$$\therefore I_s = \frac{l_2 * h^3}{12} \qquad \alpha = \frac{E_{cb} \cdot I_b}{E_{cs} \cdot I_s}$$

ملاحظة: في حالة عدم وجود beam فان E_{cb} = صفر اي $\alpha = 0$.

$$\frac{l_2}{l_1} = \frac{l_B\,(c/c)}{l_{A'}\,(c/c)}$$

وعليه نجد Coff1 من الجدول {C.S. moment, Percent of total Moment at critical sections} جدول رقم -1-

$\therefore M_{c.s} = Coff1 * M_{-ve}$

$M_{beam} = Coff2 * M_{c.s}$

$M_{slab} = M_{c.s} - M_{beam}$

if $\alpha \frac{l_2}{l_1} \geq 1 \quad \therefore coff2 = 0.85$

if $\alpha \frac{l_2}{l_1} < 1 \quad \therefore coff2 = 0.85 * (\alpha \frac{l_2}{l_1})$

$\therefore M_{m.s} = M_{-ve} - M_{c.s}$

B) $M_{+ve} = 0.35\, M_o$:-

find I_b, I_s, α, $\frac{l_2}{l_1}$, from tables find Coff. 3

$\therefore M_{c.s} = \text{Coff. } 3 * M_{+ve}$

$M_{beam} = \text{Coff. } 2 * M_{c.s.}$

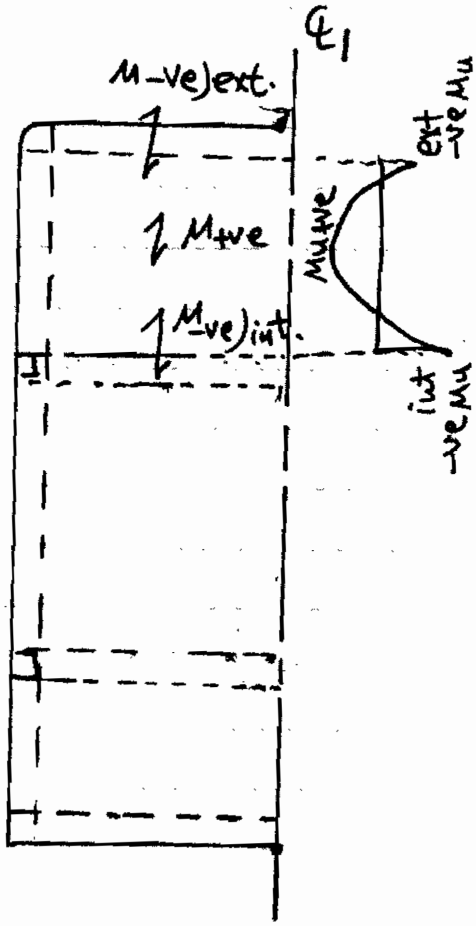
$M_{slab} = M_{c.s} - M_{beam}$

if $\alpha \frac{l_2}{l_1} \geq 1$ $\therefore$ Coff. 2 = 0.85

if $\alpha \frac{l_2}{l_1} < 1$ $\therefore$ Coff. 2 = $\alpha \frac{l_2}{l_1} * 0.85$

$\therefore M_{m.s.} = M_{+ve} - M_{c.s}$

Second: End Strip / End Span:



$W_u = 1.2D + 1.6L$

عمودي $l_2 = \frac{l_B}{2} + \frac{b_w}{2}$

موازي $l_n = l_A - \text{Col. width}$

$$M_o = \frac{W_u \cdot l_2 \cdot l_n^2}{8}$$

ثم نجد C_1 ، C_2 و C_3 من جدول رقم -2-

Distribution factors applied to Static Moment M_o for positive and negative moments in end span.

$\therefore M_{int)-ve} = C_1 * M_o$

$M_{+ve} = C_2 * M_o$

$M_{ext)-ve} = C_3 * M_o$

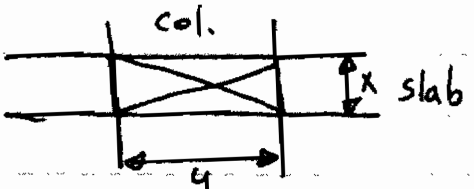
كل عزم من هذه العزوم الثلاثة يتألف من $M_{m.s}$ و $M_{c.s}$ ولحسابهم

نبدأ بالعزم السالب الخارجي

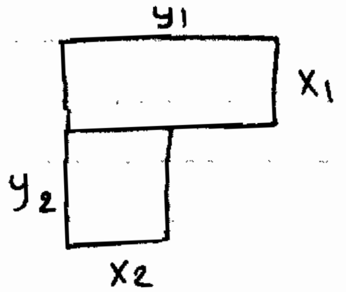
اولاً: Distribution of $M_{-ve})_{ext.}$:-

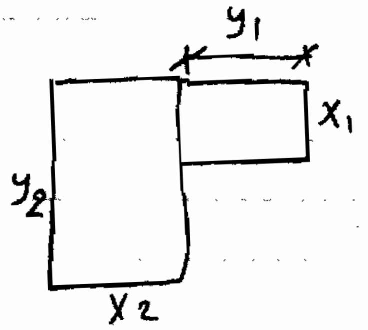
find موازية I_b , $I_s = \frac{\text{عرض الشريحة} * h^3}{12}$, $\alpha = \frac{I_b}{I_s}$, $\frac{\ell_2}{\ell_1}$ $\frac{\text{c/c عمودي}}{\text{موازي c/c}}$

عمودي $C = \sum\left[\left(1-0.63\frac{x}{y}\right) * \frac{x^3 * y}{3}\right]$



Beamless slab





حيث ان:
x: البعد الصغير
y: البعد الكبير

$y_1 - x_2 = \min\{4h, y_2\}$
where $h = x_1$

$y_1 = \min\{H-h, 4h\}$
where $h = x_1$
$H = y_2$

ندرس الاحتمالين ونأخذ اكبر قيمة للمعامل C.

$I_{s1} = \frac{\ell_2 \text{ العمودي} * h^3}{12}$

$\beta_t = \frac{C}{2 * I_{s1}}$

وعندها نجد Coff.3 من جدول رقم -1- Col. strip moment, Percent of total moment at critical sections

$\therefore M_{c.s} = \text{Coff.3} * M_{-ve})_{ext.}$

$M_{beam} = 0.85 * M_{c.s}$ if $\alpha\frac{\ell_2}{\ell_1} \geq 1$

$M_{beam} = \alpha\frac{\ell_2}{\ell_1}\, 0.85 * M_{c.s}$ if $\alpha\frac{\ell_2}{\ell_1} < 1$

$M_{slab} = M_{c.s} - M_{beam}$

$\therefore M_{m.s} = M_{-ve})_{ext} - M_{c.s}$

ثانياً: Distribution of M_{+ve} :-

Find I_b , I_s , α , $\frac{\ell_2}{\ell_1}$ ومن جدول رقم -1- نجد Coff.2

$\therefore M_{c.s} = \text{Coff 2} * M_{+ve}$

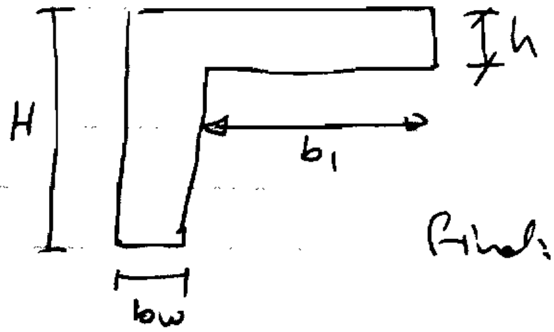
$M_{beam} = 0.85 * M_{c.s}$ if $\alpha\frac{\ell_2}{\ell_1} \geq 1$

$$M_{beam} = 0.85 * M_{c.s} * \alpha \frac{\ell_2}{\ell_1} \qquad \text{if} \quad \alpha \frac{\ell_2}{\ell_1} < 1$$

$$M_{slab} = M_{c.s} - M_{beam}$$

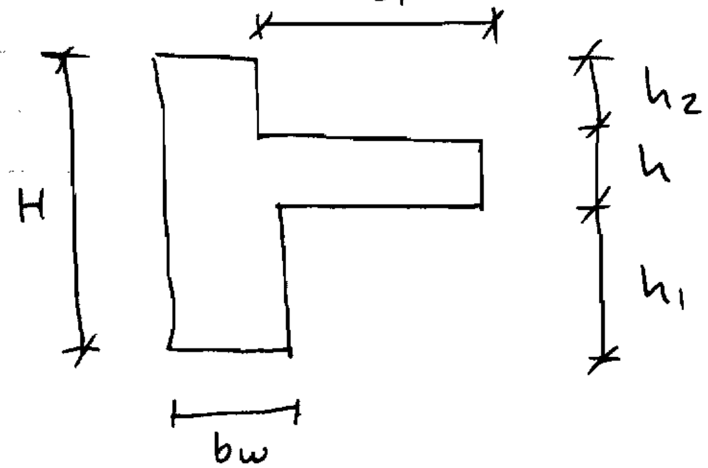
$$\therefore M_{m.s.} = M_{+ve} - M_{c.s}$$

ثانيا: Distribution of $M_{-ve})_{int}$:-



$$\left.\begin{array}{l} b_1 = H - h \\ b_1 = 4h \end{array}\right\} \min$$

Find: b_1, $\bar{y}$, I_b, $I_s = \dfrac{\text{عرض الشريحة} * h^3}{12}$



$$\alpha = \frac{I_b}{I_s} \quad , \quad \frac{\ell_2}{\ell_1} = \frac{\ell_B \, c/c}{\ell_A \, c/c}$$

من الجدول رقم -١- نجد coff.1

$$\therefore M_{c.s} = coff.1 * M_{-ve})_{int}$$

$$M_{beam} = 0.85 * M_{c.s} \qquad \text{if} \quad \alpha \frac{\ell_2}{\ell_1} \geq 1$$

$$M_{beam} = \alpha \frac{\ell_2}{\ell_1} * 0.85 * M_{c.s} \qquad \text{if} \quad \alpha \frac{\ell_2}{\ell_1} < 1$$

$$M_{slab} = M_{c.s} - M_{beam}$$

$$\therefore M_{ms} = M_{-ve})_{int} - M_{c.s}$$

Design Procedures:

$$d_s = h - 20 - \frac{\phi}{2} \qquad d_L = h - 20 - 1.5\phi$$

M = either M_s for c.s. or M_s for $M_{m.s}$

$$R_u = \frac{M * 10^6}{0.9\, b\, d^2}$$

$M_{m.s}$ للعزم $b_{m.s} = b$ او $M_s)_{c.s}$ للعزم $b_{c.s} = b$

$d =$ اما d_L او d_s

$$\mu = \frac{f_y}{0.85 f'_c}$$

$$\rho = \frac{1}{\mu}\left[1 - \sqrt{1 - \frac{2 * R_u * \mu}{F_y}}\right]$$

$$\rho_{max} = 0.75\left[0.85 \beta_1 \frac{f'_c}{f_y} \frac{600}{600 + f_y}\right]$$

Check:

if $\rho \leq \rho_{max}$ $\therefore$ o.k

$A_s = \rho * 1000 * d$ (نفس قيمة d التي استخدمت لإيجاد R_u)

$A_{s\,min} = 0.002 * 1000 * h$ if $f_y < 400$ Mpa (300 - 350

$A_{s\,min} = 0.0018 * 1000 * h$ if $f_y = 400$ Mpa

Check: if $A_s \geq A_{s\,min}$ $\therefore$ o.k

if $A_s < A_{s\,min}$ $\therefore$ use $A_s = A_{s\,min}$

$$S = \frac{\frac{\pi}{4}(\phi)^2 * 1000}{A_s} \qquad S_{max} = 2h$$

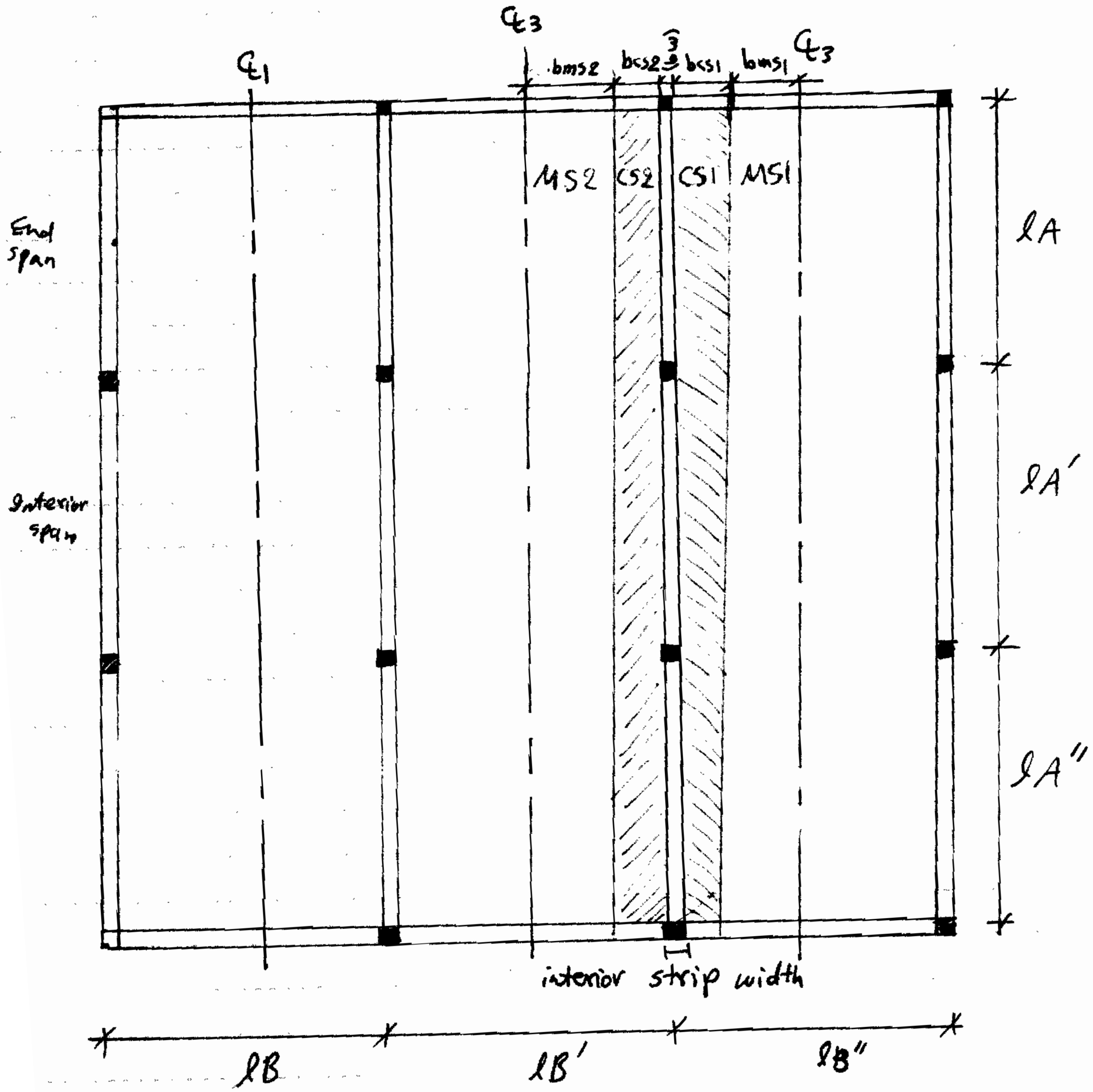
Check: if $S \leq S_{max}$ $\therefore$ o.k

