Check Shear

Allowable Shear Stresses For Concrete.

إجهادات القص التى تتحملها الخرسانه

Nominal Ultimate concrete resistance. (q_{cu})

$$q_{cu} = 0.24\sqrt{\frac{F_{cu}}{\gamma_c}} \quad N\backslash mm^2$$

هو إجهاد القص الذى تتحمله الخرسانه بدون تسليح للقص .

و لزياده معامل الامان نفترض أن الخرسانه تتحمل نصف هذه القيمه

أى أن الخرسانه تتحمل بدون تسليح $\frac{q_{cu}}{2}$

$$q_{cu} = 0.16\sqrt{\frac{F_{cu}}{\gamma_c}} \quad N\backslash mm^2$$ للكمرات المدفونه و القواعد و البلاطات

Nominal Ultimate maximum shear strength. (q_{Umax})

$$q_{Umax} = 0.70\sqrt{\frac{F_{cu}}{\gamma_c}} \leq 3.0 \quad N\backslash mm^2$$

هو إجهاد القص الذى يتحمله القطاع مع وجود أكبر كانات ممكنه $10\phi10\backslash m'$

max. Stirrups = $10\phi10\backslash m'$ 4 branches

و يجب أن لا يتعدى اجهاد الـ *shear* على الخرسانه هذه القيمه حتى نتفادى وجود شروخ كثيره ناتجه عن الـ *shear* مما يؤثر على استخدام الكمره .

To avoid exccessive Shear cracks.

Actual Shear Stress.

$$q = \frac{Q\,S}{I\,b} \longrightarrow \text{Homogeneous Sections.}$$

$$q = \frac{Q\,S_{nv.}}{I_{nv.}\,b} \longrightarrow \text{Heterogeneous Sections.}$$

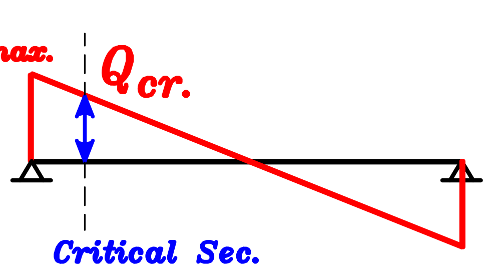
According to N.E.C. (New Egyptian Code)

Actual Shear Stress = $$q_U = \frac{Q_{cr.}}{b\,d}$$ $N\backslash mm^2$

Where:

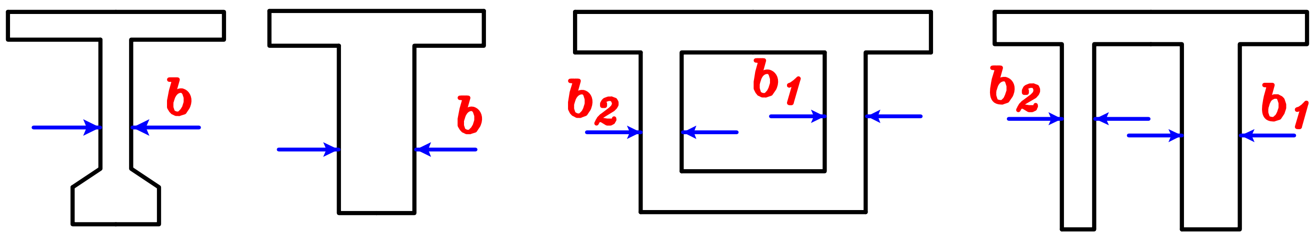
- $Q_{cr.}$ (N) = Shear Force at Critical Section.

  و عاده تؤخذ Q_{max} للتسهيل



- d (mm) = Effective depth = $t - 50\,mm$
- b (mm) = min. width of the Section.

