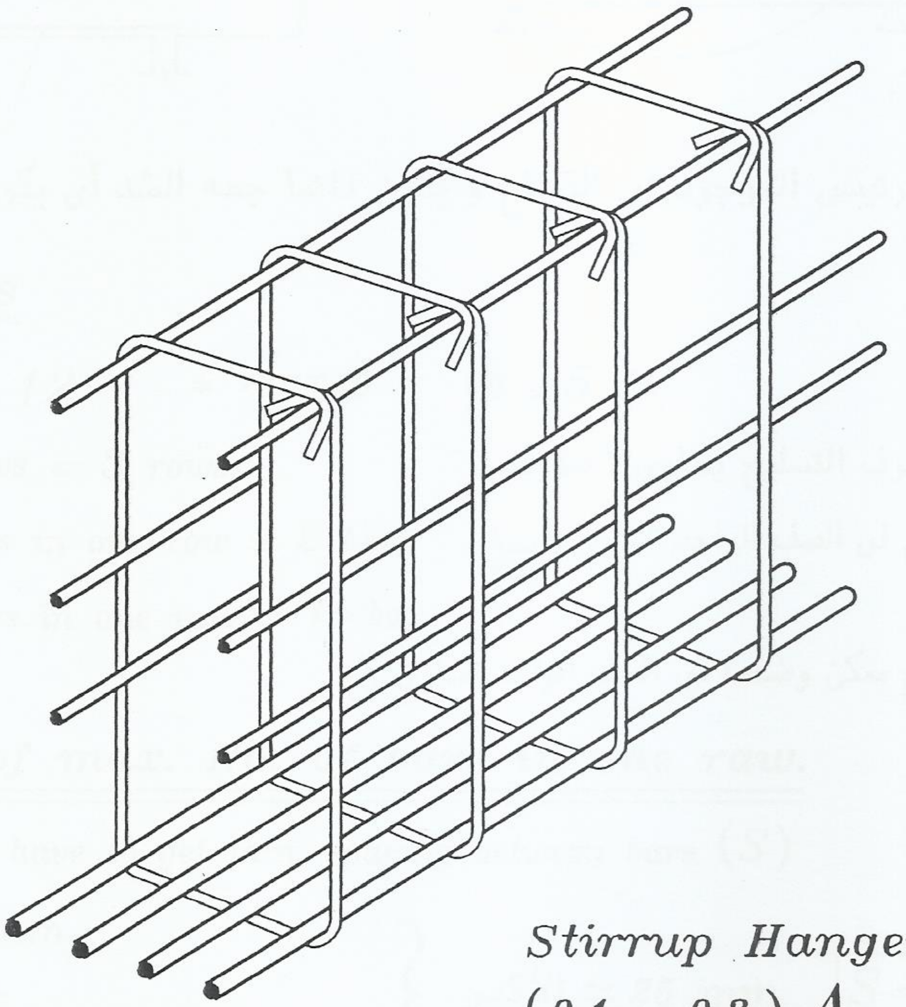
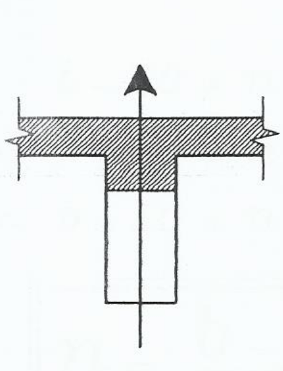
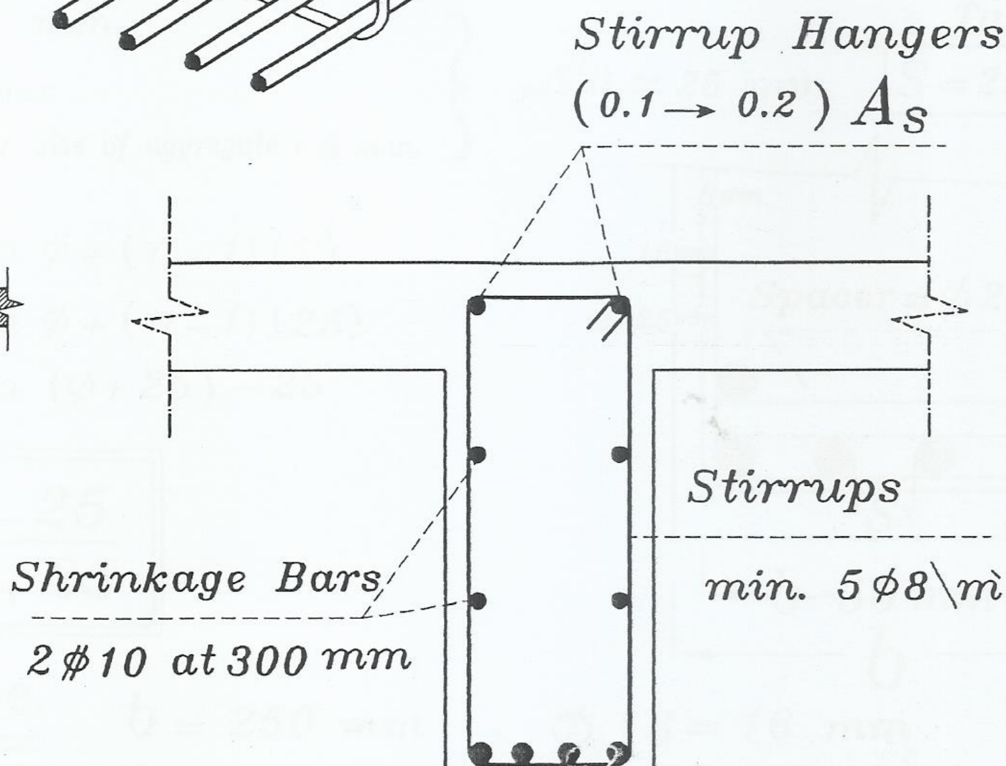
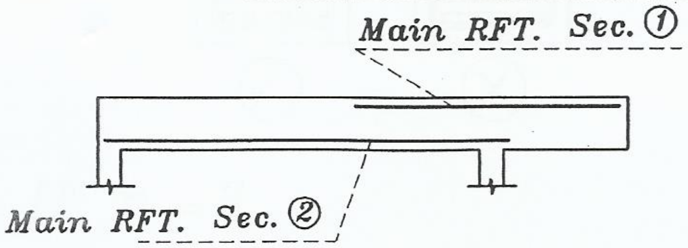
# *Details of Reinforcement (RFT.)*
# *For Beams in Cross section.*

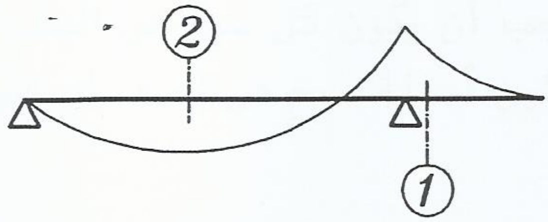






## ① Main RFT. ($A_s$)




هو الحديد الرئيسى الموجود فى القطاع و يكون دائما جهه الشد أى يكون جهه ال moment

### Choosing $A_s$

* min $\phi$ = $\phi$ 12  * max $\phi$ = $\phi$ 25
* max. No. of rows = 3 rows — أكبر عدد لصفوف التسليح يساوى ٣ صفوف .
* min. No. of bars in one row = 2 bars — أقل عدد أسياخ فى الصف الواحد تساوى ٢ سيخ .
* max. No. of bars in one row = $n$ bar

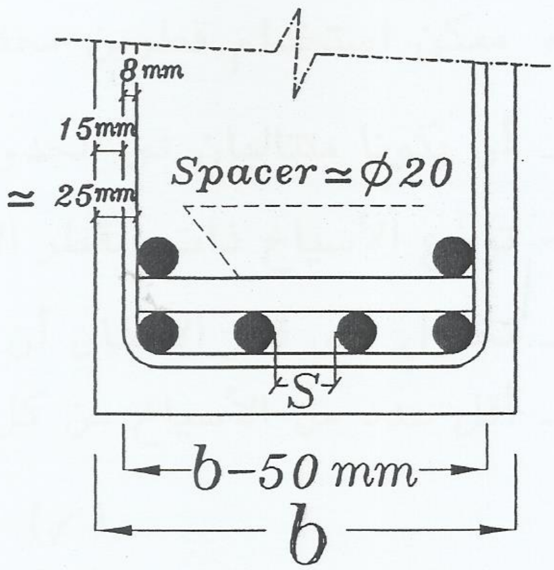
أكبر عدد أسياخ ممكن وضعها فى الصف الواحد تساوى $n$

### Calculation of max. No. of bars in one raw.

To get $n$, we have to get min. spacing between bars ($S$)

$$S = \begin{Bmatrix} 25 \text{ mm} \\ \phi_{max} \\ \text{max. size of aggregate} + 5 \text{ m.m.} \end{Bmatrix} \text{الأكبر} \simeq 25 \text{ mm}$$

Take $\boxed{S = 25\,mm}$




$$b - 50 = n\,\phi + (n-1)(S)$$

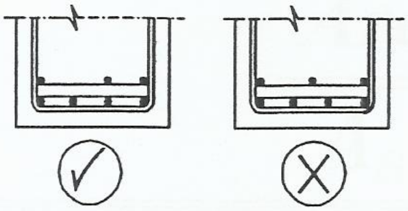
$$\therefore\ b - 50 = n\,\phi + (n-1)(25)$$

$$\therefore\ b - 50 = n\,(\phi + 25) - 25$$

$$\boxed{n = \frac{b - 25}{\phi + 25}}$$

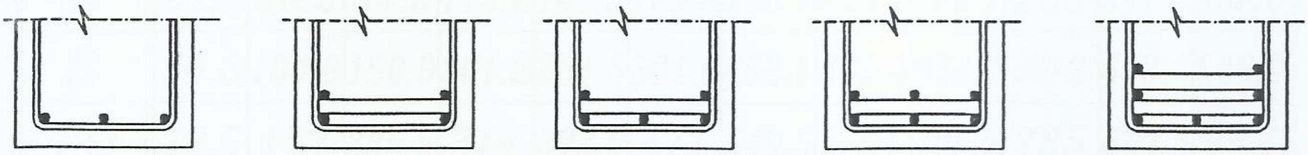
**Example.** $b = 250$ mm , $\phi\,16 = 16$ mm

$$\therefore\ n = \frac{b - 25}{\phi + 25} = \frac{250 - 25}{16 + 25} = 5.48 = 5.0 \text{ bars in one row.}$$



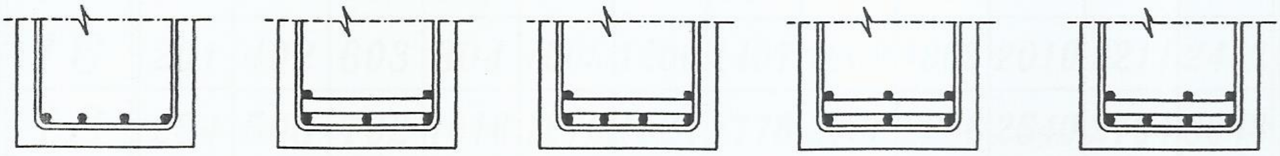
عند وجود أكثر من صف تسليح فى الكمره .
يجب أن يكون كل سيخ فى الصف العوى
يكون أسفلة سيخ فى الصف السفلى .