if $S > S_{max}$ $\therefore$ use $S = S_{max}$

$\therefore$ Use $\phi \begin{Bmatrix} 10 \\ 12 \end{Bmatrix}$ @ S mm c/c

المحاضرة الثانية

Direct Design Method
Interior Strip



$$\text{width } CS_1 = \left\{ \frac{lB'}{4} \text{ or } \frac{lA}{4} \text{ or } \frac{lA'}{4} \text{ or } \frac{lA''}{4} \right\} \text{ take min}$$

$$\therefore \text{ width } MS_1 = \frac{lB'}{2} - \text{width } CS1$$

$$\text{width } c.s_2 = \left\{ \frac{\ell B}{4} \text{ or } \frac{\ell A}{4} \text{ or } \frac{\ell A'}{4} \text{ or } \frac{\ell A''}{4} \right\} \text{ take min}$$

$$\therefore \text{ width } ms_2 = \frac{\ell B}{2} - \text{width } cs_2$$

First: Interior span :- $\quad w_u = 1.2D + 1.6L$

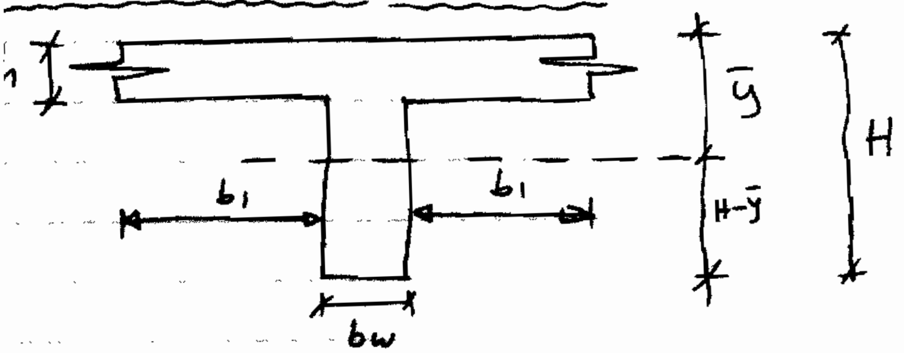
$$\ell_2 = \frac{\ell B'}{2} + \frac{\ell B'}{2} \qquad \ell_n = \ell A' - \text{col. width}$$

$$M_o = \frac{w_u * \ell_2 * \ell_n^2}{8}$$

$$M_o \begin{cases} M_{+ve} = 0.35 M_o \\ M_{-ve} = 0.65 M_o \end{cases}$$

أولاً: $M_{+ve} = 0.35 M_o$

$$M_{+ve} \begin{cases} M_{c.s} \\ M_{m.s} \end{cases}$$



$$\left.\begin{array}{l} b_1 = H - h \\ b_1 = 4h \end{array}\right\} \text{min}$$

$$\bar{y} = \frac{2b_1 * h * \frac{h}{2} + H * b_w * \frac{H}{2}}{2b_1 * h + H * b_w}$$

$$I_b = (2b_1 + b_w) * \frac{(\bar{y})^3}{3} + b_w * \frac{(H-\bar{y})^3}{3} - \frac{2b_1 * (\bar{y}-h)^3}{3}$$

$$I_s = \frac{\text{عرض الشريحة} * h^3}{12} \qquad \alpha = \frac{I_b}{I_s} \qquad \text{find } \frac{\ell_2}{\ell_1}$$

حيث ℓ_2 عرض الشريحة و ℓ_1 عرض ال span وكلاهما c/c

اي ℓ_2 عمودي مع الشريحة و ℓ_1 موازي لها.

وبالتالي نجد coff1 من الجدول :

$$M_{cs} = \text{coff1} * M_{+ve}$$

A) $M_{beam} = 0.85 * M_{c.s} \quad \text{if } \alpha \frac{\ell_2}{\ell_1} \geq 1$ (في حالة وجود عتبة موازية)

$$= \alpha \frac{\ell_2}{\ell_1} * 0.85 * M_{cs} \quad \text{if } \alpha \frac{\ell_2}{\ell_1} < 1$$

B) $M_{slab} = M_{c.s} - M_{beam}$

$$M_{ms} = M_{+ve} - M_{c.s}$$

ثانياً: $M_{-ve} = 0.65\, M_o$ → M_{cs}, $M_{m.s}$

find I_b , $I_s = \frac{(\text{عرض الشريحة}) * h^3}{12}$, $\alpha = \frac{I_b}{I_s}$, $\frac{l_2}{l_1} = \frac{\text{عرض الشريحة}}{\text{الفضاء الموازي للشريحة}}$

find coff2

$\therefore M_{cs} = M_{-ve} * \text{coff}2$

$M_{beam} = 0.85 * M_{c.s}$ if $\alpha \frac{l_2}{l_1} \geq 1$

$M_{beam} = \alpha \frac{l_2}{l_1} * 0.85 * M_{c.s}$ if $\alpha \frac{l_2}{l_1} < 1$

$$M_{slab} = M_{c.s} - M_{beam}$$

$$M_{ms} = M_{-ve} - M_{c.s}$$

Second: End Span :-

$$M_o = \frac{w_u * l_2 * l_n^2}{8}$$

End span في الفضاء الصافي ويكون موازي = l_n ، عرض الشريحة = l_2

1) $M_{-ve})_{int} = \text{coff}1 * M_o$

2) $M_{+ve}) = \text{coff}2 * M_o$

3) $M_{-ve})_{ext.} = \text{coff}3 * M_o$

أولاً: $M_{-ve})_{int} = \text{coff}1 * M_o$

يقسم هذا العزم الى $M_{c.s}$, $M_{m.s}$

find I_b , $I_s = \frac{(\text{عرض الشريحة}) * h^3}{12}$, $\alpha = \frac{I_b}{I_s}$, $\frac{l_2}{l_1 \%} = \frac{\text{عرض الشريحة}}{\text{الفضاء الموازي للشريحة}}$

(find coff from table 1) , $M_{c.s} = \text{coff} * M_{-ve})_{int}$

$M_{beam} = 0.85 * M_{c.s}$ if $\alpha \frac{l_2}{l_1} \geq 1$

$M_{beam} = \alpha \frac{l_2}{l_1} * 0.85 * M_{c.s}$ if $\alpha \frac{l_2}{l_1} < 1$

$M_{slab} = M_{c.s} - M_{beam}$

$M_{m.s} = M_{-ve})_{int} - M_{c.s}$

"ثانياً": $M_{+ve} = \text{coff}2 * M_o$ كذلك يتكون من جزئين

find I_b , $I_s = \frac{(\text{عرض الشريحة}) * (h)^3}{12}$, $\alpha = \frac{I_b}{I_s}$, $\frac{l_2}{l_1 \%} = \frac{\text{عرض الشريحة}}{\text{طول الفضاء الموازي}}$

find coff 2 , $M_{cs} = \text{coff}2 * M_{+ve}$

$M_{beam} = 0.85 * M_{c.s}$ if $\alpha \frac{l_2}{l_1} \geq 1$

$M_{beam} = \alpha \frac{l_2}{l_1} * 0.85 * M_{c.s}$ if $\alpha \frac{l_2}{l_1} < 1$

$M_{slab} = M_{c.s} - M_{beam}$

$M_{ms} = M_{+ve} - M_{c.s}$

"ثالثاً": $M_{-ve})_{ext} = \text{coff}3 * M_o$ كذلك يتكون من عزمين

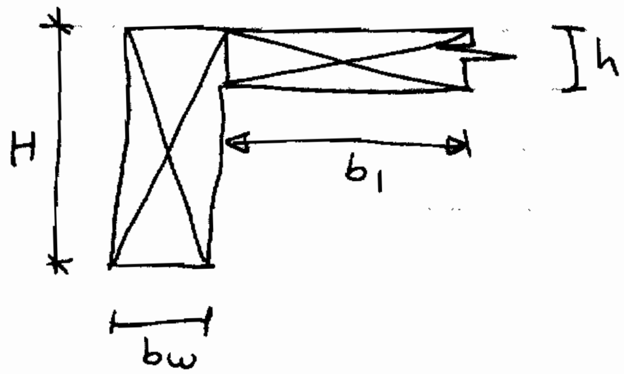
find I_b , $I_s = \frac{\text{عرض الشريحة} * h^3}{12}$, $\alpha = \frac{I_b}{I_s}$, $\frac{l_2}{l_1 \%} = \frac{\text{عرض الشريحة}}{\text{طول الفضاء الموازي}}$

$C = \sum (1 - 0.63 * \frac{x}{y}) \frac{x^3 y}{3}$

$b_1 = \min \{ H - h , 4h \}$

x: البعد الصغير
y: البعد الطويل
للعتبة العمودية على الشريحة

$$I_{s1} = \frac{l_2 * h^3}{12}$$



حيث l_2 c/c الفضاء العمودي ع الشريحة ويكون يساره

أي $l_2 = l_B$

$$I_{s2} = \frac{l_2' * h^3}{12}$$

حيث l_2' c/c الفضاء العمودي ع الشريحة ويكون يمينها

أي $l_2' = l_B'$

$$\therefore \beta_{t1} = \frac{C}{2\, I_{s1}} \qquad \beta_{t2} = \frac{C}{2\, I_{s2}} \qquad \therefore \boxed{\beta_t = \frac{\beta_{t1} + \beta_{t2}}{2}}$$

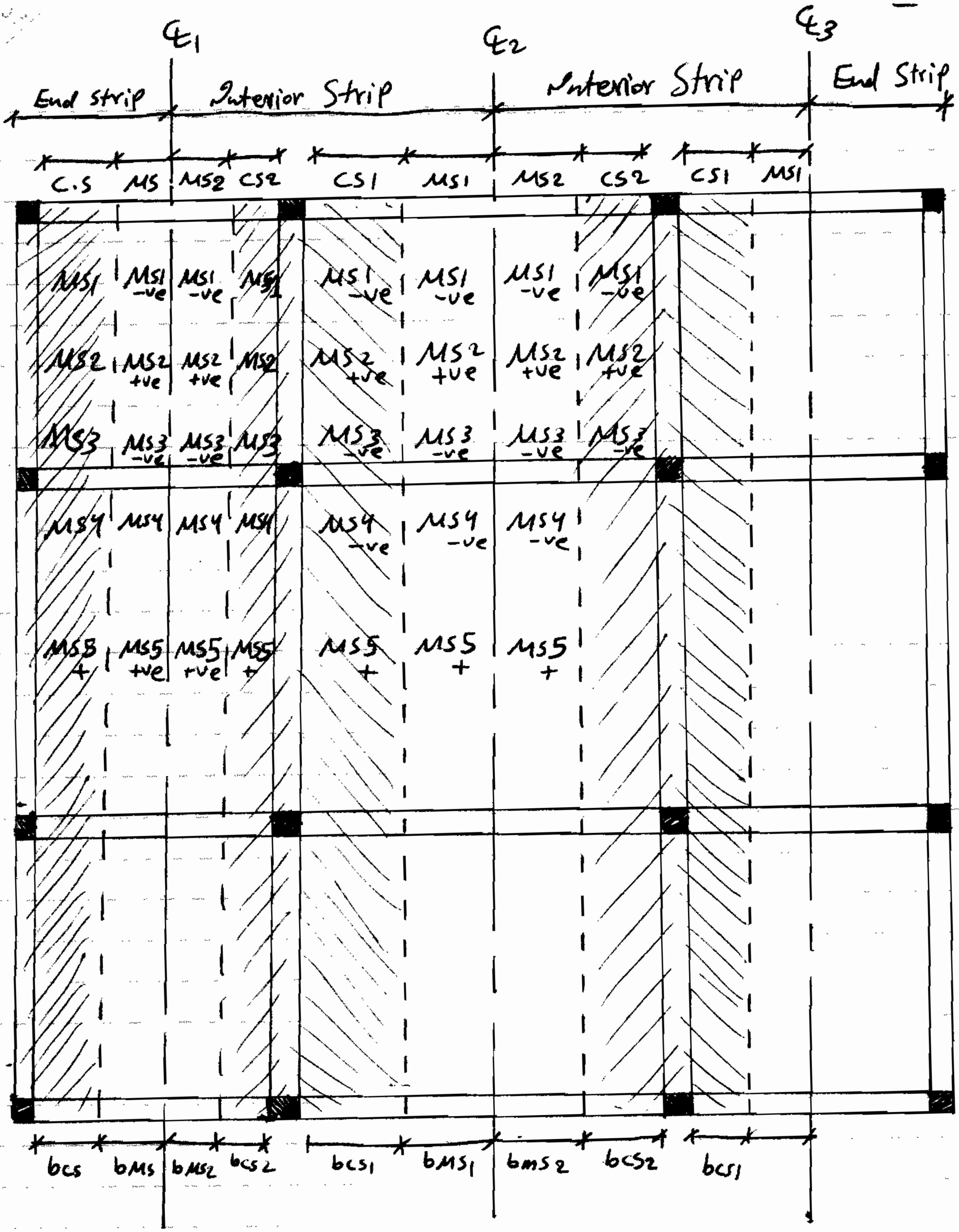
$\therefore$ find coff 3 $\qquad \therefore M_{c.s} = \text{coff } 3 * M_{-ve})_{ext}$

$$M_{beam} = 0.85 * M_{c.s} \quad \text{if} \quad \alpha \frac{l_2}{l_1} \geq 1$$

$$M_{beam} = \alpha \frac{l_2}{l_1} * 0.85 * M_{c.s} \quad \text{if} \quad \alpha \frac{l_2}{l_1} < 1$$

$$M_{slab} = M_{c.s} - M_{beam}$$

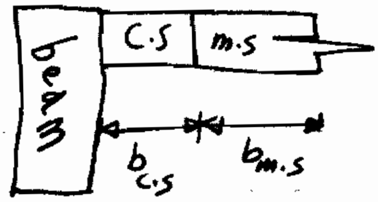
$$M_{ms} = M_{-ve})_{ext} - M_{c.s}$$



℄1
℄2
℄3
End strip
Interior Strip
Interior Strip
End Strip
C.S
MS
MS2
CS2
CS1
MS1
MS2
CS2
CS1
MS1
MS1
MS1 -ve
MS2
MS2 +ve
MS3
MS3 -ve
MS4
MS4 -ve
MS5
MS5 +ve
MS5 +
bcs
bMS
bMS2
bcs2
bcs1
bMS1
bms2
bcS2
bcs1