  b أقل عرض للقطاع



b is the smaller width

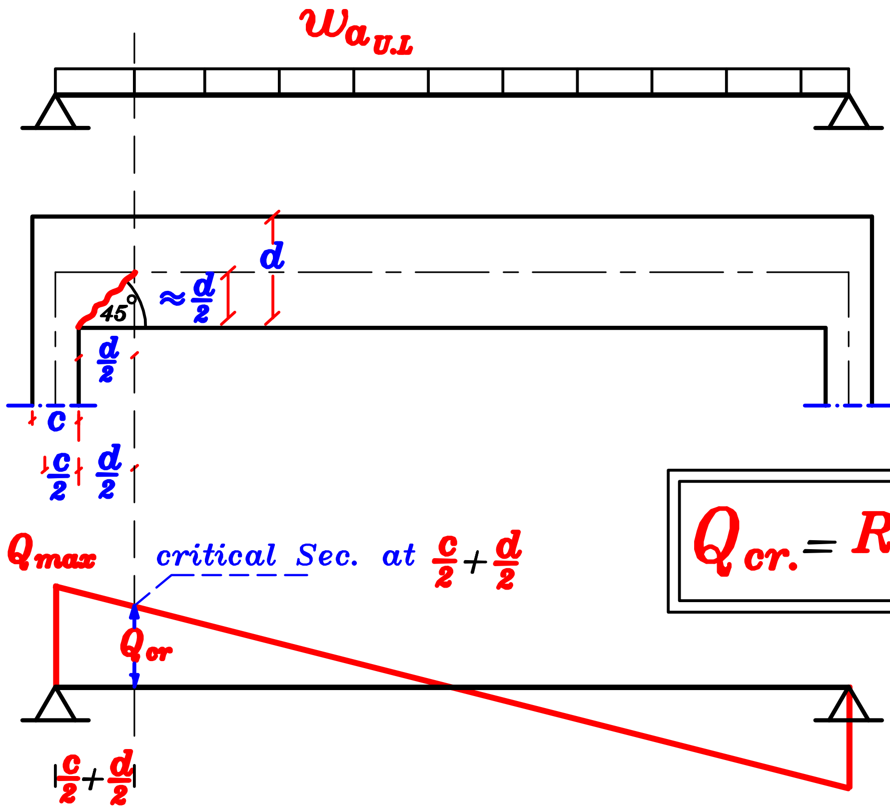
$b = b_1 + b_2$

$b = b_1 + b_2$

Critical Sections For Check of Shear.

Simple beam or Continuos beam

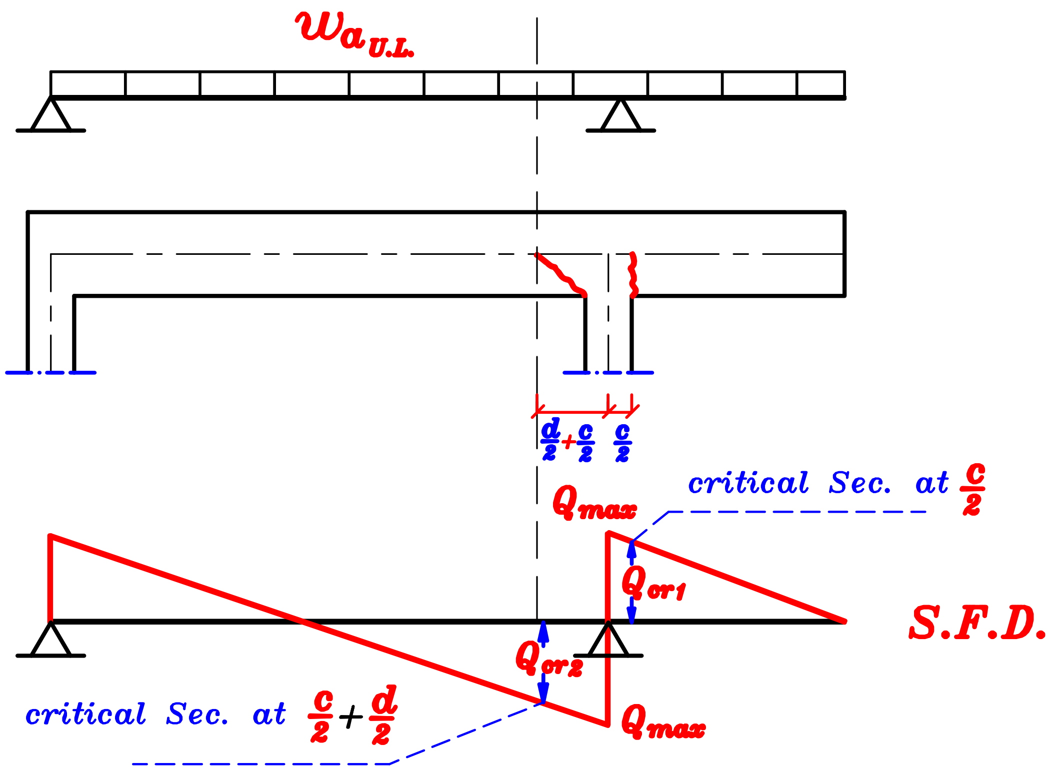
يتم عمل Check Shear
عند ال Critical Sections.