*IF n = 3*



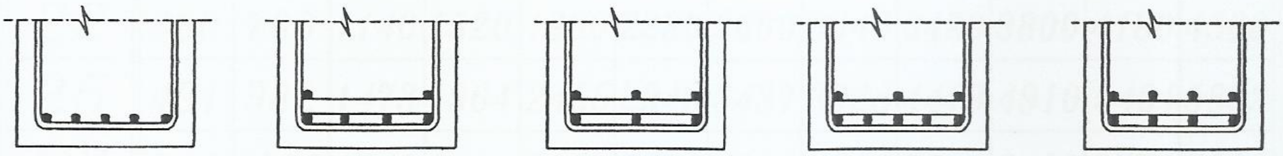
3 Bars   4 Bars   5 Bars   6 Bars   7 Bars

*IF n = 4*



4 Bars   5 Bars   6 Bars   6 Bars   7 Bars not a Symmetric Sec.

*IF n = 5*



5 Bars   6 Bars   6 Bars   8 Bars   8 Bars

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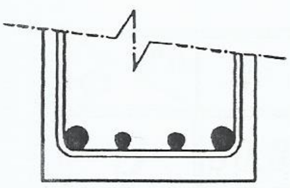


$2\phi16 + 2\phi18$

* ممكن استخدام قطرين مختليفين فى الكمره بشروط .

- أن يكونا متتاليان فى الجدول 12,16,18,20,22,25
- توضع الأسياخ ذات القطر الأكبر فى الأركان.
- نحاول على قدر الأمكان أن يكون القطاع Symmetric .
- أقل عدد من الأسياخ من كل قطر = ٢ سيخ .

## Example.

$3\phi12$ ---------------- (✓)

$2\phi12 + 2\phi16$ ------ (✓)

$2\phi12 + 1\phi16$ ------ (X)

$2\phi12 + 3\phi16$ ------ (✓)

$2\phi12 + 2\phi18$ ------ (X)

# Area of Steel

$$A_s = \checkmark \ mm^2$$

| φ \ No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 28.3 | 56.6 | 84.9 | 113.2 | 141.5 | 169.8 | 198.1 | 226.4 | 198.1 | 283 | 311.3 | 339.6 |
| 8 | 50.3 | 100.6 | 150.9 | 201.2 | 251.5 | 301.8 | 352.1 | 402.4 | 452.7 | 503 | 553.3 | 603.6 |
| 10 | 78.5 | 157 | 235.5 | 314 | 392.5 | 471 | 549.5 | 628 | 706.5 | 785 | 863.5 | 942 |
| 12 | 113 | 226 | 339 | 452 | 565 | 678 | 791 | 904 | 1017 | 1130 | 1243 | 1356 |
| 13 | 133 | 266 | 399 | 532 | 665 | 798 | 931 | 1064 | 1197 | 1330 | 1463 | 1596 |
| 16 | 201 | 402 | 603 | 804 | 1005 | 1206 | 1407 | 1608 | 1809 | 2010 | 2211 | 2412 |
| 18 | 254 | 508 | 762 | 1016 | 1270 | 1524 | 1778 | 2032 | 2286 | 2540 | 2794 | 3048 |
| 19 | 283 | 566 | 849 | 1132 | 1415 | 1698 | 1981 | 2264 | 2547 | 2830 | 3113 | 3396 |
| 20 | 314 | 628 | 942 | 1256 | 1570 | 1884 | 2198 | 2512 | 2826 | 3140 | 3454 | 3768 |
| 22 | 380 | 760 | 1140 | 1520 | 1900 | 2280 | 2660 | 3040 | 3420 | 3800 | 4180 | 4560 |
| 25 | 491 | 982 | 1473 | 1964 | 2455 | 2946 | 3437 | 3928 | 4419 | 4910 | 5401 | 5892 |
| 28 | 616 | 1232 | 1848 | 2464 | 3080 | 3696 | 4312 | 4928 | 5544 | 6160 | 6776 | 7392 |

الاقطار المشهوره فى مصر الوقت الحالى

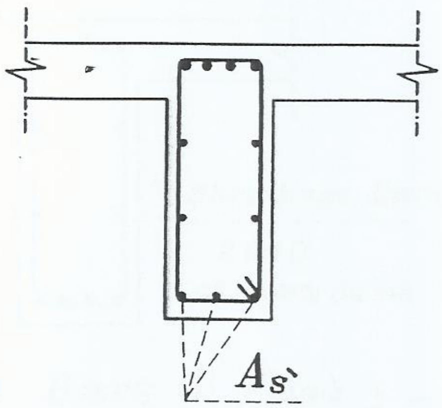
| φ \ No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 50.3 | 100.6 | 150.9 | 201.2 | 251.5 | 301.8 | 352.1 | 402.4 | 452.7 | 503 | 553.3 | 603.6 |
| 10 | 78.5 | 157 | 235.5 | 314 | 392.5 | 471 | 549.5 | 628 | 706.5 | 785 | 863.5 | 942 |
| 12 | 113 | 226 | 339 | 452 | 565 | 678 | 791 | 904 | 1017 | 1130 | 1243 | 1356 |
| 16 | 201 | 402 | 603 | 804 | 1005 | 1206 | 1407 | 1608 | 1809 | 2010 | 2211 | 2412 |
| 18 | 254 | 508 | 762 | 1016 | 1270 | 1524 | 1778 | 2032 | 2286 | 2540 | 2794 | 3048 |
| 20 | 314 | 628 | 942 | 1256 | 1570 | 1884 | 2198 | 2512 | 2826 | 3140 | 3454 | 3768 |
| 22 | 380 | 760 | 1140 | 1520 | 1900 | 2280 | 2660 | 3040 | 3420 | 3800 | 4180 | 4560 |
| 25 | 491 | 982 | 1473 | 1964 | 2455 | 2946 | 3437 | 3928 | 4419 | 4910 | 5401 | 5892 |

## ② Compressive Steel ($A_{s}^{`}$)

و هو الحديد الذى يوضع فى منطقة الضغط إذا ما إحتاج القطاع إلى ذلك .

ممكن وضع ال $A_{s}^{`}$ فى ال R-Sec. فقط

و لا يمكن وضعة فى ال T-Sec. & L-Sec.




R-Sec.

$$A_{s\,max.}^{`} = 0.40\ A_s$$

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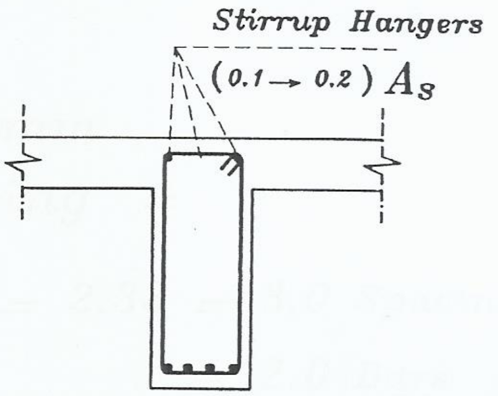
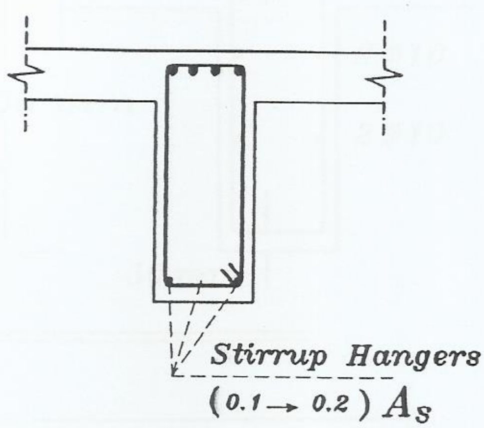
## ③ Stirrup Hangers. تعليق الكانات




T-Sec.

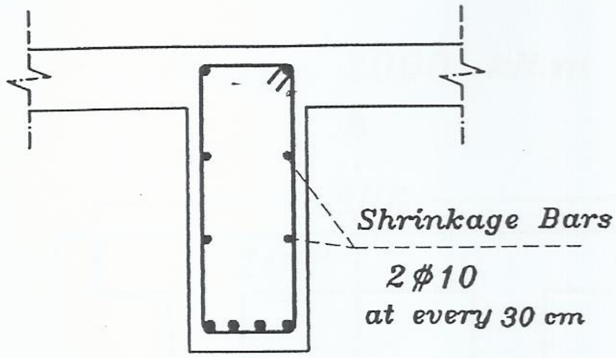



R-Sec.

- هى أسياخ توضع فى جهه الضغط إذا لم نحتاج الى $A_{s}^{`}$ .
- وظيفتها هى تعليق الكانات عليها لذا تسمى Stirrup Hangers.
- تعتبر ال Stirrup Hangers عباره عن Secondary Steel.
  أى أننا نهمل وجودها فى الحسابات .
- توضع ال Stirrup Hangers فى كلاً من R-Sec. & L-Sec. & T-Sec.
- قيمه ال Stirrup Hangers فى القطاع تكون الأكبر من .

الأكبر من:
- (0.1 → 0.2) $A_s$
- $2\phi 10$ Beams
- $2\phi 12$ Frames

## ④ *Shrinkage Bars.*

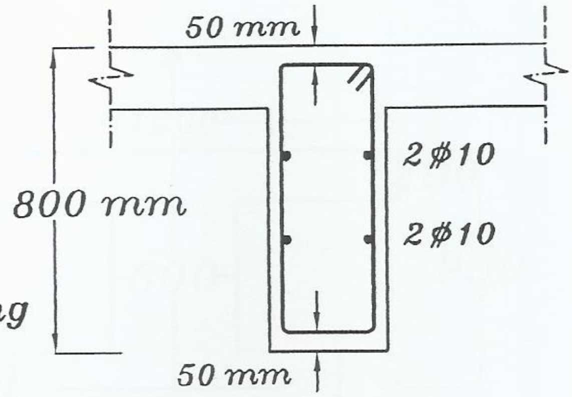



- و هى عباره عن أسياخ حديد توضع فى جانبى الكمره لتقليل إنكماش الخرسانه

- و نحتاج ال *Shrinkage Bars* فقط عندما تكون $t > 700\ mm$

- قيمة ال *Shrinkage Bars* هى الأكبر من
  - $0.08\ A_s$
  - ✓✓ $2\phi10$ at every 300 mm

### *Example.*




IF $t = 800\ mm$

$\therefore$ No. of Spacing =

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

$$= 2.0 \text{ Bars}$$

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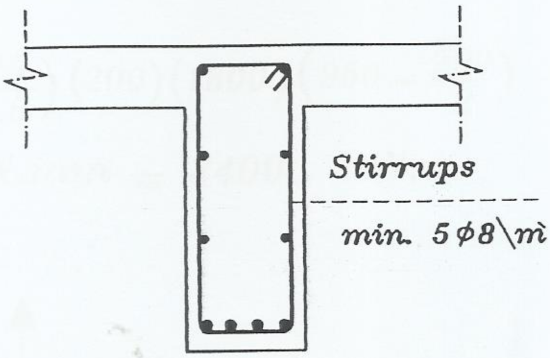
## ⑤ *Stirrups.* الكانات

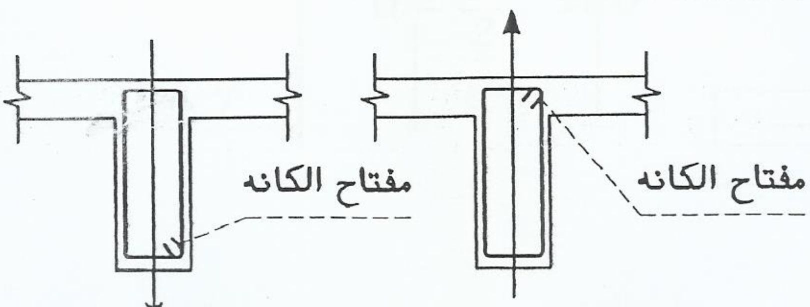



توضع الكانات فى الكمرات ل

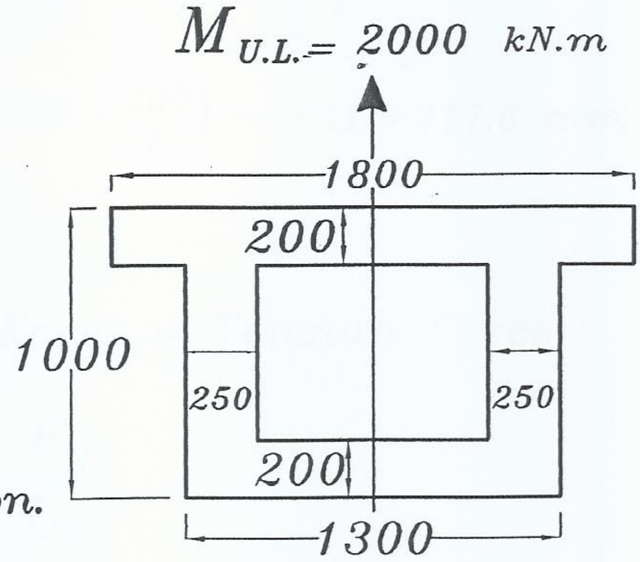
- مقاومه ال *Shear Stress*.
- للربط بين الخرسانه فى منطقه الضغط و الحديد فى منطقه الشد.