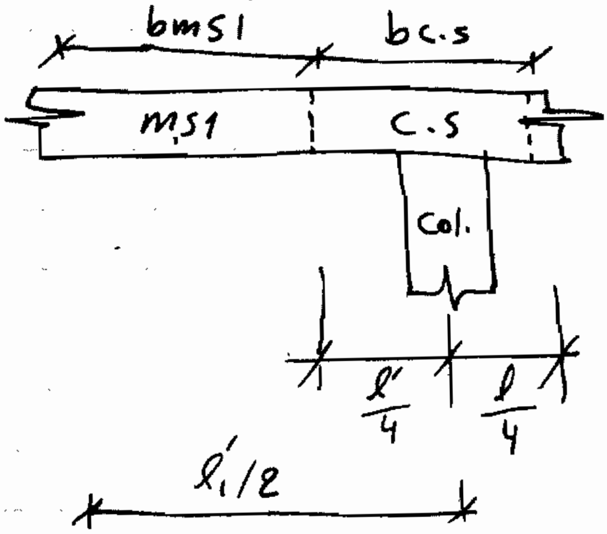
ملاحظات:

① في حالة الشريحة النهائية (End Strip) فيوجد عزم $M_{slab})_{c.s}$ واحد وعزم $M_{m.s}$ واحد فقط



② لحساب العزوم (C.S) و (M.S) في الشريحة الوسطى (Interior strip) في ال Slab
هناك حالتين :

أولاً: بدون جسور داخلية

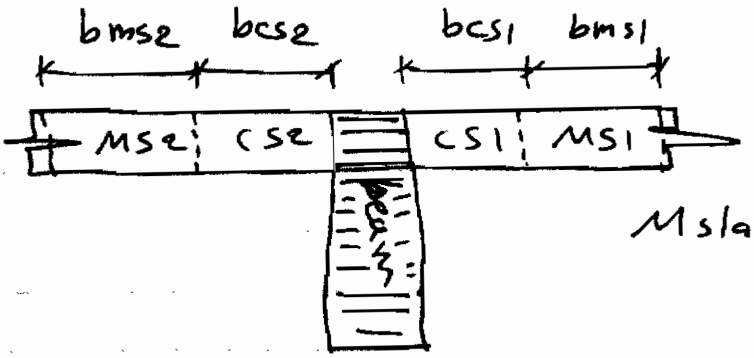


في هذه الحالة عزم c.s لا يتجزأ، اما عزم ($M_{m.s}$) فيتم تجزئته الى:

$$M_{ms1} = M_{ms} \cdot \frac{b_{ms1}}{b_{ms1} + b_{ms2}}$$

$$M_{ms2} = M_{ms} \cdot \frac{b_{ms2}}{b_{ms1} + b_{ms2}}$$

ثانياً: بوجود جسور داخلية



$$M_{slab} = M_{c.s} - M_{beam}$$

$$M_{slab})_{c.s1} = M_{slab})_{c.s} * \frac{b_{cs1}}{b_{cs1} + b_{cs2}}$$

$$M_{slab})_{c.s2} = M_{slab})_{c.s} * \frac{b_{c.s2}}{b_{cs1} + b_{cs2}}$$

وكذلك نفس الحالة تطبق على عزوم ال middle strip :

$$M_{ms1} = M_{m.s} * \frac{b_{ms1}}{b_{ms1} + b_{ms2}}$$

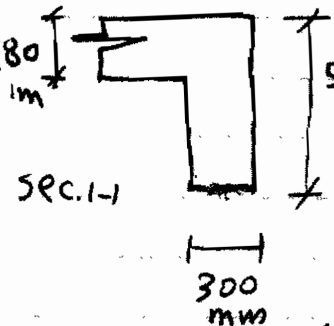
$$M_{ms2} = M_{m.s} * \frac{b_{ms2}}{b_{ms2} + b_{ms1}}$$

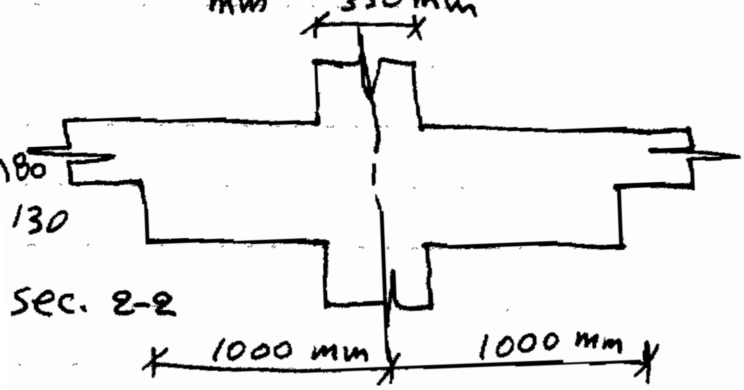
(٢) عزوم الـ middle strip دائماً تجمع

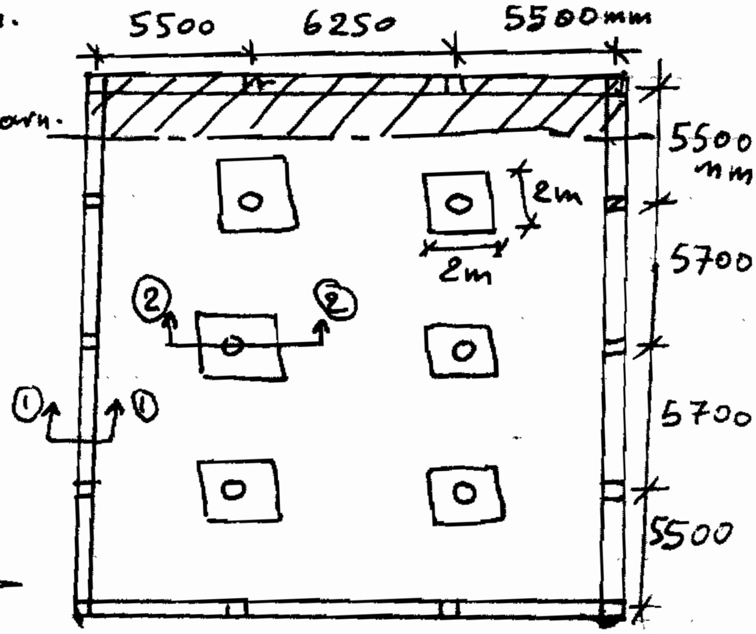
المحاضرة الثالثة

3 Examples for "Direct Design Method"

EX: $DL_{add.} = 2.5\ KN/m^2$, $LL = 3.6\ KN/m^2$, $h = 180$ mm , col. = 300×300 mm , Col. Dia. = 350 mm , $f_y = 300$ Mpa
$f'_c = 22$ Mpa , $H = 550$ mm.
Design End Span for the ext strip shown.







Sol. $DL = 2.5 + 0.18 * 24 = 6.82\ KN/m^2$

$Wu = 1.2D + 1.6L = 1.2 * 6.82 + 1.6 * 3.6 = 13.944\ KN/m^2$

عرض الشريحة $l_2 = \frac{5500}{2} + \frac{300}{2} = 2900$ mm   الفضاء الصافي $l_n = 5500 - 300 = 5200$ mm

$\therefore M_o = \frac{1}{8} * 13.944 \times 2.9 * (5.2)^2 = 136.68$ KN.m

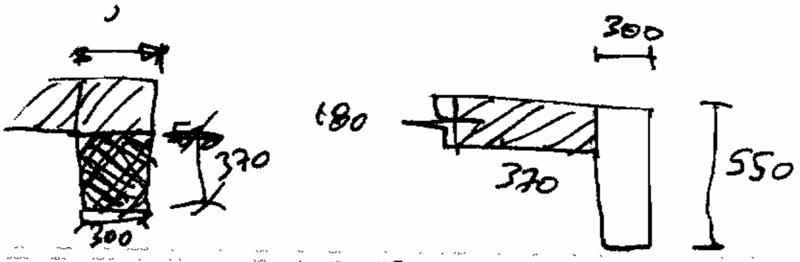
نجد المعامل Coff.3 الخاص بالعزم $M_{-ve})_{ext.}$: من الجدول 2: Coff.3 = 0.3

$\therefore M_{-ve})_{ext} = 0.3 * 136.68 = 41$ KN.m

ولاستخراج المعامل الخاص بالـ M c.s. للعتبات الموازية للشريحة:

$$\left.\begin{aligned} b_1 &= 550 - 180 = 370 \\ b_1 &= 4 * 180 = 720 \end{aligned}\right\} \quad \therefore b_1 = 370\text{ mm}$$

$$\bar{y} = \frac{300 * \frac{550^2}{2} + 370 * \frac{180^2}{2}}{300 * 550 + 370 * 180} = 222\text{ mm}$$



$$I_b = \frac{(300+370)*(222)^3}{3} + \frac{300\,(550-222)^3}{3} - 370\,\frac{(222-180)^3}{3} = 5.96 * 10^9\ mm^4$$

$$I_s = \frac{2900*(180)^3}{12} = 1.41*10^9\ mm^4\ ,\ \alpha = \frac{I_b}{I_s} = \frac{5.96}{1.41} = 4.227$$

$$\frac{l_2}{l_1} = \frac{5500}{5500} = 1 \qquad \therefore \alpha\frac{l_2}{l_1} = 4.227\times 1 = 4.25$$

لإيجاد قيمة βt

$$C_1 = \left(1-0.63*\frac{300}{550}\right)\frac{300^3*550}{3} + \left(1-0.63\,\frac{180}{370}\right)*\frac{180^3*370}{3} = 3.75 * 10^9\ mm^3$$

$$C_2 = \left(1-0.63\,\frac{180}{670}\right)*\frac{(180)^3*670}{3} + \left(1-0.63\,\frac{300}{370}\right)*\frac{300^3*370}{3} = 2.53*10^9\ mm^3$$

$\therefore$ we use $c = 3.75*10^9\ mm^3$

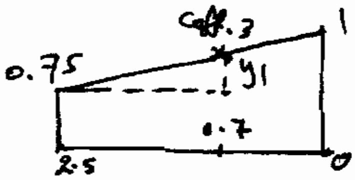
$$I_{S_1} = \frac{5500*180^3}{12} = 2.673*10^9\ mm^4\ ,\ \beta t = \frac{c}{2I_{S_1}} = \frac{3.75*10^9}{2*2.673*10^9} = 0.7$$

table 1:

$\alpha\frac{l_2}{l_1} = 4.25 \quad \beta t = 0.7$

at $\beta t = 0$ coff3 = 1

at $\beta t = 2.5$ coff3 = 0.75



$$\frac{y_1}{2.5-0.7} = \frac{1-0.75}{2.5} \qquad \therefore y_1 = 0.18 \qquad \therefore \text{coff3} = 0.18+0.75 = 0.93$$

$\therefore M_{c.s} = 0.93*41 = 38.13$ KN.m , $M_{beam} = 0.85*38.13 = 32.41$ KN.m

$M_{slab} = 38.13 - 32.41 = 5.72$ KN.m , $\therefore M_u = 5.72$ KN.m

width of c.s $= \frac{5500}{4}$ or $\frac{5500}{4}$ or $\frac{6280}{4}$ or $\frac{5500}{4}$ $= 1375$ mm

$\therefore b_{c.s} = 1375 - \frac{300}{2} = 1225$ mm , $d_L = 180 - 20 - 1.5*12 = 142$ mm

$$R_u = \frac{5.72*10^6}{0.9*1225*(142)^2} = 0.257\ ,\ m = \frac{f_y}{0.85*f_c'} = \frac{300}{0.85*22} = 16.04$$

$$\rho = \frac{1}{16.04}\left[1-\sqrt{1-\frac{2*0.257*16.04}{300}}\right] = 0.000863$$

$$\rho_{max} = 0.75\left[0.85*0.85\,\frac{22}{300}*\frac{600}{600+300}\right] = 0.0265$$

$\rho_{max} > \rho \qquad \therefore$ O.K

$A_s = 0.00086 * 1000 * 142 = 123 \quad mm^2/m$

$A_{s\,min} = 0.002 * 1000 * 180 = 360 \quad mm^2 \qquad \therefore$ use $A_{s\,min}$

$S = \dfrac{\frac{\pi}{4}(12)^2 * 1000}{360} = 314 \ mm \quad , \quad S_{max} = 180 * 2 = 360 \ mm$

$S_{max} > S \quad \therefore$ ok $\qquad$ use $\phi 12 @ 310$ mm c/c

<u>H.W.</u> design for $\left.\begin{matrix} M_{+ve} \\ M_{-ve)_{int}} \end{matrix}\right\}$

Analysis of Beam:

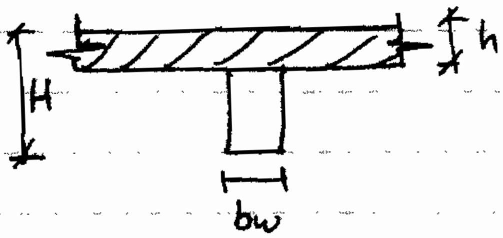
في حالة تصميم العتبة تكون الشريحة المعتمدة موازية للعتبة المطلوبة :

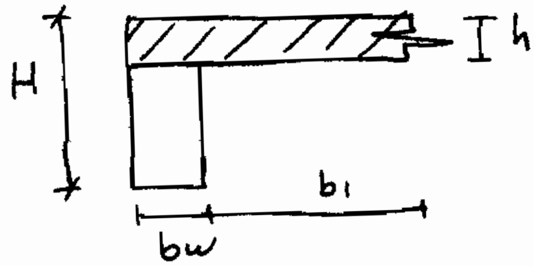
١) نحدد نوع العزم المطلوب ونوع الشريحة وال span ،

٢) نجد M_o ونحدد بعدها M_{-ve} او M_{+ve} وحسب الحاجة

٣) نتبع نفس الخطوات السابقة لتحويل العزم الى $M_{c.s}$ ،

٤) نجد M_{beam} وهو قادم من وزن البلاطة (الجزء المخطط) ، لنسمي هذا العزم M_{beam1}