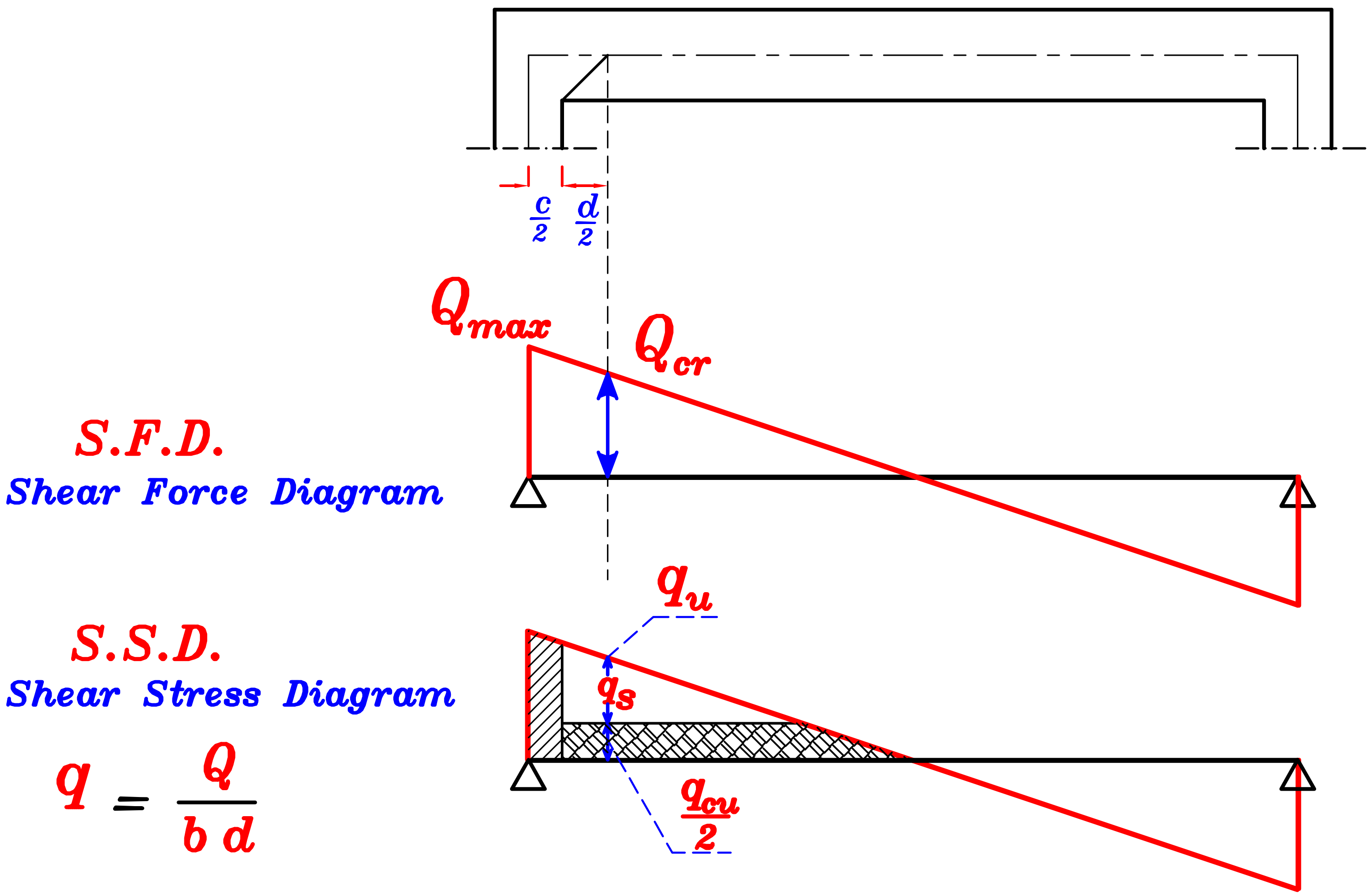
$$Q_{cr.} = R - w_a\left(\frac{c}{2} + \frac{d}{2}\right)$$

S.F.D.

Cantilever



Check Shear
Using VL. Stirrups



$$q = \frac{Q}{b\,d}$$

q_u = Actual Shear Stress.

$\frac{q_{cu}}{2}$ = Shear Stress Taken by Concrete only.

q_{su} = Shear Stress Taken by Stirrups only.

$$\boxed{q_{su} = q - \frac{q_{cu}}{2}} \quad N\backslash mm^2$$

Steps of Check Shear in Beams.