- أقل قيمه للكانات فى الكمره هى $5\phi8\backslash m'$ .

- مفتاح الكانه يكون دائما جهه الضغط .



## Example.




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

, st. 360/520

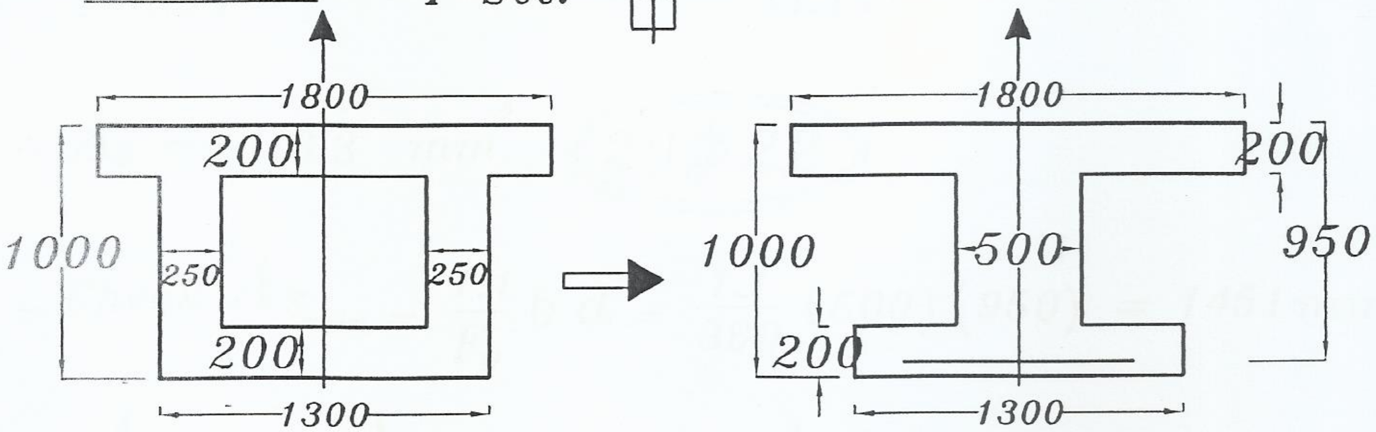
$M_{U.L.} = 2000$ kN.m

Design the section.

Draw details of RFT. in section.

## Solution.

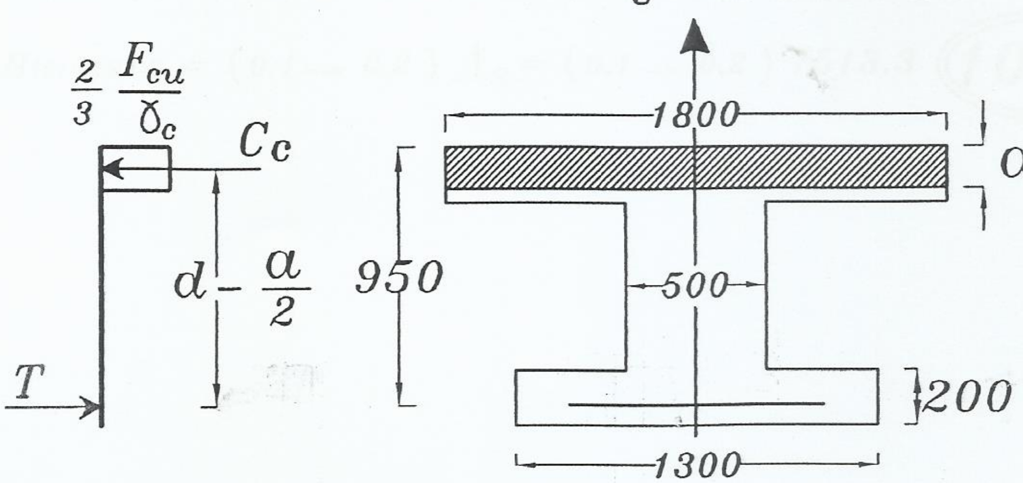
T−Sec.




$$- M_{Flange} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\, t_s\, B\left(d - \frac{t_s}{2}\right) = \frac{2}{3}\left(\frac{25}{1.5}\right)(200)(1800)\left(950 - \frac{200}{2}\right)$$

$$= 3400000000 \text{ N.mm} = 3400 \quad \text{kN.m}$$

$$\therefore M_{U.L.} < M_{Flange} \longrightarrow a < t_s$$



– Get $a$ From $M_{U.L.} = \frac{2}{3} \frac{F_{cu}}{\gamma_c} a B \left(d - \frac{a}{2}\right)$

$\therefore 2000 * 10^6 = \frac{2}{3}\left(\frac{25}{1.5}\right)(a)(1800)\left(950 - \frac{200}{2}\right) \longrightarrow a = 117.6 \text{ mm}$

$\therefore a > 0.1\, d$

Get $A_s$ From Compression Force = Tension Force

$$\boxed{C_c = T} \quad \frac{2}{3} \frac{F_{cu}}{\gamma_c} a B = A_s * \frac{F_y}{\gamma_s}$$

$$\therefore \frac{2}{3}\left(\frac{25}{1.5}\right)(117.6)(1800) = A_s * \left(\frac{360}{1.15}\right)$$

$\therefore A_s = 7513.3 \text{ mm}^2$ **20ϕ22**

– Check $A_{s_{min.}} = \frac{1.1}{F_y} b\, d = \frac{1.1}{360}(500)(950) = 1451 \text{ mm}^2$

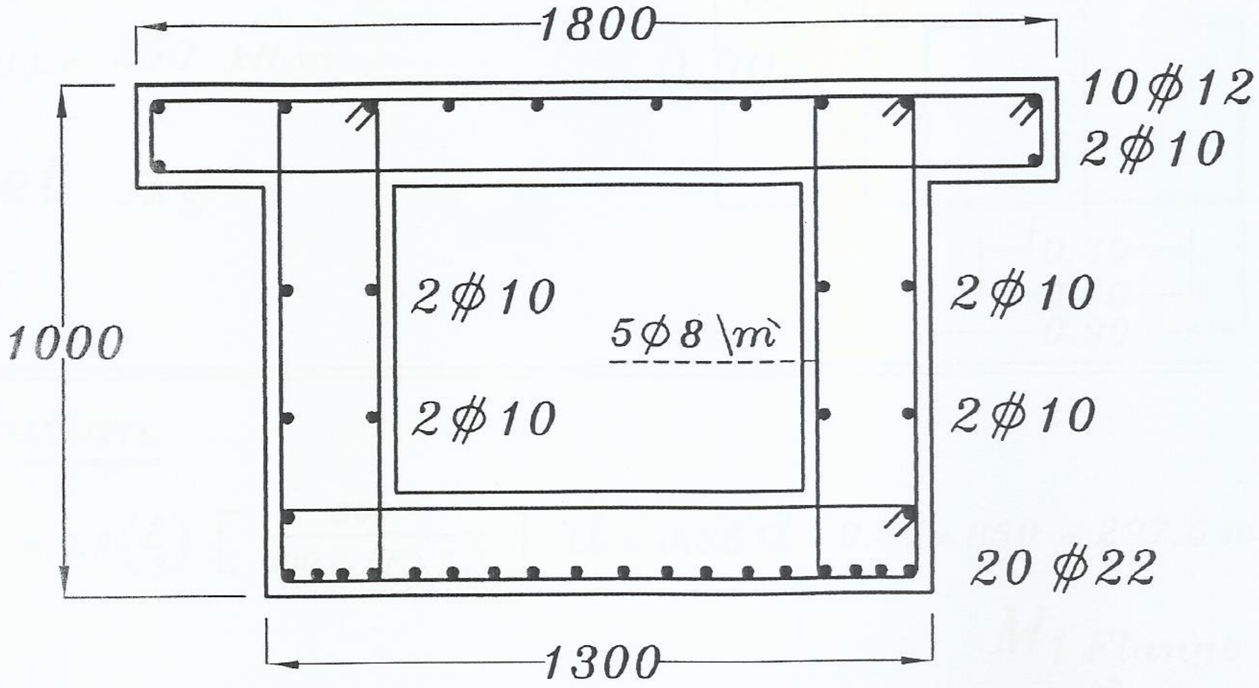
$\therefore A_{s_{min.}} < A_s = 7513.3 \text{ mm}^2$

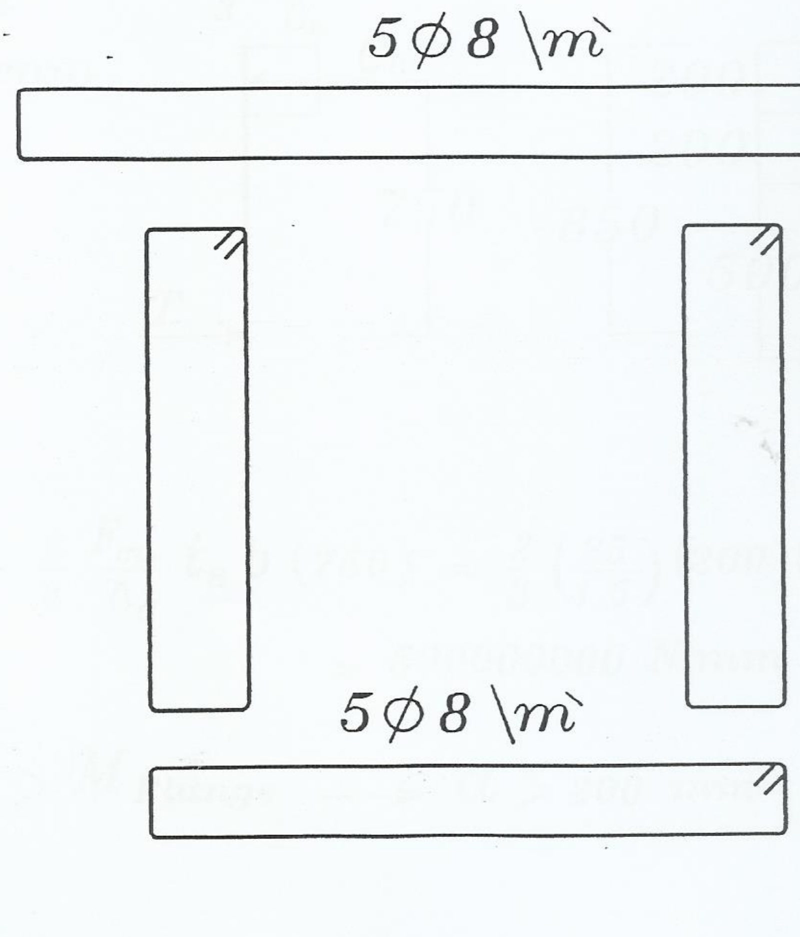
$$\therefore n = \frac{b - 25}{\phi + 25} = \frac{1300 - 25}{22 + 25} = 27.1 = 27.0$$

Stirrup Hangers $= (0.1 \rightarrow 0.2)\, A_s = (0.1 \rightarrow 0.2)\, 7513.3$ **10ϕ12**

$A_s$ = 20⌀22

Stirrup Hangers = 10⌀12



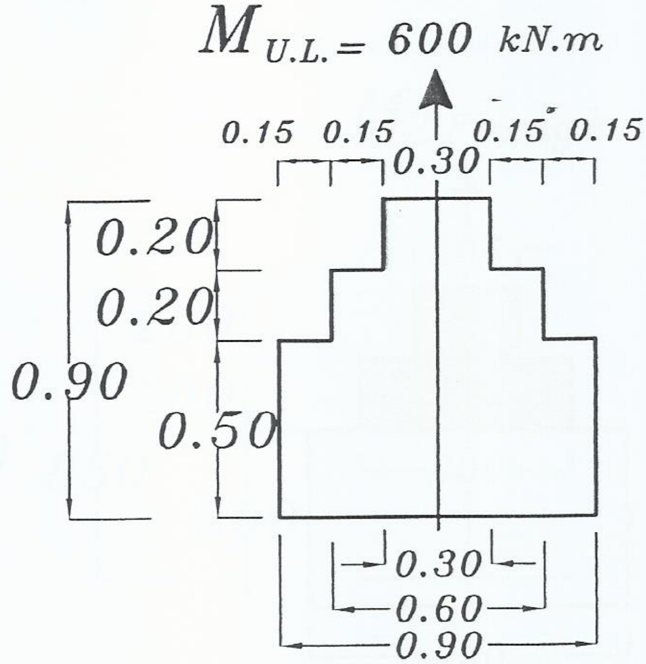
## Example.