٥) نجد $M_{beam\,2}$ والذي يمثل وزن العتبة نفسها (اي الجزء غير المخطط اعلاه)،

$$W_{D_b} = [24 * b_w * (H-h) + W_1] * 1.2$$

W_1 هو وزن الجدار ووحدته KN/m

$$M_{o_b} = W_{D_b} * (l_n)^2 / 8$$

$$M_{beam2} = \text{Coeff.} * M_{o_b}$$

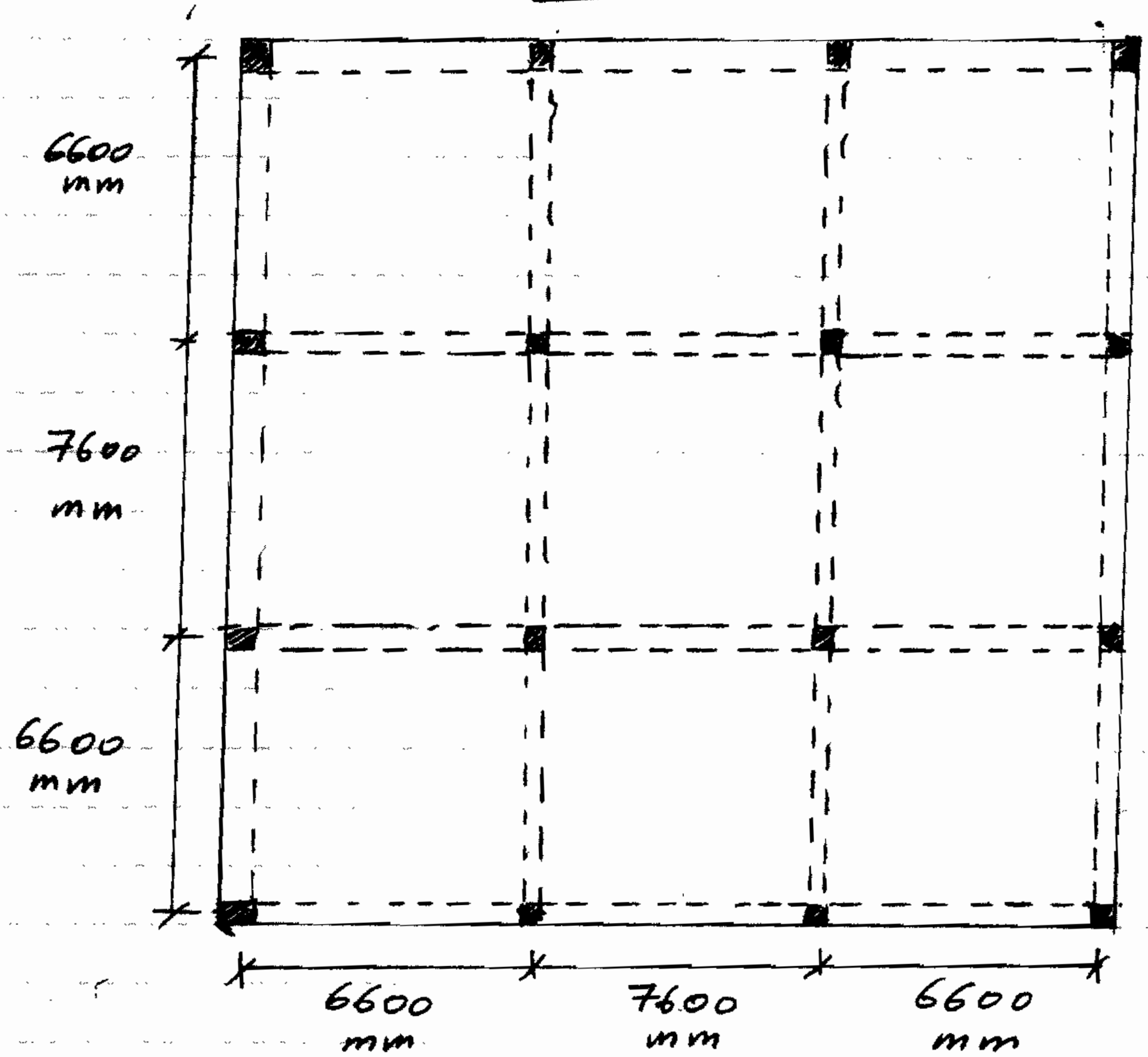
حيث .Coeff هو نفسه الذي تم استخدامه لاستخراج M_{-ve} او M_{+ve} في الخطوة (٢)،

٦) نجمع M_{beam1} مع $M_{beam\,2}$ ليصبح $M_{beam\,Total}$ في مكان محدد في العتبة

D.D.M

خطاب سليم

ex:



service live load = 4 kN/m^2

service superimposed dead load = 3.5 kN/m^2

Slab thickness = 200 mm

all beams = 300 * 700 mm

all columns = 300 * 300 mm

f'_c = 20 Mpa

f_y = 400 Mpa

Design internal strip

2

Sol.

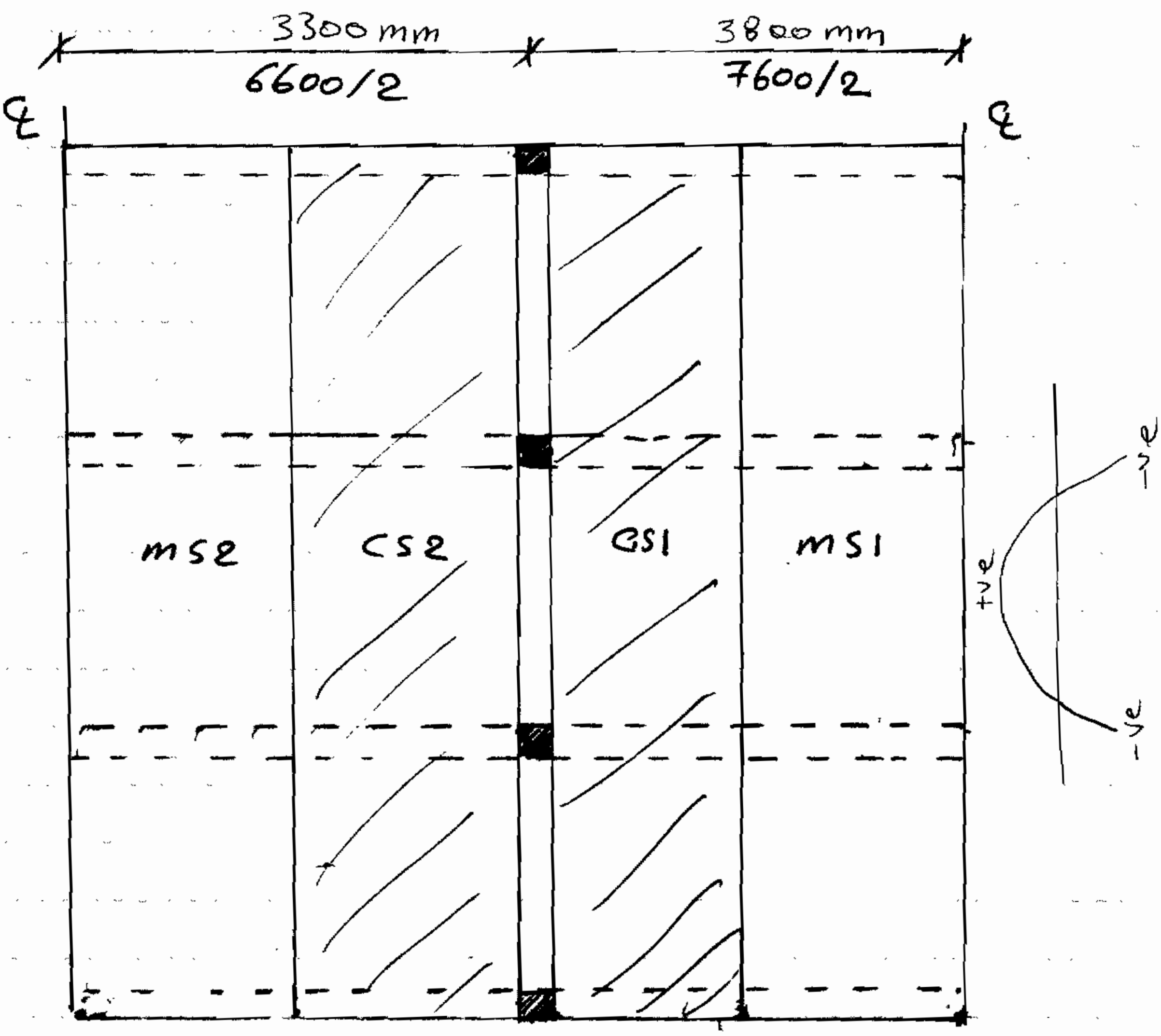
$$W_u = 1.2(3.5 + 0.2 * 24) + 1.6 * 4 = 16.36 \text{ kN/m}^2$$

$$l_2 = \frac{6.6}{2} + \frac{7.6}{2} = 7.1 \text{ m}$$

$$l_n = 7.6 - 0.3 = 7.3 \text{ m} > 0.65 * 7.6 = 4.94 \text{ o.k}$$

$$M_o = \frac{16.36 * 7.1 * 7.3^2}{8} = 773.744 \text{ kN.m}$$

$$M_{+ve} = 0.35 * 773.744 = 270.81 \text{ kN.m}$$



$$b_1 = 700 - 200 = 500 \text{ mm}$$
$$b_1 = 4 * 200 = 800 \text{ mm}$$
$$\Big\} \; b_1 = 500 \text{ mm}$$

$$\bar{y} = \frac{(700)^2 * \frac{300}{2} + 2 * 500 * \frac{200^2}{2}}{700 * 300 + 2 * 500 * 200} = 228 \text{ mm}$$

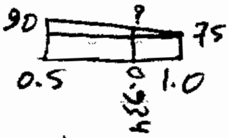
$$I_b = (2 * 500 + 300) * \frac{228^3}{3} + \frac{300}{3}(700 - 228)^3 - \frac{2 * 500}{3}(228 - 200)^3$$

$$I_b = 1.564 * 10^{10}$$

$$I_s = \frac{7100 * 200^3}{12} = 4.733 * 10^9 \text{ mm}^4$$

$$\alpha = \frac{1.564 * 10^{10}}{4.733 * 10^9} = 3.3 \qquad \frac{l_2}{l_1} = \frac{7100}{7600} = 0.934$$

$\alpha \frac{l_2}{l_1} = 3.083$ from table 1 coeff. $= 0.78$



$$\therefore M_{c.s} = 0.78 * 276.81 = 215.9118 \text{ kN.m}$$

$$\therefore M_{m.s.} = 270.81 - 215.9118 = 60.8982 \text{ kN.m}$$

هذا العزم سوف يتجزأ الى قسمين :

width of $C.S_1 = \frac{7600}{4}$ or $\frac{6600}{4}$ or $\frac{7600}{4}$ or $\frac{6600}{4} = 1650$ mm

width of $C.S_2 = \frac{6600}{4}$ or $\frac{6600}{4}$ or $\frac{7600}{4}$ or $\frac{6600}{4} = 1650$ mm

$\therefore$ width of $ms.1 = 3800 - 1650 = 2150$ mm

$\therefore$ width of $ms\,2 = 3300 - 1650 = 1650$ mm

$$\therefore M_{ms1} = 60.8982 * \frac{2150}{2150 + 1650} = 34.455 \text{ kN.m}$$

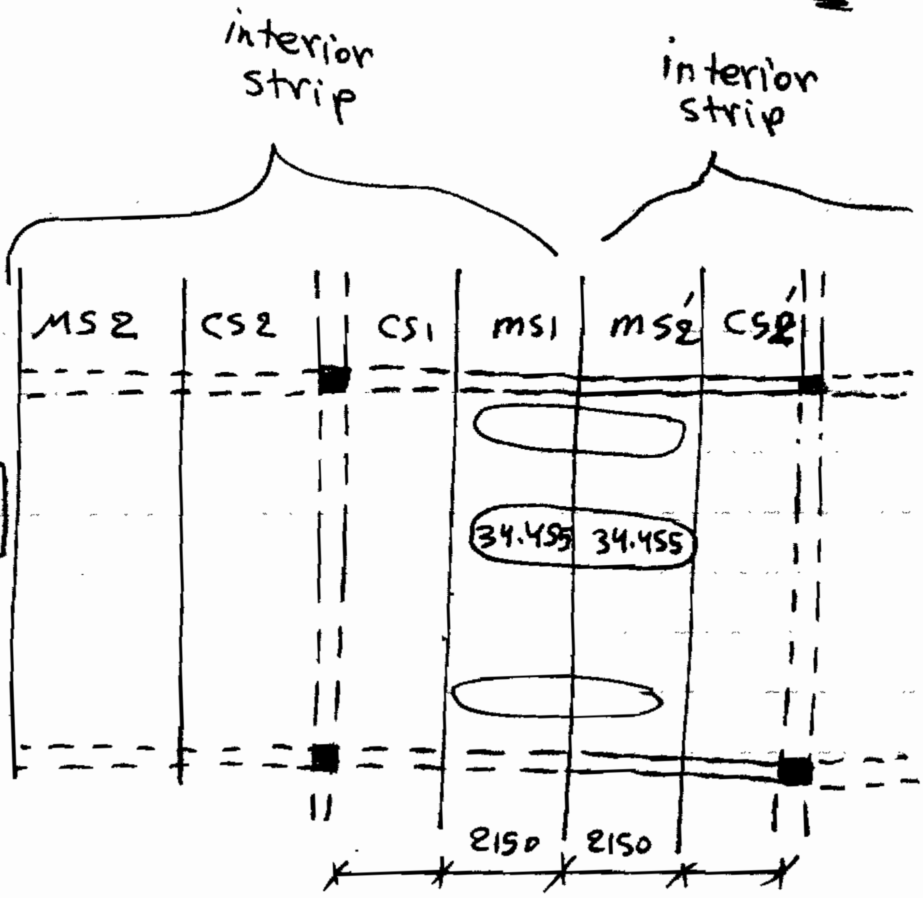
هذا العزم يمثل جزء من عزم ال m.s ولكي نجد جزءه الآخر يجب ان نحلل شريحة مجاورة ونجد Mms2 ونجمعهم . لكننا هنا سنكتفي بضرب 2 * Mms1 :

$$\therefore M_{m.s} = 2 * 34.455 = 68.91 \text{ kN.m}$$

<u>**Design:**</u> $M_u = 68.91$ kN.m

$b_{ms} = 4300$ mm, assume $\phi 12$ for Slab reinf.

$$d = 200 - 20 - \frac{12}{2} = 174 \text{ mm}$$



$$R_u = \frac{68.91 * 10^6}{0.9 \times 4300 * 174^2} = 0.588$$

$$m = 400/(0.85 * 20) = 23.53$$

$$\rho = \frac{1}{23.53}\left[1 - \sqrt{1 - \frac{2 * 0.588 * 23.53}{400}}\right]$$

$$\rho = 0.0015$$

$$\rho_{max} = 0.75 * 0.85 * 0.85 * \frac{20}{400} * \frac{600}{600+400}$$

$\rho_{max} = 0.0162 > \rho$ o.k

$As = 0.0015 * 1000 * 174 = 260.3 \ mm^2$

$As_{min} = 0.0018 * 200 * 1000 = 360 \ mm^2$

$AS < As_{min}$ ∴ use $As = As_{min} = 360 \ mm^2$

$$S = \frac{\frac{\pi}{4}(12)^2 * 1000}{360} = 314 \ mm$$

$S_{max} = 2 * 200 = 400 \ mm > S$ o.k

∴ use $\phi 12$ @ 310 mm c/c

H.W.