Given : F_{cu} , F_y

b , d → From Design the Beam

Q_{cr} → From S.F.D.

Req. : Check Shear.

Solution :

① Calculate Allowable Shear Stresses.

$$q_{cu} = 0.24 \sqrt{\frac{F_{cu}}{\gamma_c}} \quad N\backslash mm^2$$

$$q_{max.} = 0.70 \sqrt{\frac{F_{cu}}{\gamma_c}} \quad N\backslash mm^2$$

② Calculate Actual Shear Stress.

$$q_U = \frac{Q_{cr.}}{b\,d} \quad N\backslash mm^2$$

③ IF

IF q_U

- $q_U \leqslant q_{cu}$ — Use min. Stirrups. $5\phi 8 \backslash m'$
- $q_{cu} < q_U \leqslant q_{Umax.}$ — We need Stirrups More Than $5\phi 8 \backslash m'$
- $q_U > q_{Umax.}$ — Increase Dim. b or d

* IF $q_{cu} < q_U < q_{U\,max.}$

We need Stirrups more than $5\phi 8 \backslash m`$

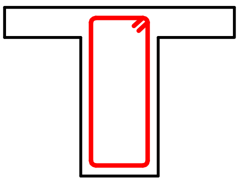
$$q_{su} = q_u - \frac{q_{cu}}{2} = \frac{n\,A_s\,(F_y \backslash \gamma_s)}{b\,S}$$ حفظ

Where : q_{su} = Shear Stress Taken by Stirrups only.

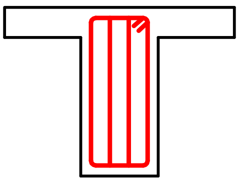
q_u = Actual Shear Stress.

$\frac{q_{cu}}{2}$ = Shear Stress Taken by Concrete only.

– n = No. of Branches.



$n = 2$



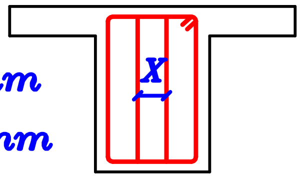
$n = 4$

ملحوظه IF $b \geqslant 400$ mm OR $b > t$

Take $n = 4$

$X \nless 50$ mm

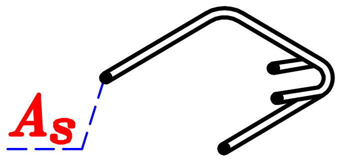
$X \ngtr 250$ mm



– A_s مساحه سطح السيخ الواحد من الكانه

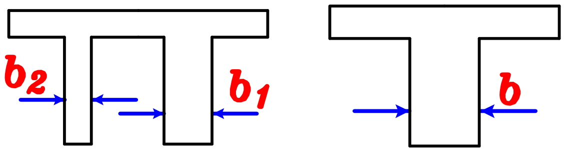
IF using $\phi 8$ ⟶ $A_s = 50.3$ mm^2

IF using $\phi 10$ ⟶ $A_s = 78.5$ mm^2



– $F_y = 240$ $N \backslash mm^2$ Mild Steel

– b = min. width in the Sec.



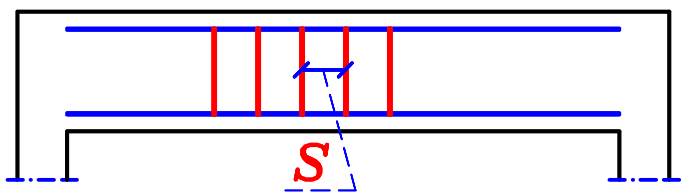
$b = b_1 + b_2$

– S = Spacing between stirrups in the Long Direction.