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

, st. 360/520

$M_{U.L.} = 250 \ kN.m$

Get $A_s$

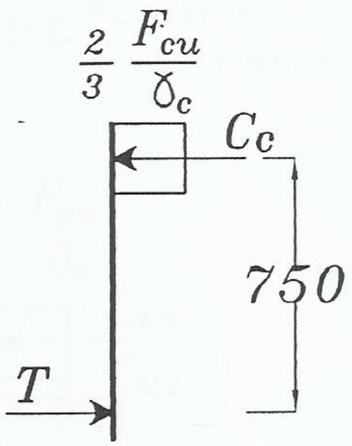


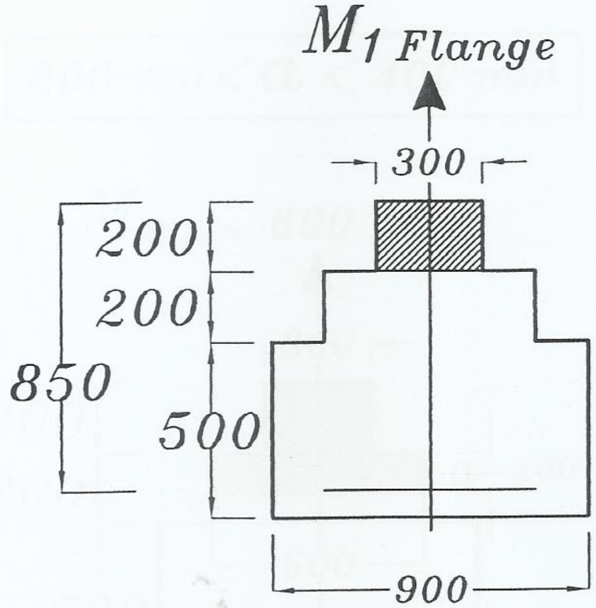

## Solution.

$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y\backslash \gamma_s)}\right] * d = 0.35\, d = 0.35 * 850 = 297.5 \ mm$$

assume

$a = 200 \ mm$



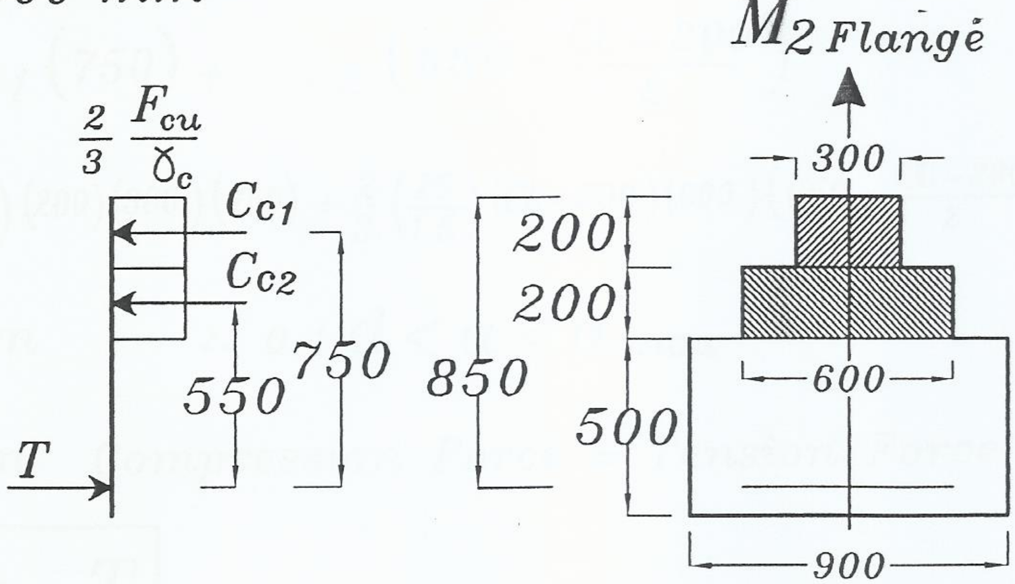

$$- M_{1_{Flange}} = \frac{2}{3}\frac{F_{cu}}{\gamma_c} t_s \, b \,(750) = \frac{2}{3}\left(\frac{25}{1.5}\right)(200)(300)(750)$$

$$= 500000000 \ N.mm = 500 \ kN.m$$

$\therefore M_{U.L.} > M_{Flange} \longrightarrow a > 200 \ mm$

*assume*

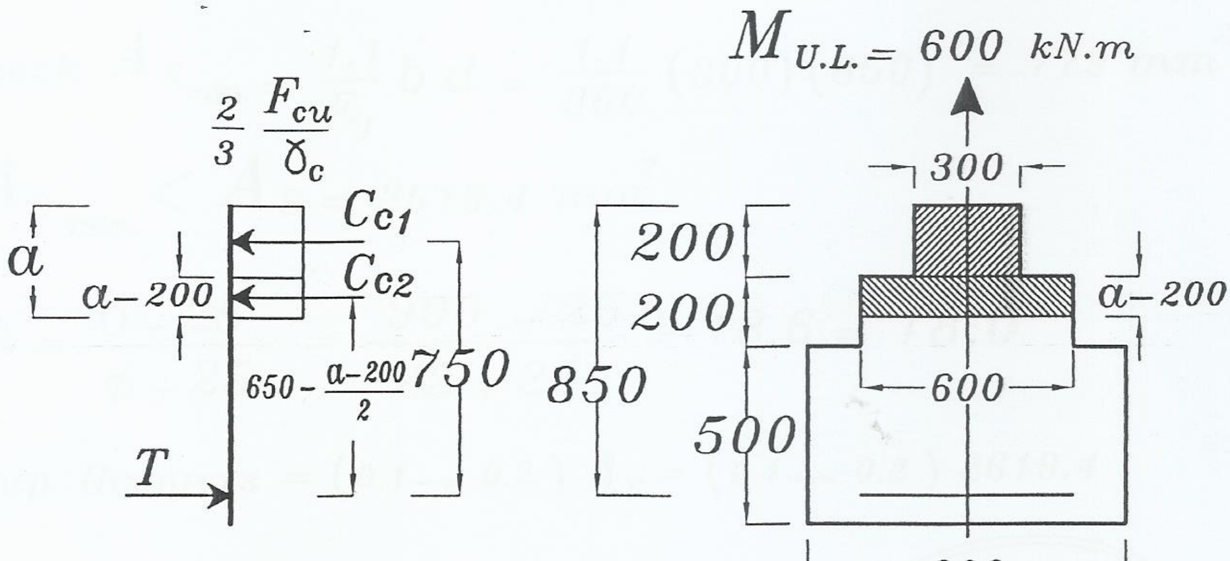
$a = 400\ mm$




$$-\ M_{2\ Flange} = \frac{2}{3}\left(\frac{25}{1.5}\right)(200)(300)(750) + \frac{2}{3}\left(\frac{25}{1.5}\right)(200)(600)(550)$$

$$= 1233333333\ N.mm = 1233.3\ kN.m$$

$$\because M_{1\ Flange} < M_{U.L.} < M_{2\ Flange} \qquad \therefore \boxed{200\,mm < a < 400\ mm}$$




$$C_{c1} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}(200)(300) = \frac{2}{3}\left(\frac{25}{1.5}\right)(200)(300)$$

$$C_{c2} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}(a-200)(600) = \frac{2}{3}\left(\frac{25}{1.5}\right)(a-200)(600)$$

Get $a$ From

$$M_{U.L.} = C_{c1}(750) + C_{c2}\left(650 - \frac{a-200}{2}\right)$$

$$\therefore 600 * 10^6 = \frac{2}{3}\left(\frac{25}{1.5}\right)(200)(300)(750) + \frac{2}{3}\left(\frac{25}{1.5}\right)(a-200)(600)\left(650 - \frac{a-200}{2}\right)$$

$\therefore a = 223 \text{ mm}$ $\qquad \therefore 0.1\, d < a < a_{max}$

Get $A_S$ From Compression Force = Tension Force

$$\boxed{C_{c1} + C_{c2} = T}$$

$$\therefore \frac{2}{3}\left(\frac{25}{1.5}\right)(200)(300) + \frac{2}{3}\left(\frac{25}{1.5}\right)(223-200)(600) = A_S * \left(\frac{360}{1.15}\right)$$

$\therefore A_S = 2619.4 \text{ mm}^2$ $\quad$ **7 $\phi$ 22**

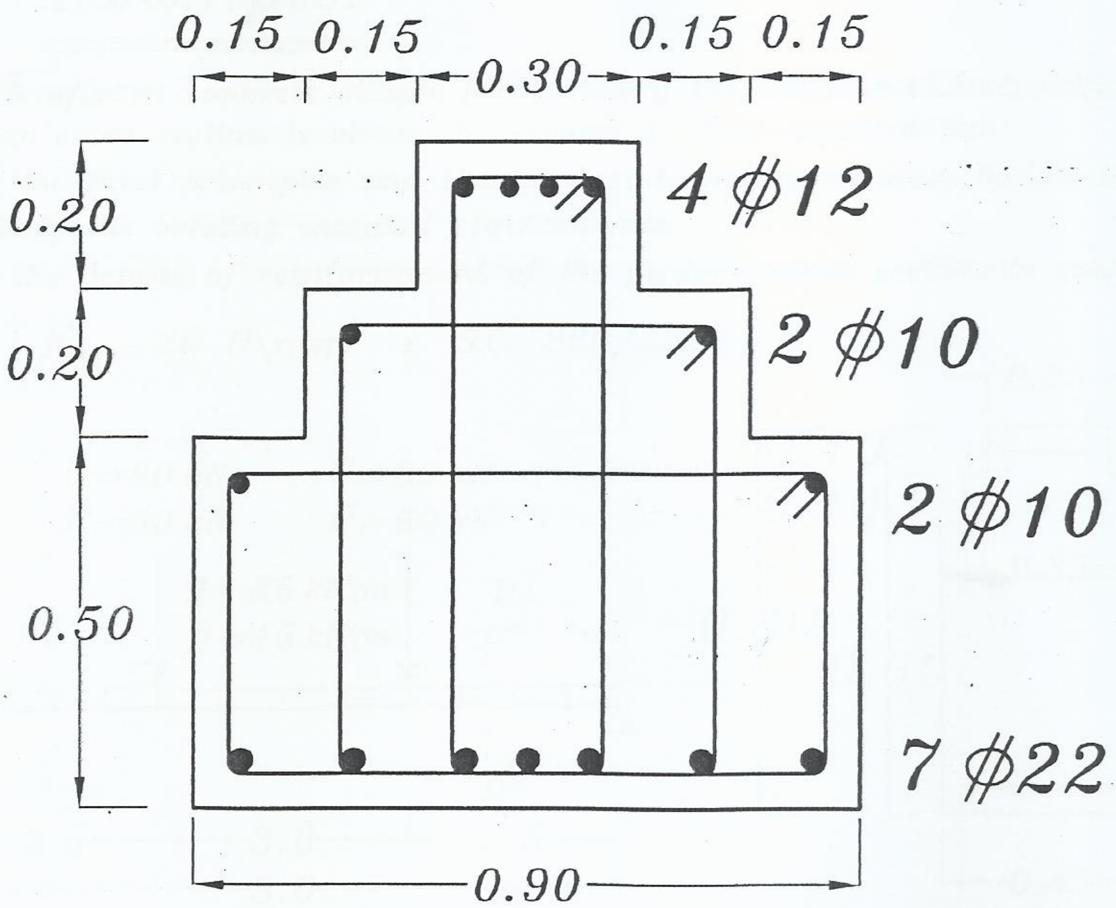
_ Check $A_{S_{min.}} = \frac{1.1}{F_y}\, b\, d = \frac{1.1}{360}(300)(850) = 779 \text{ mm}^2$