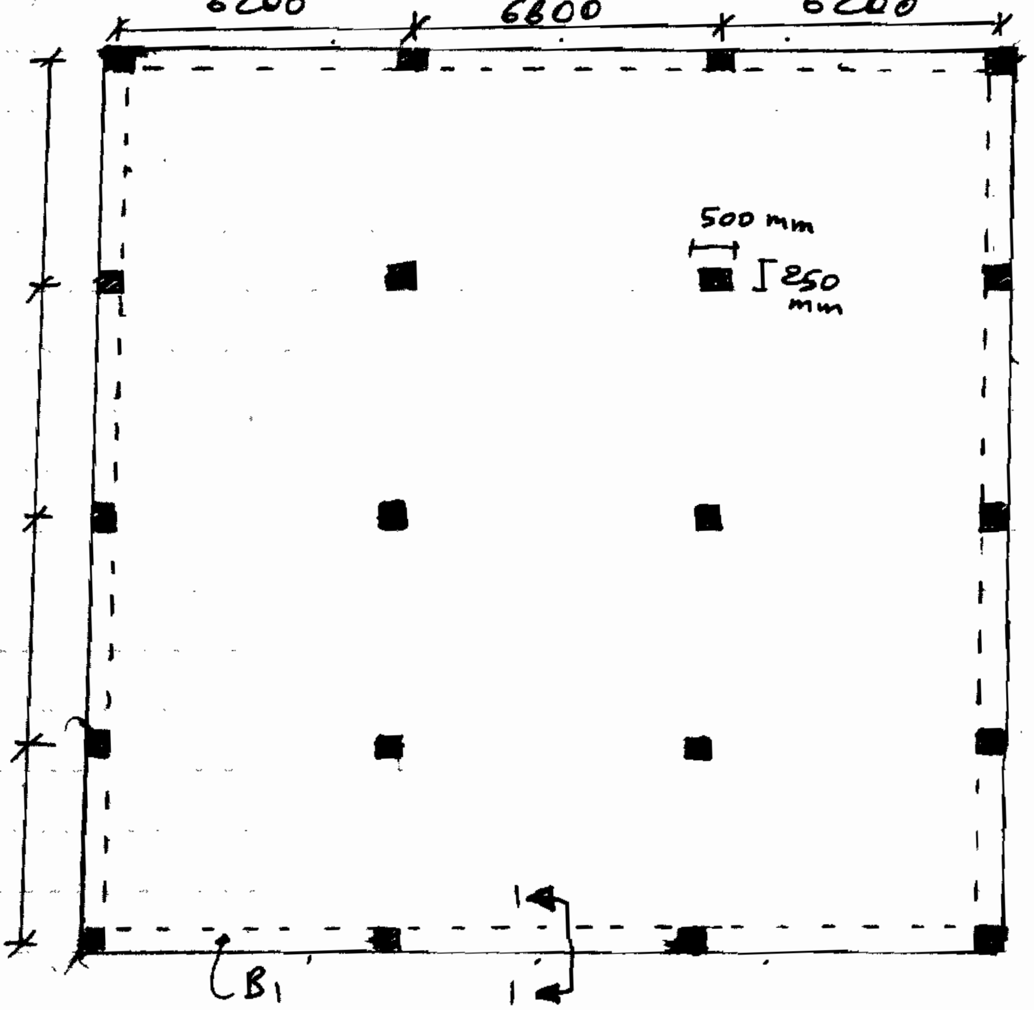
design for

$MS)_{-ve}$

..خطاب سليم

D.D.M.

ex:

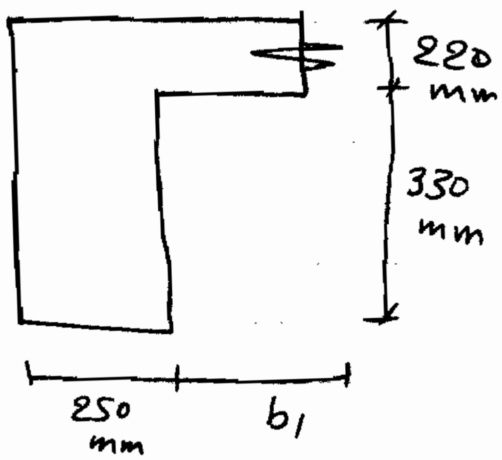


thickness = 0.22 m

$D_{add} = 3.5 \quad KN/m^2$

$LL = 1.2 \quad KN/m^2$

find M_{-ve} ext applied on B1.



Sol. Design B1 :

$W_{Ds} = 0.22 * 24 + 3.5 = 8.78 \quad KN/m^2$

$W_{us} = 1.2 * 8.78 + 1.6 * 1.2 = 12.456 \quad KN/m^2$

$l_2 = \frac{4900}{2} + \frac{250}{2} = 2575 \ mm \ , \ l_n = 6200 - 500 = 5700 \ mm$

$$M_o = \frac{12.456 * 2.575 * 5.7^2}{8} = 130.2613 \quad KN.m$$

coeff. = 0.3 from (table 2)

$\therefore M_{-ve})_{ext.} = 0.3 * 130.2613 = 39.07$ KN.m

$\bar{y} = 218$ mm , $I_b = 5.05 * 10^9$ mm^4

$I_s = \frac{2575 * (220)^2}{12} = 2.285 * 10^9$ mm^4

$b_1 = 4 * 220 = 880$ mm

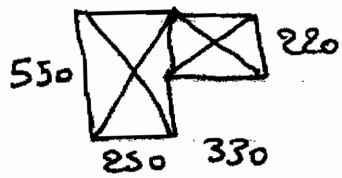
$b_1 = 550 - 220 = 330$ mm $\Big\}$ $\therefore b_1 = 330$ mm

$\alpha = \frac{I_b}{I_s} = \frac{5.05 * 10^9}{2.285 * 10^9} = 2.21$ $\qquad \frac{\ell_2}{\ell_1} = \frac{4900}{6200} = 0.79$

$\therefore \alpha \frac{\ell_2}{\ell_1} = 1.747$

$C = \left[1 - 0.63 \frac{250}{550}\right] \frac{(250)^3 * 550}{3} + \left[1 - 0.63 \frac{220}{330}\right] \frac{220^3 * 330}{3}$

$C = 2.724 * 10^9$ mm^4



$I_s = \frac{4900 (220)^3}{12} = 4.348 * 10^9$ mm^4

$\beta_t = \frac{2.724 * 10^9}{2 * 4.348 * 10^9} = 0.313$, from (table) coef. = 0.94

$\therefore M_{c.s} = 0.94 * 39.078 = 36.7337$ KN.m

$\therefore M_{b1} = 0.85 * 36.7337 = 31.223$ KN.m

To find M_{b2}: $W_{u2} = 1.2 * 0.25 * 0.33 * 24 = 2.376$ KN/m

$M_o)_2 = \frac{2.376 * (5.7)^2}{8} = 9.64953$ KN.m

$\therefore M_{b2}) = 0.3 * 9.649 = 2.8948$ KN.m

-ve. at $\therefore M_b) = M_{b1} + M_{b2} = 31.228 + 2.8948 = 34.123$ KN.m

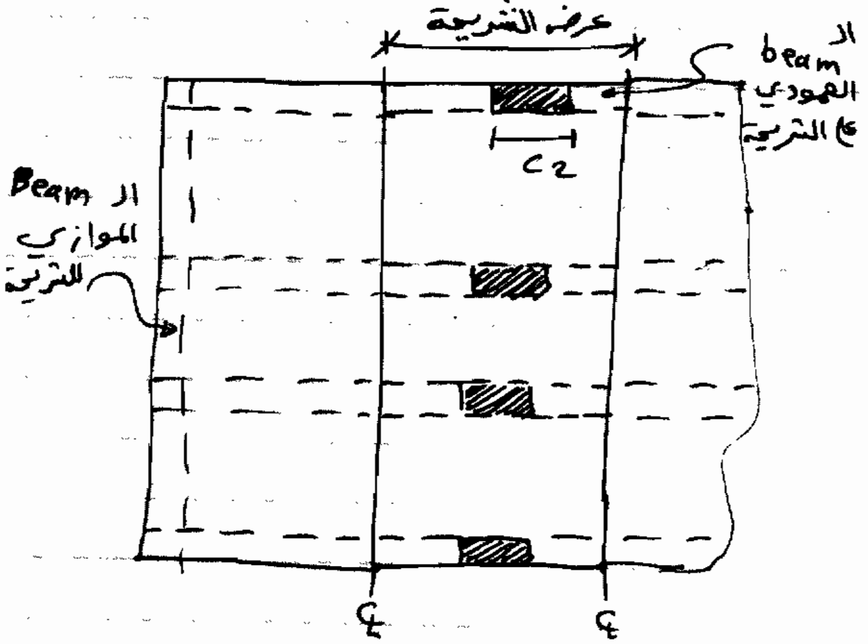
المحاضرة الرابعة D.D.M.

حالات خاصة لطريقة D.D.M. :

1) لا يتم تجزئة $M_{-ve\ ext}$ الى $M_{c.s}$ و $M_{m.s}$ في حالة كون: $c_2 \geq \frac{3}{4}$ (عرض الشريحة)

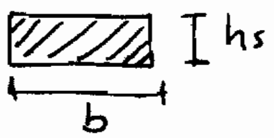
حيث نصمم $M_{-ve\ ext}$ وعرضها

b هو عرض الشريحة المقصودة.



2) في حالة عدم وجود (beam) عمودي ع الشريحة في الـ (End span) وعدم وجود (column) وانما يوجد فقط (Wall) فعندها لا يتم تجزئة $M_{-ve\ ext.}$ الى $M_{c.s}$ و $M_{m.s}$ بل تصمم المنطقة ع $M_{-ve\ ext.}$ فقط الا ان قيمة b هي عرض الشريحة سواء interior أو End. (b تدخل بقانون Ru).

3) في حالة عدم وجود (beam) عمودي ع الشريحة في الـ (end span) لكن يوجد (column) فعندها يتم تجزئة $M_{-ve\ ext.}$ الى $M_{c.s}$ و $M_{m.s}$ لكن شكل المقطع لحساب $M_{c.s}$ هو:



hs : سماكة السقف

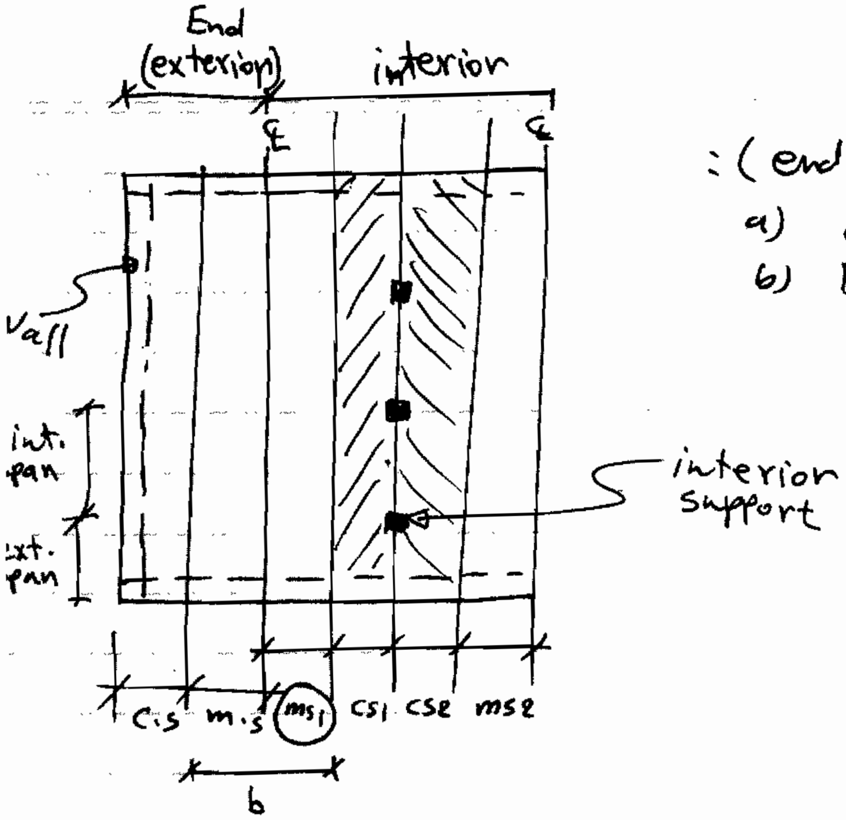
b : بعد العمود الموازي لعرض الشريحة

$I_b = 0$

$\alpha = \frac{I_b}{I_s} = 0$

4) في الـ (End strip) في حالة عدم وجود (beam) موازي لها وكان مكانه (Wall) فعندها لا يتم استخراج اي عزم من (End strip). ولن نصمم الـ C.S فيها. فلذلك نلجأ الى الشريحة المجاورة (interior strip) ونجد m.s القريب من الـ (end strip)

2



ونضربه $2*$ ونصمم به ال (end strip) :

a) find ms_1

b) Design, $M_u = 2 * ms_1$

$b = b_{ms} + b_{ms_1}$

٥) لزوم (m.s) دائماً تجمع حيث نحلل ال (end strip) ونجد (ms.) ونحلل (interior strip) ونجد ms1 ، نجمعهما ونصمم بالمجموع.