المسافات بين الكانات فى الإتجاه الطولى

$S_{min} = 100$ mm

$S_{max.} = 200$ mm



$$q_u - \frac{q_{cu}}{2} = \frac{n\,A_s\,(F_y \backslash \gamma_s)}{b\ S}$$

يوجد ثلاثه مجاهيل فى هذه المعادله $n\ ,\ A_s\ ,\ S$

نفرض قيمه كلاً من $n\ ,\ A_s$ ثم نوجد قيمه S و نقارنها ب

$S_{min} = 100\ mm \quad , \quad S_{max.} = 200\ mm$

① **Assume** $n = 2\ , \quad \phi 8 \longrightarrow A_s = 50.3\ mm^2$

Then Get S

IF $\boxed{S}$

- IF $S \geqslant 200\ mm$

  Use min. Stirrups. $5\ \phi 8 \backslash m'$

- IF $100\ mm \leqslant S < 200\ mm$

  Take no. of stirrups\m` $= \dfrac{1000}{S}$

  Example. $S = 140\ mm$

  $\therefore$ No. of stirrups\m` $= \dfrac{1000}{S} = \dfrac{1000}{140} = 7.14$

  $= 8\ \phi\ 8 \ \backslash m'$

- IF $S < 100\ mm$

  $\therefore$ No. of stirrups\m` > 10 **Refused**

  $\therefore$ Try another assumption of $n\ ,\ A_s$

ترتيب الفروض يكون كالأتى

Assumption No.	n	ϕ
1	2	8
2	2	10
3	4	8
4	4	10

ملحوظه

$$\mu = \frac{A_{st}}{b\ S} = \frac{n\ A_s}{b\ S} \qquad \mu_{min} = \frac{0.4}{F_y}$$

Example.

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

st. 240/350 For Stirrups

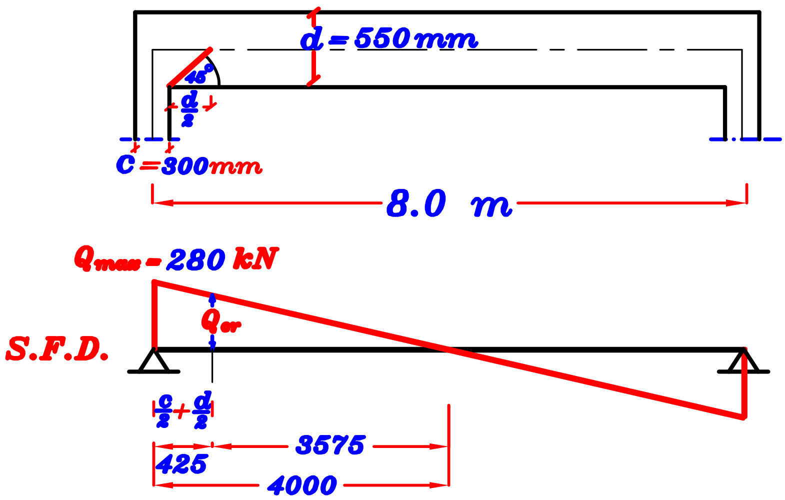
$b = 250\ mm$

$d = 550\ mm$

$c = 300\ mm$

Req. :

Check Shear.



Solution :

$$- q_{cu} = 0.24\sqrt{\frac{F_{cu}}{\gamma_c}} = 0.24\sqrt{\frac{25}{1.5}} = 0.979\ N\backslash mm^2$$

$$- q_{max.} = 0.7\sqrt{\frac{F_{cu}}{\gamma_c}} = 0.7\sqrt{\frac{25}{1.5}} = 2.85\ N\backslash mm^2$$

$$Q_{cr.} = \frac{3575}{4000} * 280 = 250.25\ kN$$

$$\therefore q_U = \frac{Q_{cr.}}{b\,d} = \frac{250.25 * 10^3}{250 * 550} = 1.82\ N\backslash mm^2$$

$\therefore q_{cu} < q_U < q_{max.}$ $\therefore$ We need Stirrups more Than $5\phi 8\backslash m'$

$$\therefore \text{Use} \quad q_S = q_u - \frac{q_{cu}}{2} = \frac{n A_s (F_y\backslash\gamma_s)}{b\ S}$$

$*$ Take $n = 2$, $\phi 8 \longrightarrow A_s = 50.3\ mm^2$

$$1.82 - \frac{0.979}{2} = \frac{2 * 50.3\ (240\backslash 1.15)}{250 * S} \longrightarrow S = 63.1\ mm < 100\ mm$$

$*$ Take $n = 2$, $\phi 10 \longrightarrow A_s = 78.5\ mm^2$

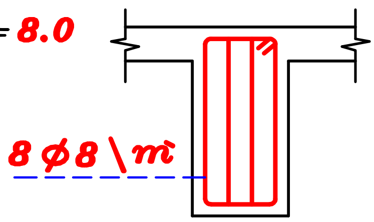
$$1.82 - \frac{0.979}{2} = \frac{2 * 78.5\ (240\backslash 1.15)}{250 * S} \longrightarrow S = 98.5\ mm < 100\ mm$$