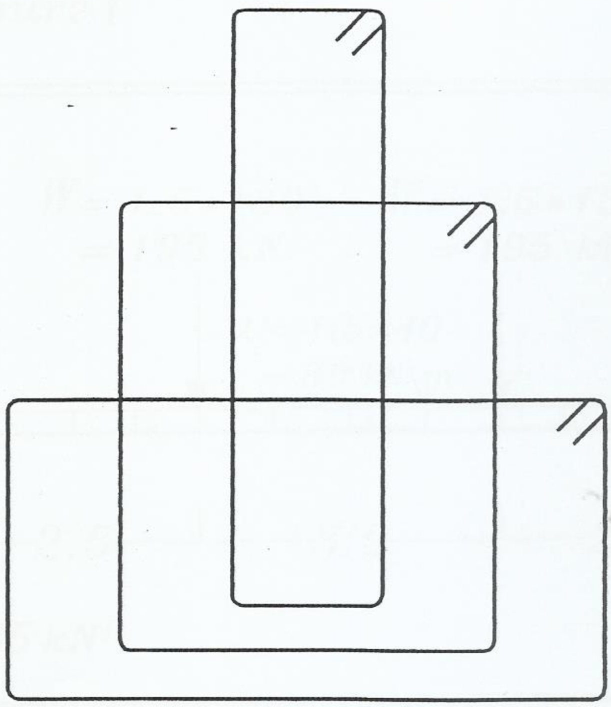
$\therefore A_{S_{min.}} < A_S = 2619.4 \text{ mm}^2$

$$\therefore n = \frac{b-25}{\phi+25} = \frac{900-25}{22+25} = 18.6 = 18.0$$

Stirrup Hangers $= (0.1 \rightarrow 0.2)\, A_S = (0.1 \rightarrow 0.2)\, 2619.4$

**4 $\phi$ 12**



5φ8 \m

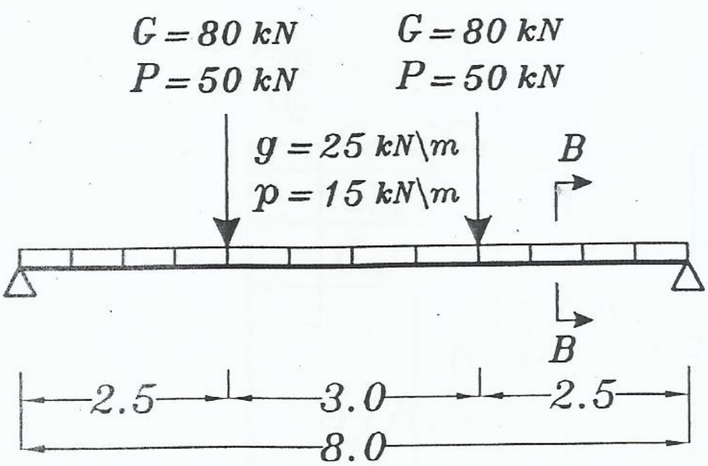
# Example.

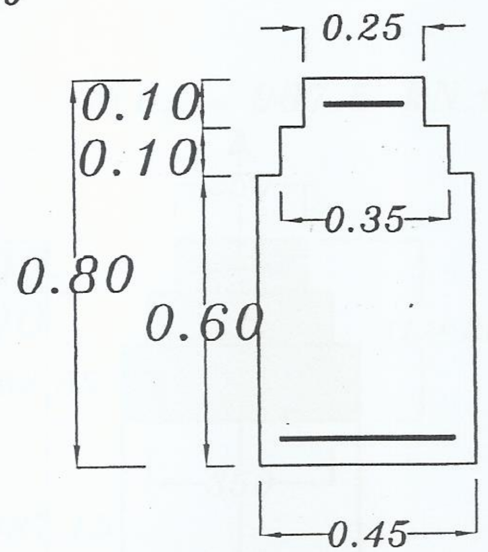
For the reinforced concrete simple girder carry the dead and live working loads and whose cross section is shown in Figure 1 It is required to:

1 – Using the First principles and the limit state design method, design the girder to satisfy the bending moment requirements.

2 – Draw the details of reinforcement of the girder's croos section to scale 1:25

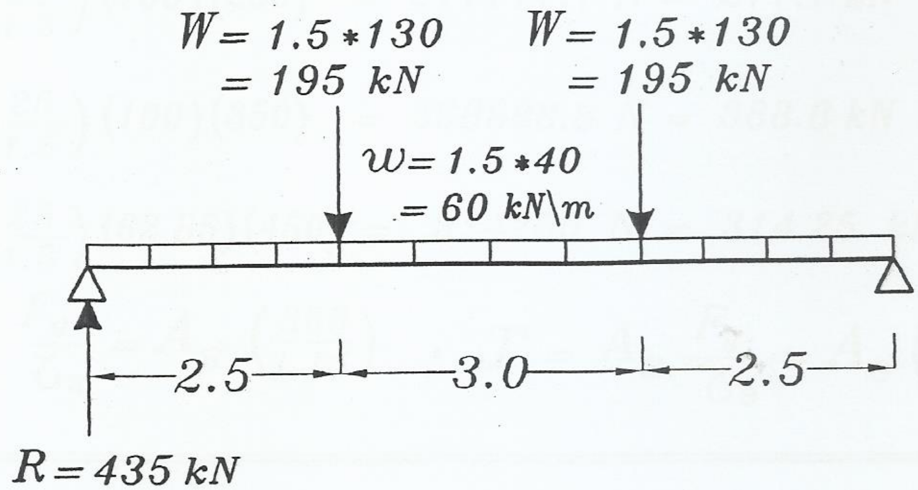
**Data :** $F_{cu} = 25\ N\backslash mm^2$ , st. 360/520

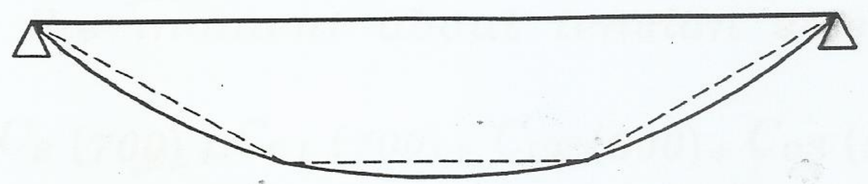



Cross Section B

Figure 1



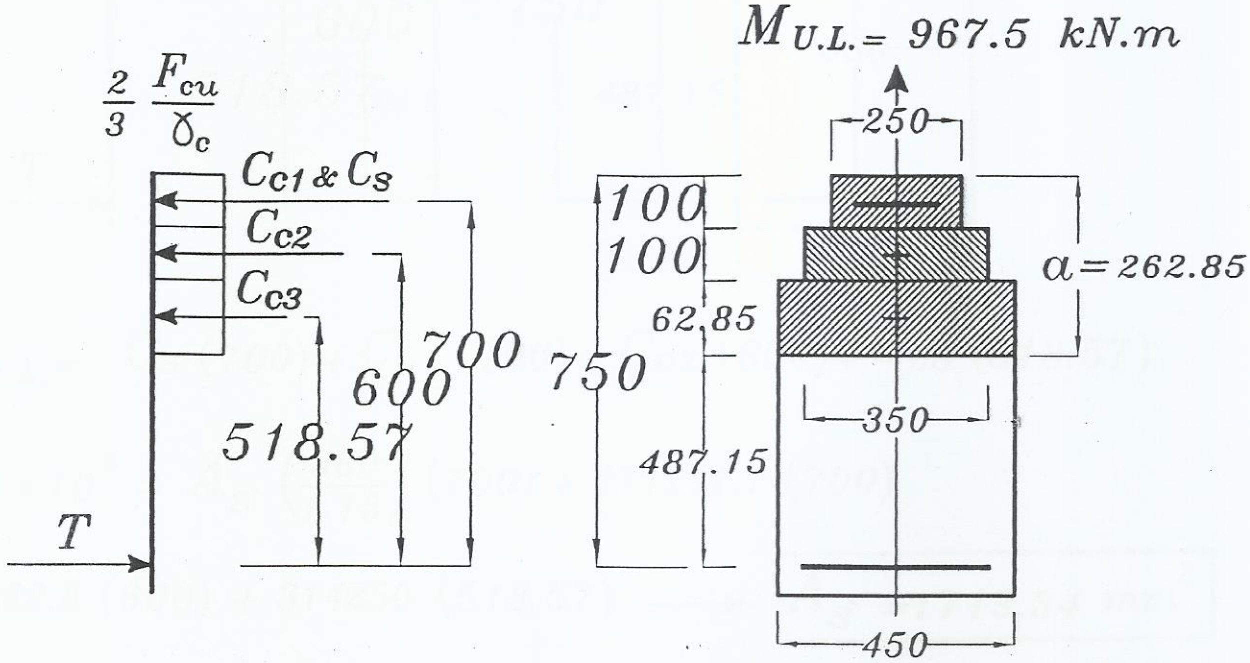



$M_{U.L.} = 967.5\ kN.m$

$\because$ $A_{s'}$ *is given.*

$$\therefore a = a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600+(F_y \backslash \gamma_s)}\right]d$$

$$\therefore a = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600+(360 \backslash 1.15)}\right]750 = 262.85 \text{ mm}$$




$$C_{c1} = \frac{2}{3}\left(\frac{25}{1.5}\right)(100)(250) = 277777.7 \text{ N} = 277.7 \text{ kN}$$

$$C_{c2} = \frac{2}{3}\left(\frac{25}{1.5}\right)(100)(350) = 388888.8 \text{ N} = 388.8 \text{ kN}$$

$$C_{c3} = \frac{2}{3}\left(\frac{25}{1.5}\right)(62.85)(450) = 314250 \text{ N} = 314.25 \text{ kN}$$