٦) عند الرغبة بتصميم ال (interior support) باستخدام العزم M-ve :

1) for interior span : find M_o , find $M_{-ve})_{int.}$ و find $M_{c.s}$ or $M_{m.s}$ (حسب السؤال)

$\therefore m_1 = M_{c.s}$ or $M_{m.s}$

2) for exterior span : find M_o, find $M_{-ve})_{int}$, find $M_{c.s}$ or $M_{m.s}$ (حسب السؤال)

$\therefore m_2 = M_{c.s}$ or $M_{m.s}$

$\therefore M_u = \max\{m_1 , m_2\}$

ع

٧) في الشريحة (interior strip) وعند تصميم منطقة C.S ، في حالة عدم وجود (beam) موازي للشريحة هذا يعني ان ($M_{c.s}$) لا يتجزء الى (M_{cs1}) و (M_{cs2}) وانما يكون ($M_{c.s}$) هو العزم التصميمي ، اما قيمة b الداخلة في R_u تكون : $b = width\ C.S_1 + width\ C.S_2$

٨) في الشريحة (interior strip) وعند تصميم منطقة C.S ، في حالة وجود (beam) موازي للشريحة هذا يعني ان ($M_{c.s}$) يتجزأ الى M_{cs1} و $M_{c.s2}$

$$M_{c.s1} = M_{c.s} * \frac{width\ C.S1}{width\ C.S1 + width\ C.S2}$$

$$M_{c.s2} = M_{c.s} * \frac{width\ CS2}{width\ C.S1 + width\ C.S2}$$

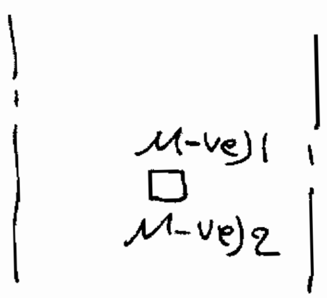
اما قيمة b في R_u :

$$b_{c.s1} = width\ c.s1 - \frac{b_w}{2}$$

$$b_{c.s2} = width\ C.S2 - \frac{b_w}{2}$$

٩) في حالة تصميم/ال منطقة internal support فان ال M_{-ve} الذي نعتمده هو الاكبر الذي نحصل عليه من الفضاءات المتجاورة .

$$M_{-ve} = \max\{M_{-ve)1}, M_{-ve)2}\}$$



المحاضرة الرابعة

D.D.M

خطاب سليم

Ex: Concrete walls around, cast monolithically with the slab

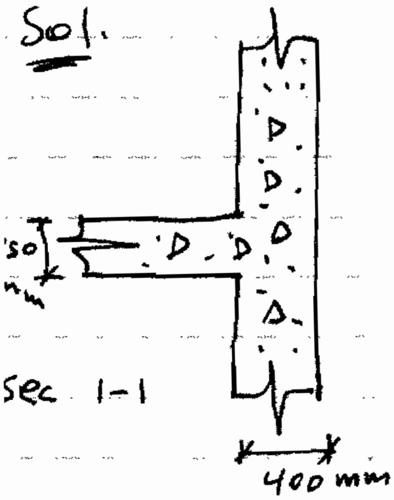
S.S.I.D.L = 1.6 kN/m^2 (superimposed)

S.L.L. = 3.6 kN/m^2

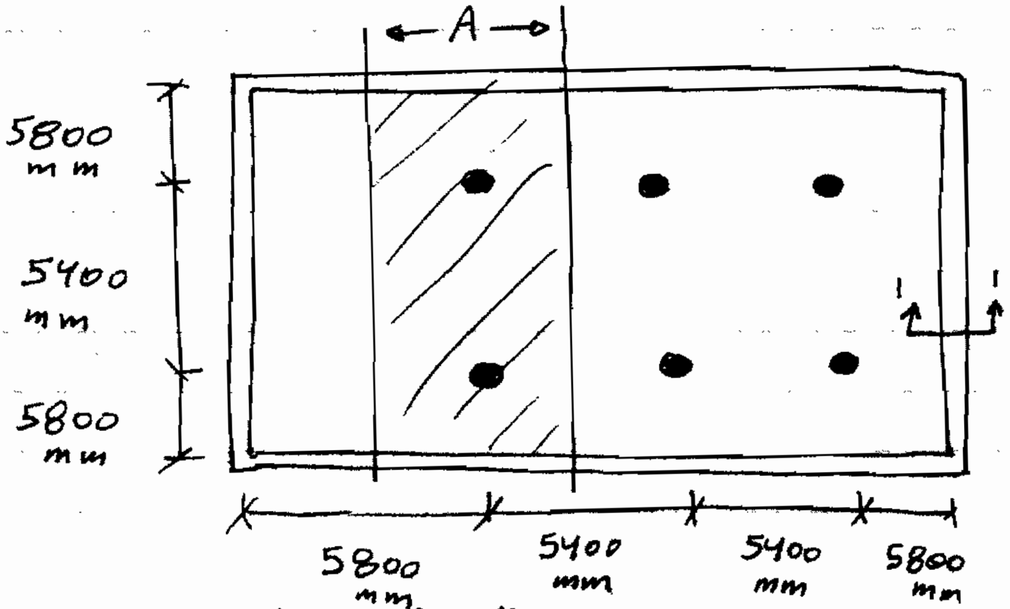
slab thickness = 250 mm, wall thickness = 400 mm, col. dia. = 450 mm, f_c' = 25 Mpa, f_y = 400 N/mm^2, use $\phi 12$ mm for slab reinf.

Design and determine the col. strip top reinf. at interiour supports of strib (A).

Sol.



Sec 1-1



note: all dimensions are c/c.

$$W_D = 1.6 + 0.25 * 24 = 7.6 \quad kN/m^2$$

$$W_u = 1.2 * 7.6 + 1.6 * 3.6 = 14.88 \quad kN/m^2$$

first: At end span:

$$a = \sqrt{\frac{\pi}{4}(450)^2} = 398.8 \text{ mm}, \quad l_2 = \frac{5400+5800}{2} = 5600 \text{ mm}$$

$$l_n = 5800 - \frac{398.8}{2} - \frac{400}{2} = 5400.6 \text{ mm}$$

$$\therefore M_o = 14.88 * 5.6 * (5.4006)^2 / 8 = 303.798 \quad kN.m$$

from table 2 $\quad$ Coef = 0.65

$$\therefore M_{-ve)_{int.}} = 0.65 * 303.798 = 197.4 \quad kN.m$$

$\alpha = 0$, table1, $\therefore M_{c.s} = 0.75 * 197.468 = 148.1$ kN.m

second: At interior span:

$a = 398.8$, $l_2 = 5600$, $l_n = 5400 - \frac{398.8}{2} - \frac{398.8}{2} = 5001.2$ mm

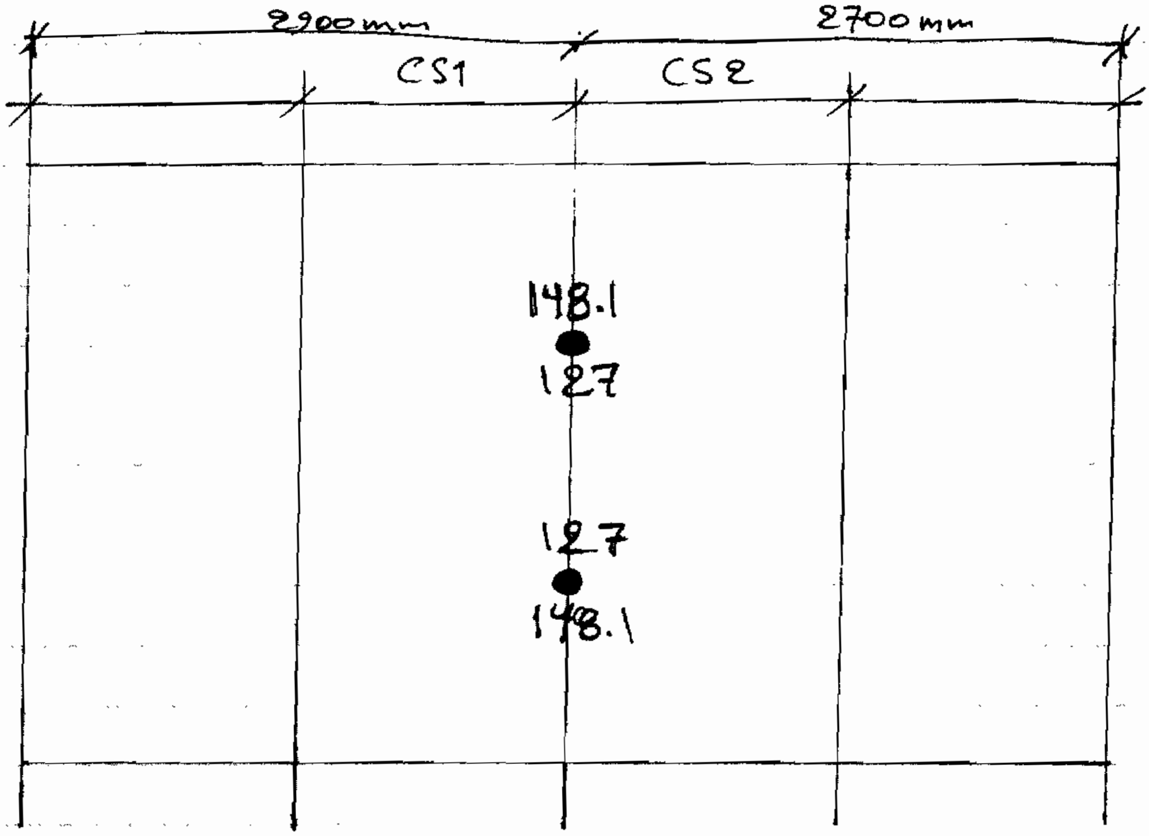
$M_o = 14.88 * 5.6 * (5.0012)^2 / 8 = 260.525$ kN.m

$M_{-ve} = 0.65 * 260.525 = 169.34125$ kN.m

$\alpha = 0$ from table(1) Coef $= 0.75$

$M_{c.s} = 0.75 * 169.34125 = 127$ kN.m

$\therefore$ use $M_{c.s} = 148.1$ kN.m



To find $b_{c.s}$:-

width of CS1 $= \frac{5800}{4}$ or $\frac{5400}{4}$ or $\frac{5800}{4} = 1350$ mm

width of CS2 $= \frac{5400}{4}$ or $\frac{5800}{4}$ or $\frac{5400}{4} = 1350$ mm

$b_{cs} = 1350 + 1350 = 2700$ mm

Design: $M_u = 148.1$ kN.m $\quad b = 2700$ mm

$d = d_s = h - 20 - 0.5*12 = 224$ mm

$$R_u = \frac{148.1 * 10^6}{0.9 * d^2 * 2700} = 1.214$$

$$m = \frac{400}{0.85 * 25} = 18.823 \qquad \rho = \frac{1}{18.823}\left[1 - \sqrt{1 - \frac{2 * 1.214 * 18.823}{400}}\right]$$

$\therefore \rho = 0.003128$, $\rho_{max} = 0.75\left[0.85 * 0.85 * \frac{25}{400} * \frac{600}{600+400}\right]$
$= 0.02$

$\rho < \rho_{max}$ <u>o.k</u>

$A_s = 0.00312 * 1000 * 224\,mm = 700.84\ mm^2$

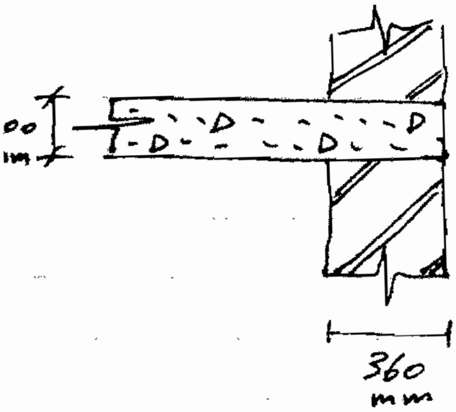
$A_{s\,min} = 0.0018 * 1000 * 250 = 450\ mm^2 < A_s$ <u>o.k</u>

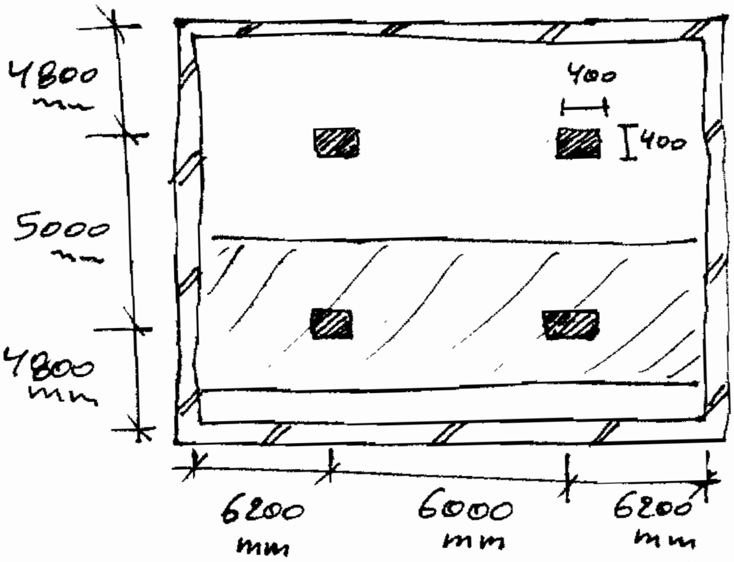
$$S = \frac{\frac{\pi}{4}(12)^2 * 1000}{700.84} = 161.29$$

$S_{max} = 2 * 250 = 500 > S \quad \therefore$ <u>o.k</u>

$\therefore$ use ϕ 12 @ 160 mm c/c

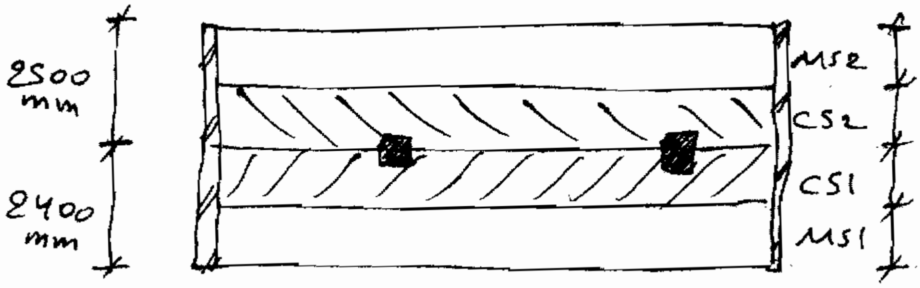
ex: Concrete Slab Supported by Brick walls, S.L.L = 2.8 kN/m^2 and S.S.I.D.L. = 3.5 kN/m^2, h = 200 mm, Col. = 400 mm × 400 mm, f'_c = 22 Mpa, f_y = 300 N/mm^2. find $M_{(c.s)critical}$





Sol $L.L = 2.8\ kN/m^2$ $\quad$ $S.I.D = 3.5\ kN/m^2$

$h_s = 200\ mm$



$$\text{width } C.S1 = \frac{4800}{4} \text{ or } \frac{6200}{4} \text{ or } \frac{6000}{4} \text{ or } \frac{6200}{4} = 1200\ mm$$

$$\text{width } C.S2 = \frac{5000}{4} \text{ or } \frac{6200}{4} \text{ or } \frac{6000}{4} \text{ or } \frac{6200}{4} = 1250\ mm$$

ملاحظة: هنا لا يتم تجزئة عزوم (C.S) لعدم وجود beams موازية للشريحة
وانما يوجد جدار طابوقي.