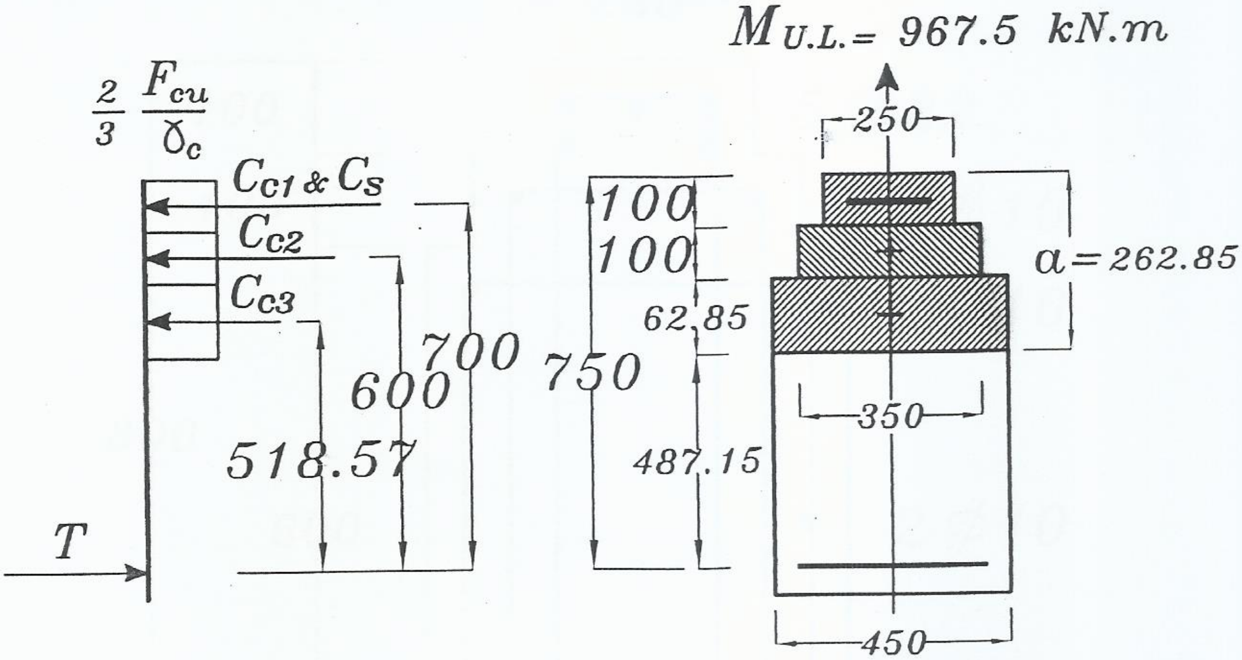
$$C_s = A_{s'}\frac{F_y}{\gamma_s} = A_{s'}\left(\frac{360}{1.15}\right) \quad , \quad T = A_s\frac{F_y}{\gamma_s} = A_s\left(\frac{360}{1.15}\right)$$

---

*By taking the moment about tension steel.*

$$* \; M_{U.L.} = C_s(700) + C_{c1}(700) + C_{c2}(600) + C_{c3}(518.57)$$

By taking the moment about tension steel.




* $M_{U.L.} = C_s\,(700) + C_{c1}\,(700) + C_{c2}\,(600) + C_{c3}\,(518.57)$

$\therefore\ 967.5 * 10^6 = A_{s'}\left(\frac{360}{1.15}\right)(700) + 277777.7\,(700)$

$+ 388888.8\,(600) + 314250\,(518.57) \longrightarrow$ $\boxed{A_{s'} = 1719.34\ mm^2}$

$\therefore\ n = \frac{b-25}{\phi+25} = \frac{250-25}{22+25} = 4.78 = 4.0$ **(5 $\phi$ 22)**

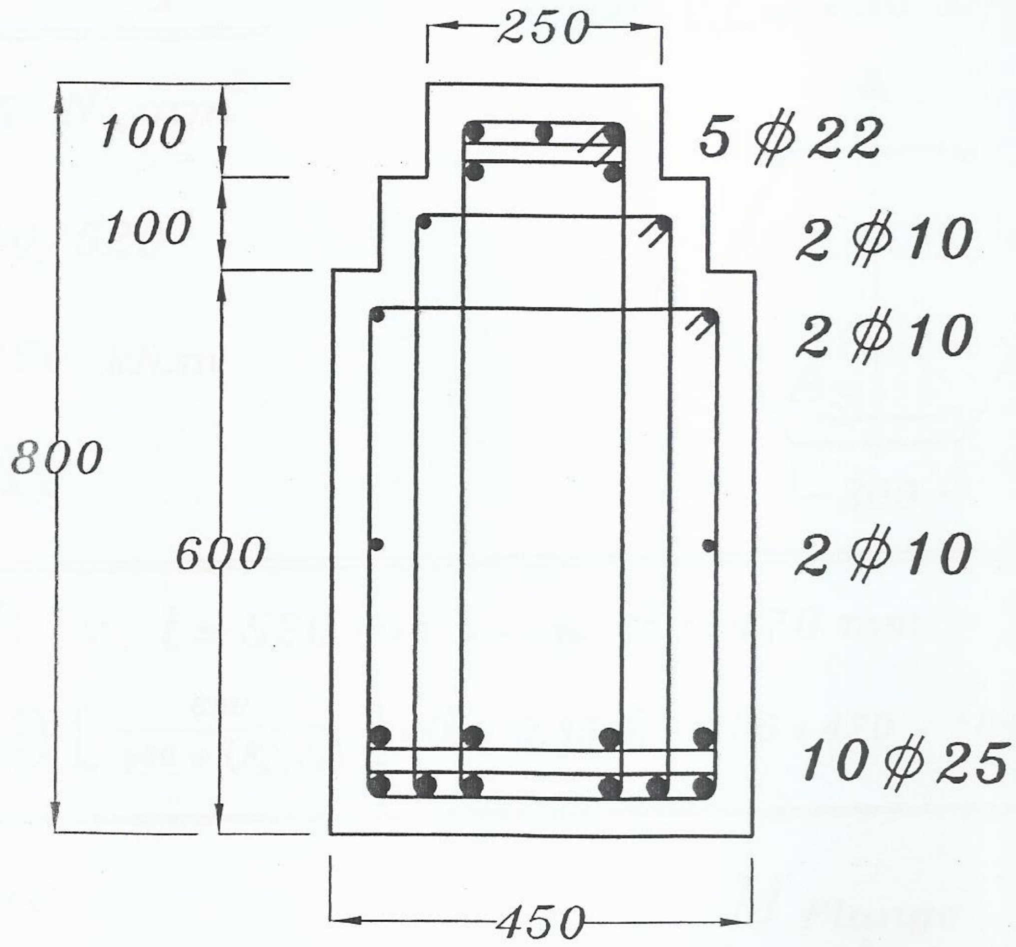
* Equilibrium equation. $C_{c1} + C_{c2} + C_{c3} + C_s = T$

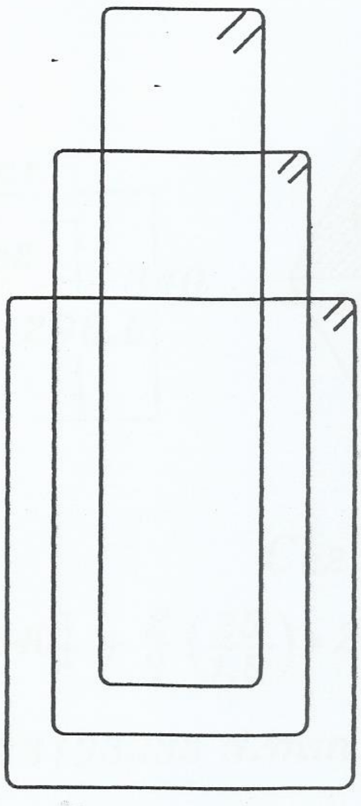
$\therefore\ 277777.7 + 388888.8 + 314250 + 1719.34\left(\frac{360}{1.15}\right) = A_s\left(\frac{360}{1.15}\right)$

$\longrightarrow$ $\boxed{A_s = 4852.8\ mm^2}$ **(10 $\phi$ 25)**

$n = \frac{b-25}{\phi+25} = \frac{450-25}{25+25} = 8.50 = 8.0$

Check $\frac{A_{s'}}{A_s} = \frac{1719.34}{4852.8} = 0.354 < 0.4 \quad \therefore$ o.k.



5ϕ8 \m̀

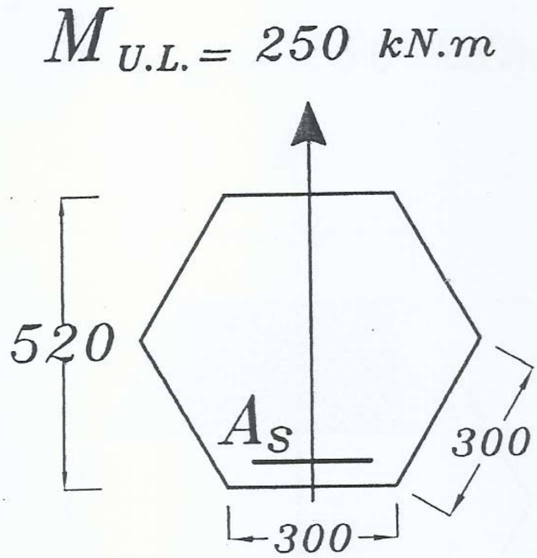
## Example.

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

, st. 360/520

$M_{U.L.} = 250 \ kN.m$

Get $A_s$

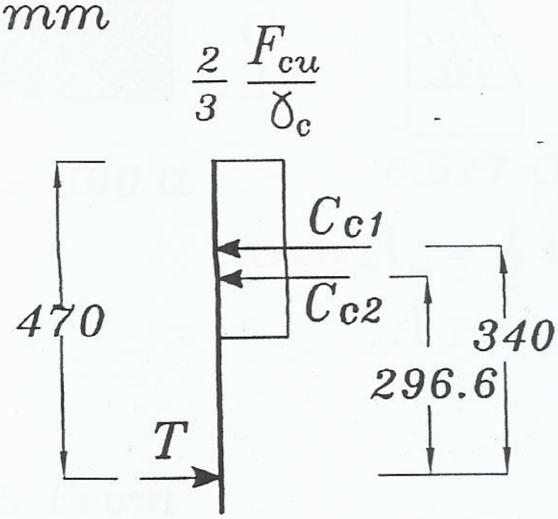


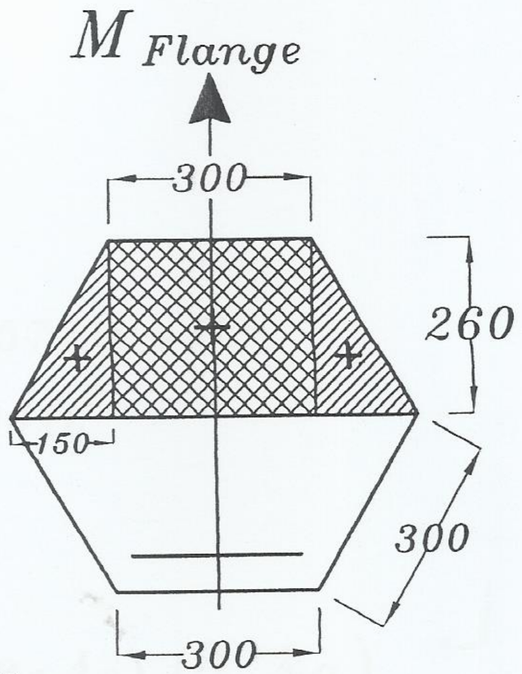

## Solution.

$\because \ t = 520 \ mm \longrightarrow d = 470 \ mm$

$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y\backslash \gamma_s)}\right] * d = 0.35\,d = 0.35 * 470 = 164.5 \ mm$$