∴ width of c.s = 1200 + 1250 mm = 1450 mm

to find $M_{c.s}$ at critical section

first: At interior span:

$$W_u = 1.2\,(3.5 + 0.2 * 24) + 1.6 * 2.8 = 14.44 \text{ kN/m}^2$$

$$l_2 = \frac{4.8}{2} + \frac{5}{2} = 4.9 \text{ m}$$

$$l_n = 6 - 0.4 = 5.6 > 0.65 * 6 = 3.9 \text{ m} \quad \text{o.K}$$

$$M_o = \frac{14.44 * 4.9\,(5.6)^2}{8} = 277.363 \text{ KN.m}$$

$$M_{-ve} = 0.65 * 277.363 = 180.2859 \text{ KN.m}$$

$$M_{+ve} = 0.35 * 277.363 = 97.077 \text{ KN.m}$$

* Distribution of $M_{-ve} = 180.2859$, $\alpha = 0$

$$\therefore M_{c.s} = 0.75 * 180.2859 = 135.214 \text{ KN.m}$$

* Distribution of $M_{+ve} = 97.077$ KN.m , $\alpha = 0$

$$\therefore M_{c.s} = 0.6 * 97.077 = 58.246 \text{ KN.m}$$

Second: At End Span

$W_u = 14.44$ KN/m², $l_2 = 4.9$ m, $l_n = 6.2 - \frac{0.4}{2} - \frac{0.36}{2} = 5.82$ m $> 0.65 * 6.2$ o.k

$$M_o = \frac{14.44 * 4.9 * (5.82)^2}{8} = 299.584 \text{ KN.m}$$

$$M_{-ve})_{int} = 0.7 * 299.584 = 209.709 \text{ KN.m}$$

$$M_{+ve} = 0.52 * 299.584 = 155.78 \text{ KN.m}$$

$$M_{-ve})_{ext} = 0.26 * 299.584 = 77.89 \text{ KN.m}$$

* Distribution of $M_{-ve})_{int} = 209.709$ KN.m

$\alpha = 0$, $M_{c.s} = 0.75 * 209.707 = 157.28$ KN.m

* Distribution of $M_{+ve} = 155.78$ KN.m

$\alpha = 0$, $M_{c.s} = 0.6 * 155.78 = 93.468$ KN.m

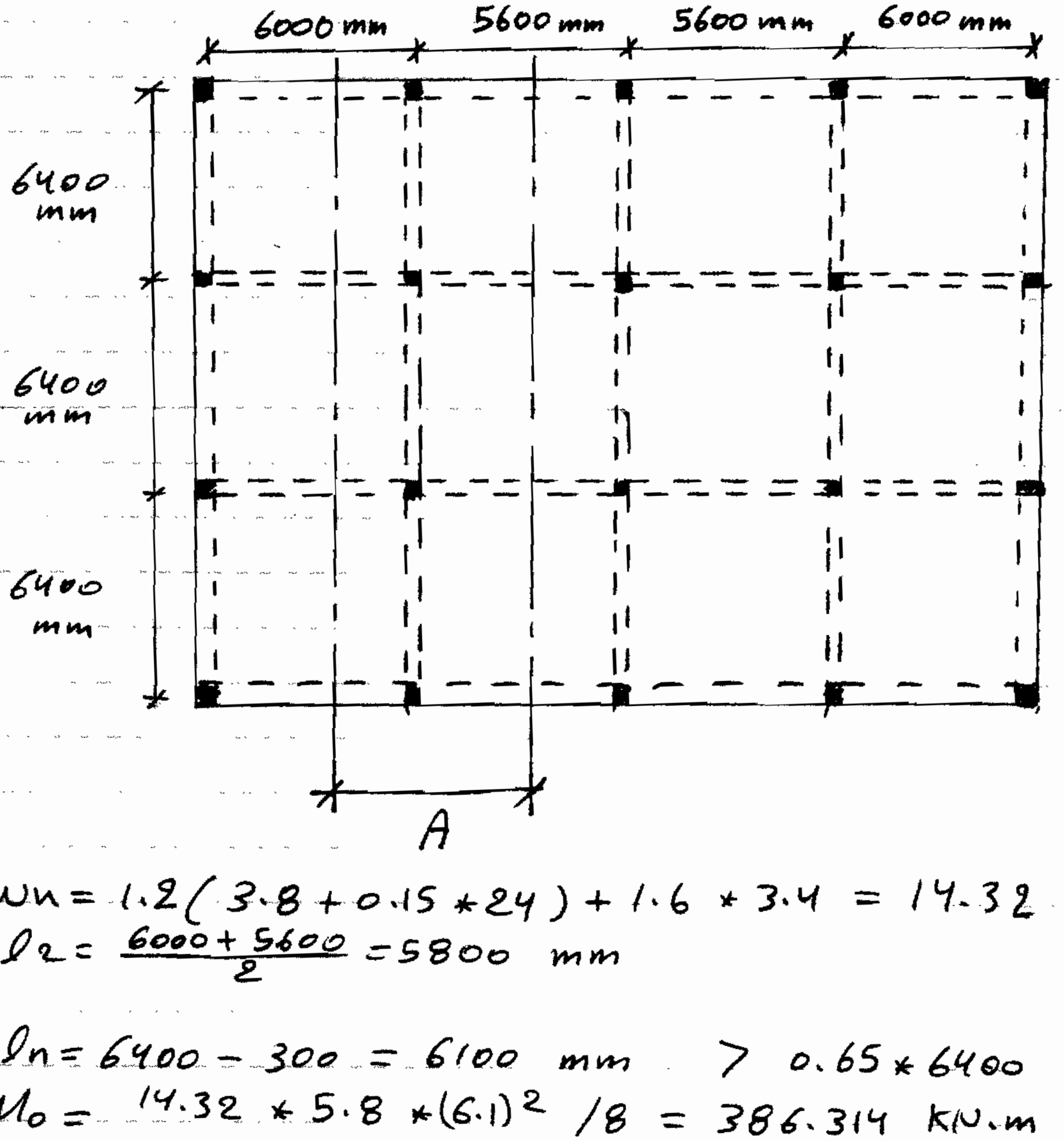
* Distribution of $M_{-ve})_{ext} = 77.89$ KN.m

ملاحظة: لا يتم تجزئة $M_{-ve})_{ext}$ الى (c.s) و (m.s) وذلك لعدم وجود beam موازية للشريحة

وبالتالي يكون $M_{c.s})_{critical}$ هو الأكبر ،

$\therefore M_{c.s})_{critical} = 157.28$ KN.m

Ex: service super imposed dead load = 3.8 KN/m^2
service live load = 3.4 KN/m^2
$h = 150$ mm , all beams = 300 mm * 600 mm
all Col. = 300 mm * 300 mm , Use $\phi 12$ mm bars
$f'c = 21$ N/mm^2 , $fy = 350$ N/mm^2 , Analyze End span of (A) strip.



Sol.

$$Wu = 1.2(3.8 + 0.15 * 24) + 1.6 * 3.4 = 14.32 \ KN/m^2$$

$$l_2 = \frac{6000 + 5600}{2} = 5800 \ mm$$

$$l_n = 6400 - 300 = 6100 \ mm \ > 0.65 * 6400 \quad o.k$$

$$M_o = 14.32 * 5.8 * (6.1)^2 / 8 = 386.314 \ KN.m$$

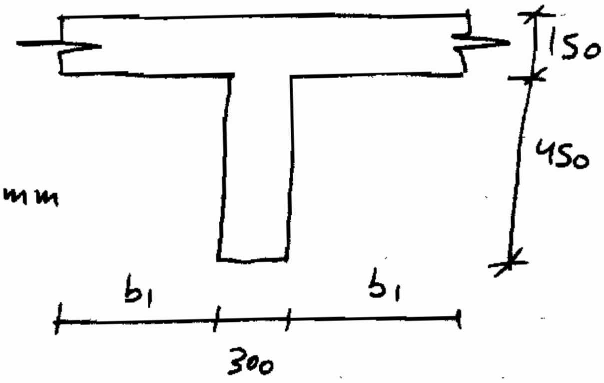
$$M_{-ve})_{int.} = 0.7 * 386.314 = 270.4198 \ KN.m \ \text{(table2)}$$

$$M_{+ve} = 0.57 * 386.314 = 220.198 \ KN.m \ \text{(table2)}$$

$$M_{-ve})_{ext.} = 0.16 * 386.314 = 61.81 \ KN.m \ \text{(table 2)}$$

first: $M_{-ve})_{int} = 270.419$ kN.m

$b_1 = 4 * 150 = 600$ mm
$b_1 = 600 - 150 = 450$ mm $\Big\}$ $b_1 = 450$ mm



$$\bar{y} = \frac{(600)^2 * \frac{300}{2} + 2*450 * \frac{(150)^2}{2}}{600 * 300 + 2*450 * 150} = 203.6 \text{ mm}$$

$\therefore I_b = 9.56 * 10^9$ mm^4
$I_s = 9.1687 * 10^9$ mm^4

$\alpha = \frac{I_b}{I_s} = 1.043$, $\frac{l_2}{l_1} = 0.906$, $\alpha \frac{l_2}{l_1} = 0.94$

table 1 coef $= 0.78$

$M_{c.s} = 0.78 * 270.419 = 210.926$ kN.m
$M_{beam} = 0.945 * 0.85 * 210.926 = 169.426$ kN.m
$M_{slab} = 210.926 - 169.426 = 41.499$ kN.m
$M_{m.s} = 270.419 - 210.926 = 59.493$ kN.m

width CS1 $= \frac{6000}{4}$ or $\frac{6400}{4}$ or $\frac{6400}{4}$ or $\frac{6400}{4} = 1500$ mm

width CS2 $= \frac{5600}{4}$ or $\frac{6400}{4}$ or $\frac{6400}{4}$ or $\frac{6400}{4} = 1400$ mm

width MS1 $= \frac{6000}{2} - 1500 = 1500$ mm

width MS2 $= \frac{5600}{2} - 1400 = 1400$ mm

$\therefore M_{c.s})_{slab} = 41.465$ kN.m

$\therefore M_{c.s_1} = 41.465 * \frac{1500}{1400+1500} = 21.465$ kN.m
$\therefore M_{c.s2} = 41.465 * \frac{1400}{1400+1500} = 20.03$ kN.m

3

$\because M_{m.s} = 59.493$ KN.m

$\therefore M_{ms1} = 59.493 * \frac{1500}{2900} = 30.772$ KN.m

$\therefore M_{ms2} = 59.493 * \frac{1400}{2900} = 28.72$ KN.m

Second: $M_{+ve} = 220.198$ KN.m

$I_b = 9.56 * 10^9 \; mm^4$, $I_s = 9.168 * 10^9 \; mm^4$

$\alpha = 1.043$, $\frac{\ell_2}{\ell_1} = 0.906$, $\alpha \frac{\ell_2}{\ell_1} = 0.945$

from table 1 coef $= 0.78$

$M_{c.s} = 0.78 * 220.198 = 171.754$ KN.m

$M_{beam} = 0.945 * 0.85 * 171.754 = 137.96$ KN.m

$M_{slab} = 171.754 - 137.96 = 33.7922$ KN.m

$M_{m.s} = 220.198 - 171.754 = 48.444$ KN.m

$\because M_{c.s)_{slab}} = 33.7922$

$\therefore M_{c.s1} = 33.7922 * \frac{1500}{2900} = 17.478$ KN.m

$\therefore M_{c.s2} = 33.7922 * \frac{1400}{2900} = 16.313$ KN.m

$\because M_{m.s} = 48.444$

$\therefore M_{ms1} = 48.444 * \frac{1500}{2900} = 25.057$ KN.m

$\therefore M_{ms2} = 48.444 * \frac{1400}{2900} = 23.386$ KN.m

third: $M_{-ve})_{ext.} = 61.81$ KN.m

$I_b = 9.56 * 10^9 \; mm^4$, $I_s = 9.687 * 10^9 \; mm^4$

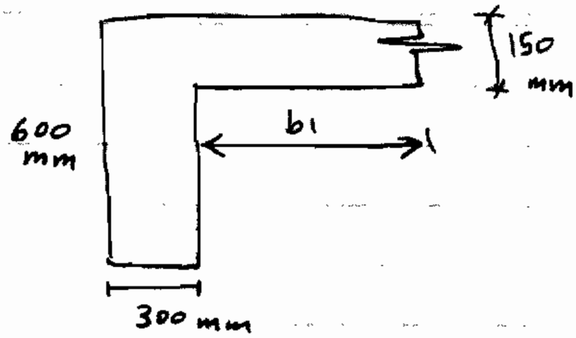
$\frac{\ell_2}{\ell_1} = 0.906$, $\alpha = 1.043$, $\alpha \frac{\ell_2}{\ell_1} = 0.905$

$b_1 = 4 * 150 = 600$ $b_1 = 600 - 150 = 450$ $\therefore b_1 = 450$ mm

4

$$C = \left(1 - 0.63\frac{300}{600}\right)\frac{600}{3}(300)^3 +$$

$$\left(1 - 0.63\frac{150}{450}\right)\frac{450}{3}(150)^3 = 4.0989 \times 10^9 \text{ mm}^4$$



$$I_{s_1} = \frac{6000(150)^3}{12} = 1.687 \times 10^9 \text{ mm}^4$$

$$\therefore \beta t_1 = \frac{4.0989 \times 10^9}{2 \times 1.687 \times 10^9} = 1.2145$$

$$I_{s_2} = \frac{5600(150)^3}{12} = 1.575 \times 10^9$$

$$\therefore \beta t_2 = \frac{4.098 \times 10^9}{2 \times 1.575 \times 10^9} = 1.304 \qquad \therefore \beta_t = \frac{\beta t_1 + \beta t_2}{2} = 1.258$$

table 1 , coeff. = 0.875

$\therefore M_{c.s} = 0.875 \times 61.84 = 54.11$

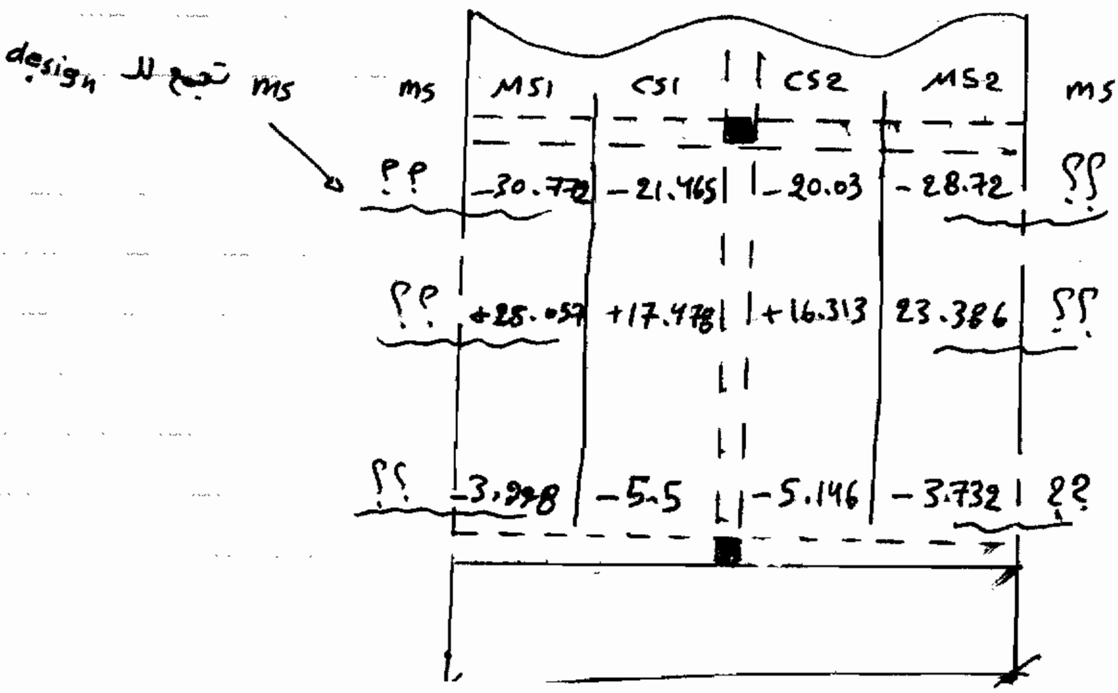
$M_{beam} = 0.945 \times 0.85 \times 54.11 = 43.463$ KN.m

$M_{slab} = 54.11 - 43.463 = 10.646$ KN.m

$M_{m.s} = 61.84 - 54.11 = 7.73$ KN.m

$\therefore M_{cs_1} = 5.5$ KN.m , $M_{ms_1} = 3.998$ KN.m

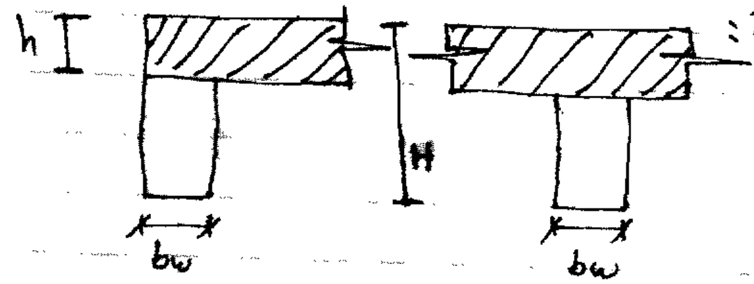
$M_{cs2} = 5.146$ KN.m , $M_{m.s2} = 3.732$ KN.m



المحاضرة الخامسة   Direct Design Method

Design of Beam

من المعلوم ان تصميم العتبة يكون ضمن الشريحة المعناة، حيث نجد M_o ثم M_{-ve} او M_{+ve} ثم نجد M_{cs} و نجزئها M_{beam} كما عرفنا سابقاً". وكذلك علمنا سابقاً" ان العزم M_{beam} قادم من قطعة السقف التي تعلو العتبة:



وبذلك نسميه M_{beam} ب M_1.