Assume
$a = 260 \ mm$

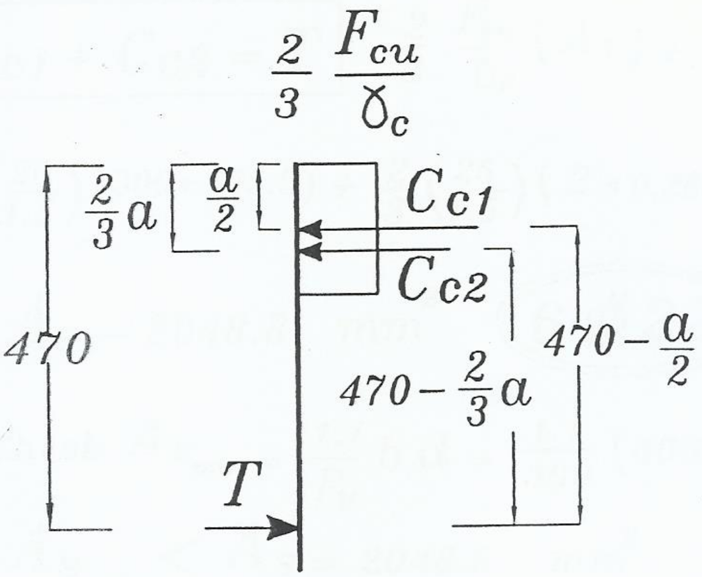


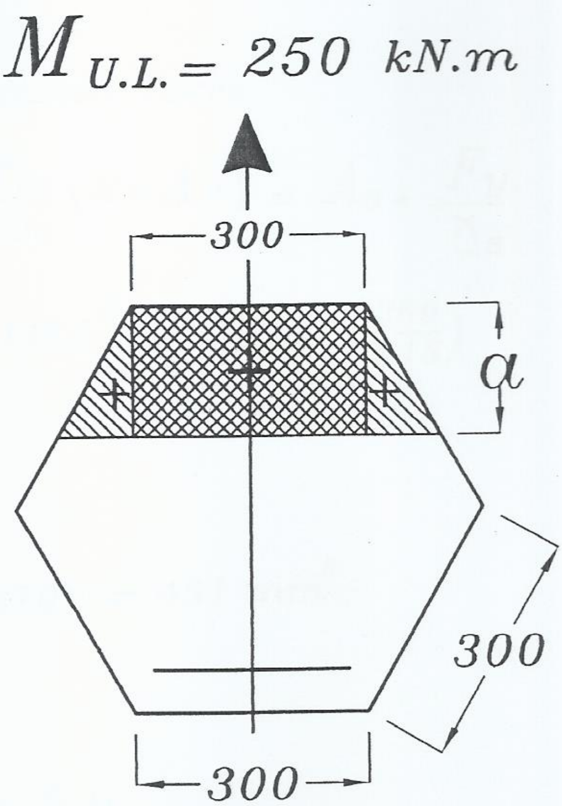



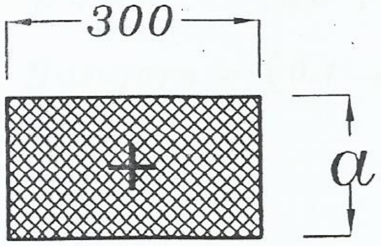

$$M_{Flange} = \underbrace{\frac{2}{3}\left(\frac{25}{1.5}\right)(260)(300)}_{C_{c1}}[340] + \underbrace{\frac{2}{3}\left(\frac{25}{1.5}\right) * 2(0.5)(150)(260)}_{C_{c2}}[296.6]$$

$$= 423193333 \ N.mm = 423.19 \ kN.m$$

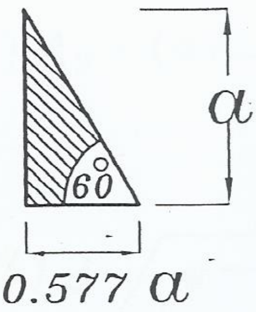
$\therefore \ M_{U.L.} < M_{Flange} \longrightarrow a < 260 \ mm$




area $A_1 = 300\,a$




$$\text{area } A_2 = \frac{1}{2} * 0.577\,a * a$$

$$A_2 = 0.288\,a^2$$

– Get a From

$$M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}(A_1)\left(d-\frac{a}{2}\right) + \frac{2}{3}\frac{F_{cu}}{\gamma_c}(2 * A_2)\left(d-\frac{2}{3}a\right)$$

$$\therefore 250 * 10^6 = \frac{2}{3}\left(\frac{25}{1.5}\right)(300\,a)\left(470-\frac{a}{2}\right) + \frac{2}{3}\left(\frac{25}{1.5}\right)(2 * 0.288\,a^2)\left(470-\frac{2}{3}a\right)$$

$a = 149.5$ mm $\quad \therefore 0.1\,d < a < a_{max}$

Get $A_S$ From Compression Force = Tension Force

$$\boxed{C_{c1} + C_{c2} = T} \qquad \frac{2}{3}\,\frac{F_{cu}}{\gamma_c}(A_1) + \frac{2}{3}\,\frac{F_{cu}}{\gamma_c}(2 * A_2) = A_S * \frac{F_y}{\gamma_s}$$

$$\frac{2}{3}\left(\frac{25}{1.5}\right)(300 * 149.5) + \frac{2}{3}\left(\frac{25}{1.5}\right)(2 * 0.288 * 149.5^2) = A_S * \left(\frac{360}{1.15}\right)$$

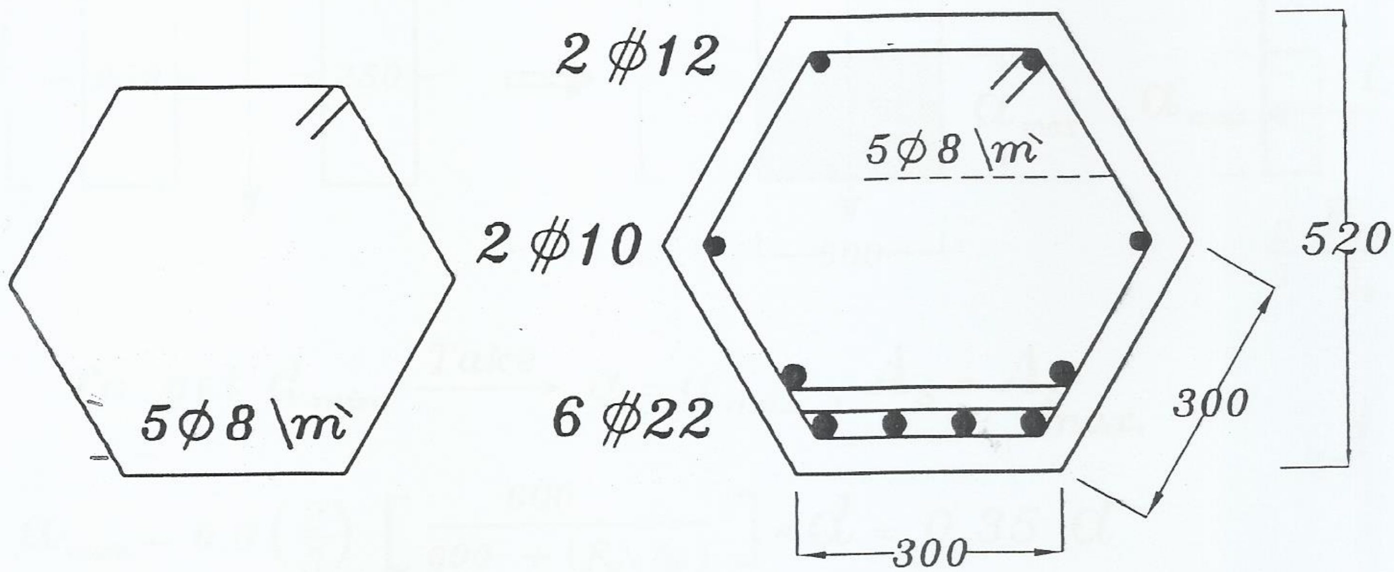
$$\therefore A_S = 2048.8 \quad mm^2 \qquad \text{(6 } \phi \text{ 22)}$$

$$\text{\_ Check } A_{S_{min.}} = \frac{1.1}{F_y}\, b\, d = \frac{1.1}{360}(300)(470) = 431 \; mm^2$$

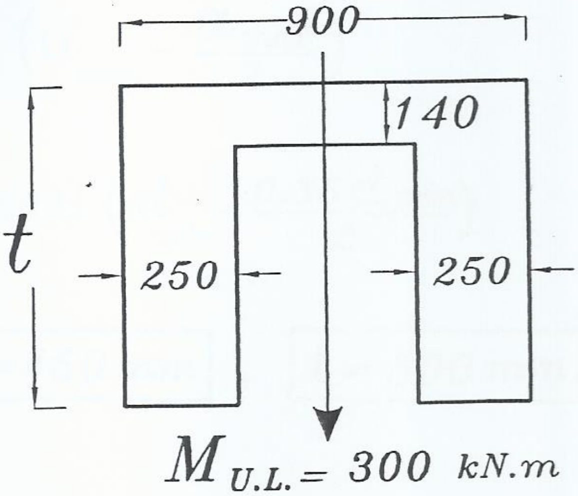
$$\therefore A_{S_{min.}} < A_S = 2048.8 \quad mm^2$$

$$\therefore n = \frac{b - 25}{\phi + 25} = \frac{300 - 25}{22 + 25} = 5.85 = 5.0$$

$$\text{Stirrup Hangers} = (0.1 \rightarrow 0.2)\, A_S = (0.1 \rightarrow 0.2)\, 2048.8 \qquad \text{(2 } \phi \text{ 12)}$$



## *Example.*




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

$M_{U.L.} = 300$ kN.m

### *Req.*

*Using First Principles Design the Sec. For Bending With min. Depth. & without $A_{s'}$*

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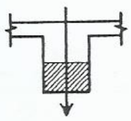
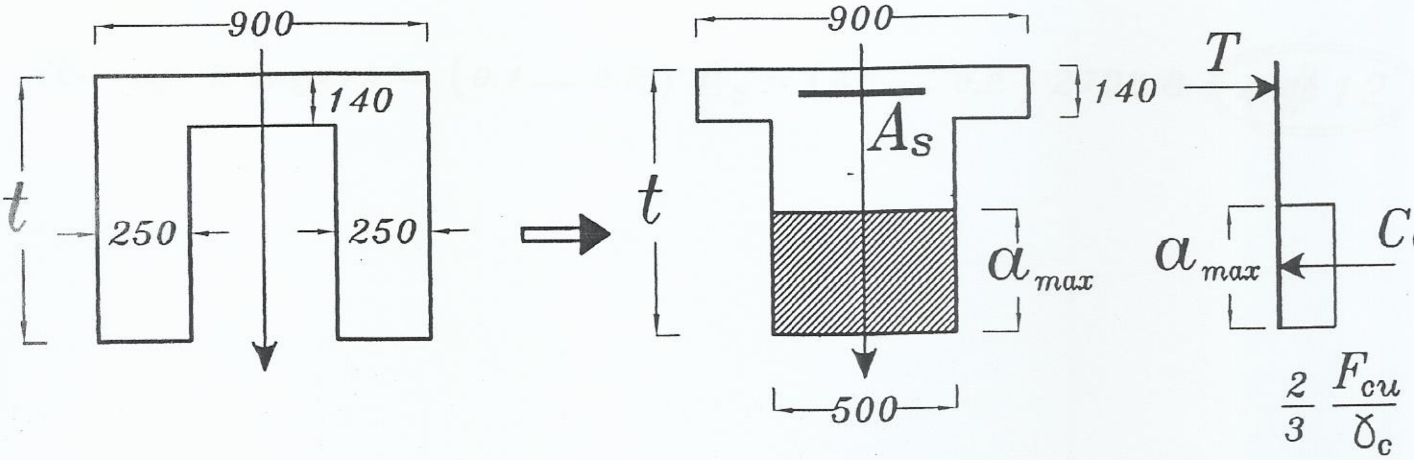
### *Solution.*

R–Sec.






To get $d_{min.}$ $\xrightarrow{Take}$ $a = a_{max.}$ , $A_s = A_{s_{max.}}$

$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \gamma_s)}\right] * d = 0.35\ d$$

$$\mu_{max.} = 5 * 10^{-4} * F_{cu} = 5 * 10^{-4}(25) = 0.0125$$

$$A_{s_{max.}} = \mu_{max.}\ b\ d = 0.0125\,(500)\ d = 6.25\ d$$

From $M_{U.L.} = \frac{2}{3} \frac{F_{cu}}{\gamma_c} a_{max.} \, b \left(d_{min} - \frac{a_{max.}}{2}\right)$

$\therefore 300 * 10^6 = \frac{2}{3} \left(\frac{25}{1.5}\right) (0.35\, d_{min}) (500) \left(d_{min} - \frac{0.35\, d_{min}}{2}\right)$

$\therefore d_{min.} = 432.45\ mm$ Take → $\boxed{d = 450\ mm}$ , $\boxed{t = 500\ mm}$

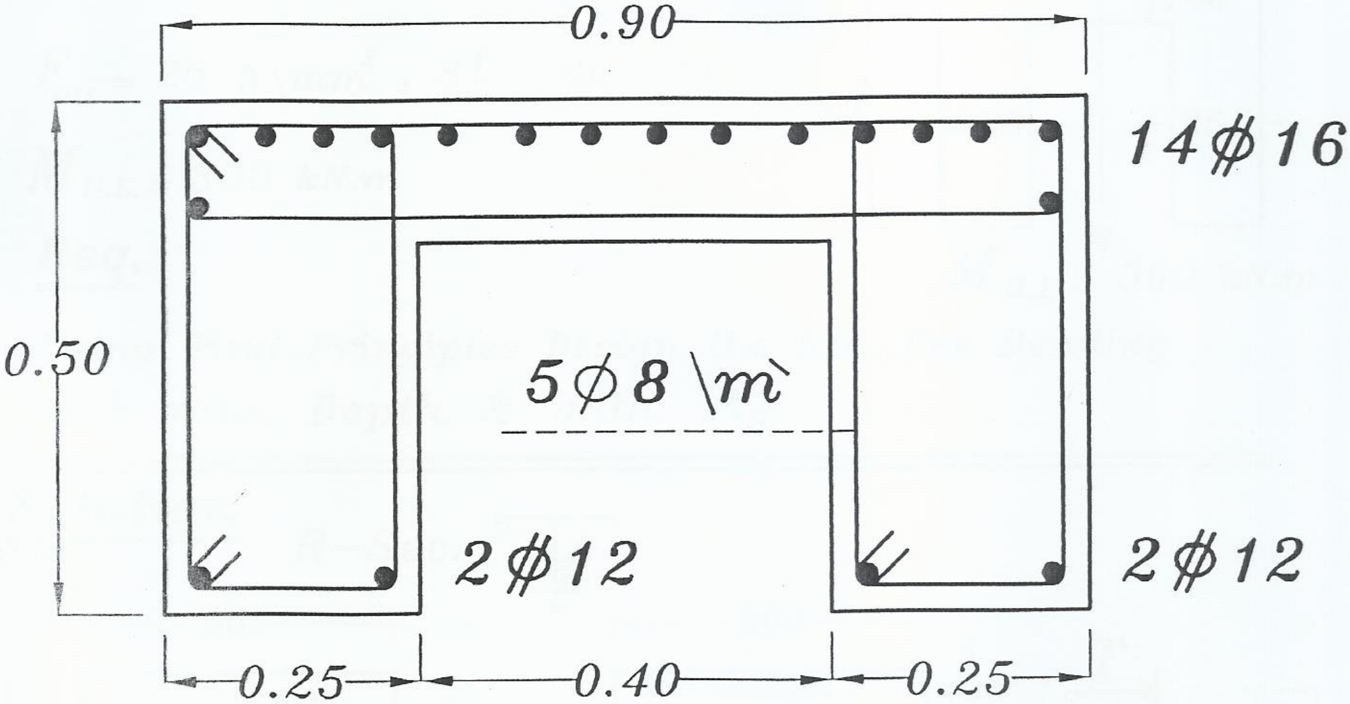
– Get $A_S$ From

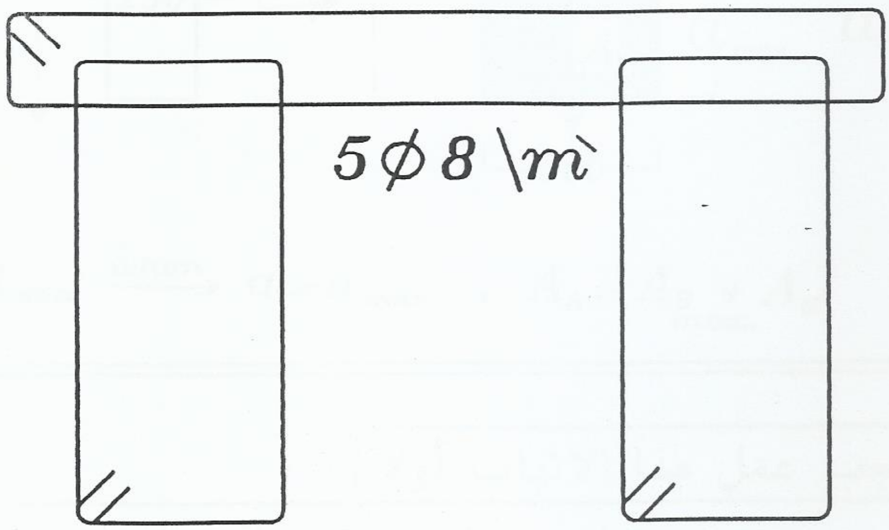
$A_S = A_{S_{max.}} = 6.25\ d = 6.25\ (432.45) = 2702.8\ mm^2$

(14 $\phi$ 16)

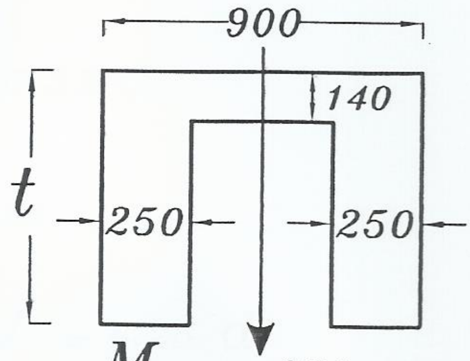
$\therefore n = \frac{b - 25}{\phi + 25} = \frac{900 - 25}{16 + 25} = 21.3 = 21.0$

Stirrup Hangers = $(0.1 \rightarrow 0.2)\ A_S = (0.1 \rightarrow 0.2)\ 2702.8$ (4 $\phi$ 12)


0.90
14∅16
0.50
5∅8 \m`
2∅12
2∅12
0.25
0.40
0.25


5∅8 \m`

## Example.




$M_{U.L.} = 300$ kN.m

$F_{cu} = 25$ N\mm², st. 360/520

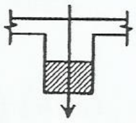
$M_{U.L.} = 300$ kN.m

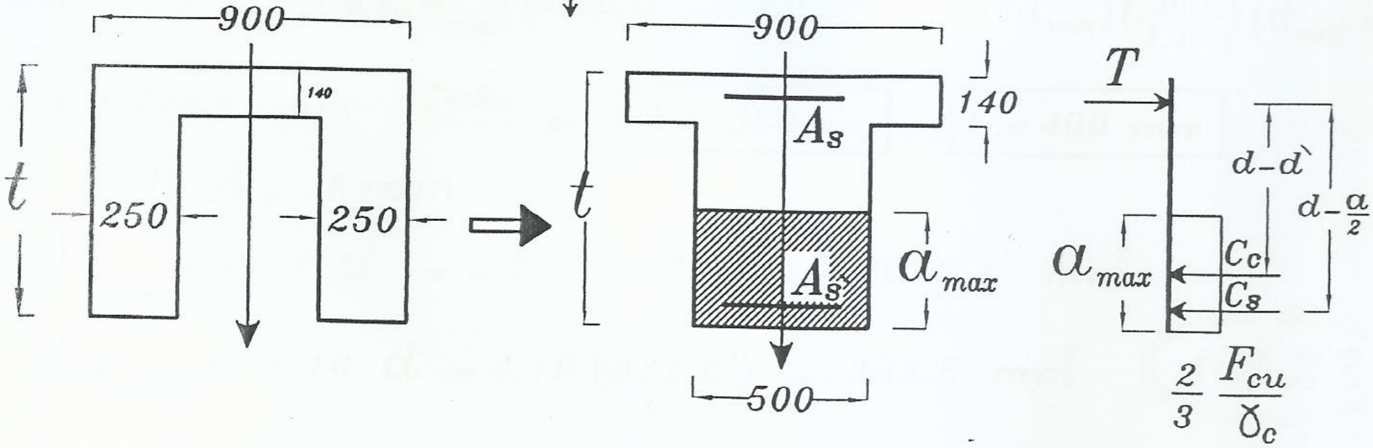
**Req.**

Using First Principles Design the Sec. For Bending With min. Depth. & with $A_{s`}$

## Solution.

R–Sec.






To get $d_{min.}$ $\xrightarrow{when}$ $a = a_{max.}$ , $A_s = A_{s_{max.}} + A_{s`}$ , $A_{s`} = A_{s`_{max.}}$

يجب عمل هذا الاثبات أولا

$$A_{s`_{max.}} = 0.4\, A_s = 0.4\,(A_{s_{max.}} + A_{s`_{max.}})$$

$$\therefore A_{s`_{max.}} = 0.4\,(\mu_{max.}\, b\, d + A_{s`_{max.}})$$

$$\therefore A_{s`_{max.}} = 0.4\,\mu_{max.}\, b\, d + 0.4\, A_{s`_{max.}}$$

$$\therefore 0.6\, A_{s`_{max.}} = 0.4\,\mu_{max.}\, b\, d$$

$$\therefore \boxed{A_{s`_{max.}} = \frac{2}{3}\,\mu_{max.}\, b\, d}$$

$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \gamma_s)}\right] * d = 0.35\, d$$

$$\mu_{max.} = 5 * 10^{-4} * F_{cu} = 5 * 10^{-4}\,(25) = 0.0125$$

$$A_{s_{max.}} = \mu_{max.}\, b\, d = 0.0125\,(500)\, d = 6.25\, d$$

$$A_{s`_{max.}} = 0.4\, A_s = \frac{2}{3}\,\mu_{max.}\, b\, d = \frac{2}{3}\,(0.0125)\,(500)\, d = 4.16\, d$$

From $$M_{U.L.} = \frac{2}{3}\,\frac{F_{cu}}{\gamma_c}\, a_{max.}\, b\left(d_{min} - \frac{a_{max.}}{2}\right) + A_{s`_{max.}}\,\frac{F_y}{\gamma_s}\left(d_{min} - d`\right)$$

$$\therefore 300 * 10^{6} = \frac{2}{3}\left(\frac{25}{1.5}\right)(0.35\, d_{min})\,(500)\left(d_{min} - \frac{0.35\, d_{min}}{2}\right) + (4.16\, d_{min})\left(\frac{360}{1.15}\right)(d_{min} - 50)$$

$\therefore d = 332.6$ mm $\xrightarrow{\text{Take}}$ $\boxed{d = 350 mm}$ , $\boxed{t = 400\ mm}$

– Get $A_s$ From

$$A_{s_{max.}} = 6.25\, d = 6.25\,(332.6) = 2078.7\ mm^2$$

$$A_{s`_{max.}} = 4.16\, d = 4.16\,(332.6) = 1383.6\ mm^2$$ **4 ϕ 22**

$$A_s = A_{s_{max.}} + A_{s`_{max.}} = 2078.7 + 1383.6 = 3462.3\ mm^2$$ **10 ϕ 22**

$$\therefore n = \frac{b - 25}{\phi + 25} = \frac{900 - 25}{22 + 25} = 18.6 = 18.0$$