ثم نجد العزم القادم من الجزء غير المؤشر اعلاه:

$$W_{D_{beam}} = [24 * b_w * (H-h) + w_1] * 1.2$$

w_1: الحمل فوق العتبة وعادة يكون وزن الجدار.

$$\therefore M_o = \frac{W_{D_{beam}} * (l_n)^2}{8}$$

l_n: نفس البعد المستخدم لاستخراج M_o.

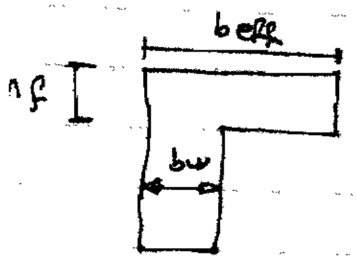
$$\therefore M_2 = coff. * M_o$$

coff: نفس الfactor الذي تم ضربه * M_o الاول لغرض تحويله الى M_{-ve} او M_{+ve}.

$$\therefore M_{total} = M_1 + M_2$$ العزم التصميمي

والآن نحدد ابعاد العتبة:

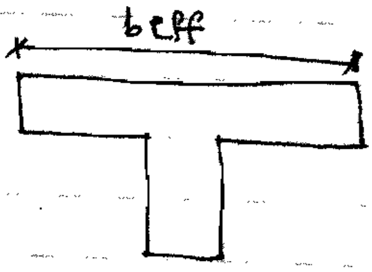
اذا كانت عتبة طرفية edge beam:



$$\min \begin{cases} b_{eff} = \frac{l_{c/c}}{12} + b_w \\ b_{eff} = 6 * h_f + b_w \\ b_{eff} = \frac{l_n}{2} + b_w \end{cases}$$

حيث: $l_{c/c}$ هو طول العتبة c/c و l_n المسافة الصافية من العتبة المقصودة الى العتبة الموازية (اي البعد عمودي على الشريحة)

اما اذا كانت عتبة وسطية interior beam:



$$\min \begin{cases} b_{eff} = \frac{l_{c/c}}{4} \\ b_{eff} = b_w + 16\, h_f \\ b_{eff} = l_n + b_w \end{cases}$$

اولاً: التصميم للعزم السالب (M-ve):

$$\rho_{max} = 0.75\left[0.85\beta_1 * \frac{f'_c}{f_y} * \frac{600}{600+f_y}\right]$$

$\beta_1 = 0.85$ if $f'_c \leq 30$

$\beta_1 = 0.85 - 0.008\,[f'_c - 30]$ if $f'_c > 30$

$\beta_1\ min = 0.65$

$$Mu)_{max} = \phi\,\rho_{max} \cdot bw \cdot d^2 \cdot f_y\left[1 - 0.59\,\rho_{max}\frac{f_y}{f'_c}\right] * 10^{-6}$$

$\phi = 0.9$

$d = H - 70\,mm$

Compare: $M_{b\,total}$ with $Mu)_{max}$

اولاً: if $M_{b\,total} \leq Mu_{max}$

$$\therefore R_u = \frac{M_{b\,total} * 10^6}{0.9 * bw * d^2} \qquad m = \frac{f_y}{0.85 * f'_c}$$

$$\rho = \frac{1}{m}\left[1 - \sqrt{1 - \frac{2 * R_u * m}{f_y}}\right] \geq \rho_{min} = \frac{1.4}{f_y}$$

$$\therefore As = \rho * bw * d \qquad \therefore No. = \frac{As}{\frac{\pi}{4}(\phi)^2}$$

ثانياً: if $M_{b\,total} > Mu)_{max}$

$As_1 = \rho_{max} * bw * d$ $\qquad Mu_2 = M_{b\,total} - Mu)_{max}$

$Mu_2 * 10^6 = As_2 * f_y\,(d - d') * 0.9 \Longrightarrow$ find As_2, $d' = 70\,mm$

$\therefore As = As_1 + As_2$ $\qquad a = \dfrac{As_1 * f_y}{0.85 * f'_c * bw}$ $\qquad c = \dfrac{a}{\beta_1}$

$f'_s = 600\left(\dfrac{c-d}{c}\right)$

compare if $f'_s \leq f_y$ $\therefore$ o.k

if $f'_s > f_y$ n.o.k $\therefore$ use $f'_s = f_y$

find $\overline{As}$: $\overline{As} * f'_s = As_2 * f_y$

3

ثانياً: التصميم للعزم الموجب (M+ve)

find A_s^* :

$$M_{b\,total} * 10^6 = 0.9 * A_s^* * f_y * \left(d - \frac{h_f}{2}\right) \quad , d = H - 70$$

find a_1 :

$$A_s^* * f_y = 0.85\, f_c' * b_{eff} * a_1$$

compare a_1 with h_f

أولاً: if $a_1 \leq h_f$ (مستطيل) $\therefore R_u = \dfrac{M_{b\,total} * 10^6}{0.9 * b_{eff} * d^2}$

$$\mu = \frac{f_y}{0.85 * f_c'} \qquad \therefore \rho = \frac{1}{\mu}\left[1 - \sqrt{1 - \frac{2 * R_u * \mu}{f_y}}\right]$$

$$A_s = \rho * b_{eff} * d \geq \frac{1.4}{f_y} * b_w * d$$

ثانياً: if $a_1 > h_f$ (T-beam)

find A_{s1} : $A_{s1} = \dfrac{0.85\, f_c' \,(b_{eff} - b_w)\, h}{f_y}$ مساحة الحديد التي تعادل انضغاط الجناح

العزم الذي يعادل انضغاط الجذع

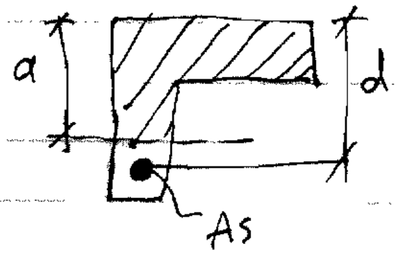
$$M_{u1} = 0.9\, A_{s1} * f_y \left[d - \frac{h_f}{2}\right] * 10^{-6}$$

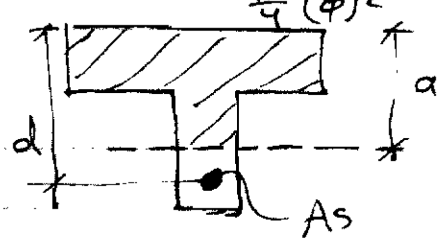
$$M_{u2} = M_{b\,total} - M_{u1} \qquad R_u = \frac{M_{u2} * 10^6}{0.9 * b_w * d^2}$$

$$\mu = \frac{f_y}{0.85\, f_c'} \qquad \rho = \frac{1}{\mu}\left[1 - \sqrt{1 - \frac{2 * R_u * \mu}{f_y}}\right]$$

$$A_{s2} = \rho\, b_w\, d \qquad A_s = A_{s1} + A_{s2}$$

$$\therefore No. = \frac{A_s}{\frac{\pi}{4}(\phi)^2}$$





تسليح العزم الموجب

ملاحظة: هذه الخطوات تخص كلا العتبتين الطرفية والوسطية .

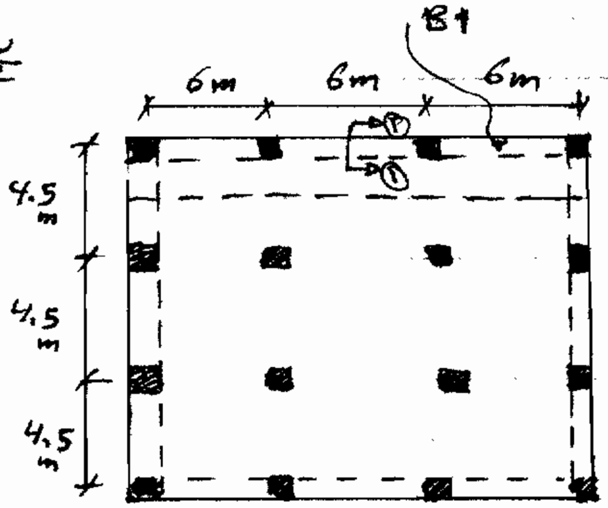
ملاحظة: بعد إيجاد عدد القضبان يجب ان نحقق ال spacing :

$S \geq$

- $25\,mm$
- ϕ_b (قطر القضيب)
- $\frac{4}{3}$ المقاس الاقصى للركام

5

Ex: DL total = 6.6 kN/m^2, S.L.L. = 2.8 kN/m^2, $h_f = 210$ mm
edge beams = 300 * 550 mm, cols = 300 * 300 mm, $f'_c = 28$ MPa, $f_y = 400$ N/mm^2, Design B1 at negative moment ext.



Sol. $W_u = 1.2 * 6.6 + 1.6 * 2.8 = 12.4 \ \frac{kN}{m^2}$

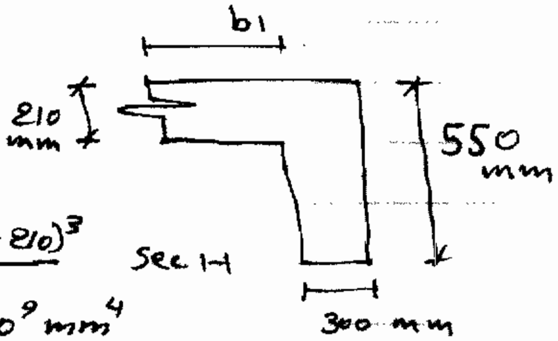
$$l_e = \frac{4.5}{2} + \frac{0.3}{2} = 2.4 \text{ m}$$

$l_n = 6 - 0.3 = 5.7 > 0.65 * 6$ o.k

$$M_o = \frac{12.4 * 2.4 * (5.7)^2}{8} = 120.8628 \text{ kN.m}$$

$$M_{-ve})_{ext} = 0.3 * 120.8628 \text{ kN.m}$$

$b_1 = 4 * 210 = 840$
$b_1 = 550 - 210 = 340$ } $b_1 = 340$ mm



$$\bar{y} = \frac{300 * \frac{(550)^2}{2} + 340 \frac{(210)^2}{2}}{300 * 550 + 340 * 210} = 223.6 \text{ mm}$$

$$I_b = (340 + 300) * \frac{(223.6)^3}{3} - 340 * \frac{(223.6 - 210)^3}{3} + 300 * \frac{(550 - 223.6)^3}{3} = 5.862 * 10^9 \text{ mm}^4$$

$$I_s = \frac{2400\,(210)^3}{12} = 1.8522 * 10^9 \text{ mm}^4 \qquad \alpha = \frac{5.862 * 10^9}{1.8522 * 10^9} = 3.165$$

$$l_2/l_1 = 4500/6000 = 0.75 \qquad \therefore \alpha \frac{l_2}{l_1} = 0.75 * 3.165 = 2.37$$

To find C: $C = (1 - 0.63 \frac{300}{550}) * \frac{(300)^3 * 550}{3} + (1 - 0.63 \frac{210}{340}) * \frac{(210)^3 * 340}{3} = 3.89 * 10^9 \text{ mm}^4$

$$I_{s1} = \frac{4500 * (210)^3}{12} = 3.473 * 10^9 \text{ mm}^4$$

$$\beta_t = \frac{3.89 * 10^9}{2 * 3.473 * 10^9} = 0.56 \qquad \therefore \text{coef} = 0.94$$

6

$M_{c.s} = 0.94 * 36.258 = 34.083$ kN.m

$M_{beam1} = 0.85 * 34.083$ $\qquad \alpha \frac{\ell_2}{\ell_1} > 1$

$\therefore M_{beam1} = 28.97$ kN.m

To find $M_{beam\,2}$: $\quad WUD)_{beam} = 0.3 \overset{*24}{*} 0.34 * 1.2 = 2.9376$ kN.m

$$MD = \frac{2.937 * (5.7)^2}{8} = 11.93 \text{ kN.m}$$

$Mb_2 = 0.3 * 11.93 = 3.579$ kN.m

$\therefore M_{beam})_{total} = 28.95 + 3.579 = 32.5$ kN.m

Design: $\quad Mu)_{-ve} = 32.5$ kN.m

$d = 550 - 70 = 480$ mm

$$\rho_{max} = 0.75 * 0.85 * 0.85 * \frac{28}{400} * \frac{600}{600+400} = 0.02275$$

$$Mu)_{max} = 0.9 * 0.02275 * 300 * (480)^2 * 400 \left[1 - 0.59 * 0.02275 * \frac{400}{28}\right]$$

$\therefore Mu_{max} = 457.54$ kN.m > 32.5 $\therefore$ single

$$Ru = \frac{32.5 * 10^6}{0.9 * 300 * (480)^2} = 0.5225 \qquad m = \frac{400}{0.85 * 28} = 16.8$$

$$\rho = \frac{1}{16.8}\left[1 - \sqrt{1 - \frac{2 * 0.525 * 16.8}{400}}\right] = 0.00132$$

$$\rho_{min} = \frac{\sqrt{28}}{4 * 400} = 0.0033 < \frac{1.4}{400} = 0.0035$$

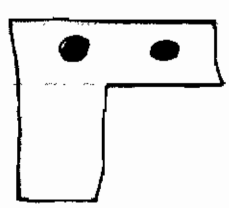
$\rho < \rho_{min}$ $\underline{o.k}$ $\quad \therefore As = 0.0035 * 300 * 480 = 504$ mm^2

$$No. = \frac{504}{\frac{\pi}{4}(\phi 20)^2} = 1.6 \quad \text{Say } No. = 2$$

$\therefore$ use $2\phi 20$ Top

$$S' = \frac{340 - 2 * 20 - 40 - 40 - 10 - 10}{3} = 66 > 25 \text{ mm}$$

o.k



H.W.
Design it for ...