$*$ Take $n = 4$, $\phi 8 \longrightarrow A_s = 50.3\ mm^2$

$$1.82 - \frac{0.979}{2} = \frac{4 * 50.3\ (240\backslash 1.15)}{250 * S} \longrightarrow S = 126.2\ mm > 100\ mm \ \therefore \text{o.k.}$$

$$\therefore \text{No. of stirrups}\backslash m' = \frac{1000}{S} = \frac{1000}{126.2} = 7.92 = 8.0$$

$$\therefore \quad S = \frac{1000}{\text{No. of st}\backslash m} = \frac{1000}{8.0} = 125\ mm$$

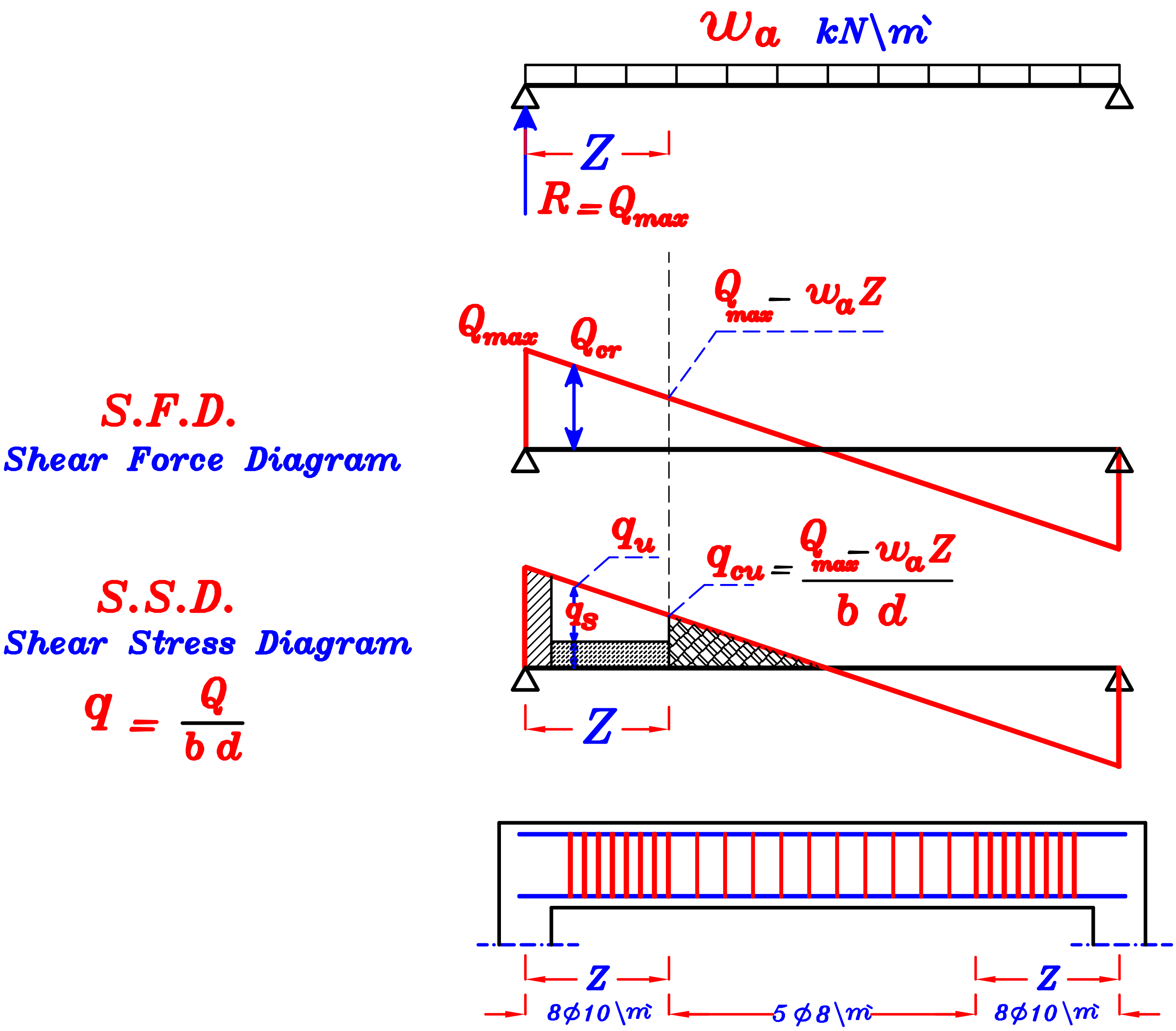


$\therefore$ Use Stirrups **$8\phi 8\backslash m'$ 4 branches**

$$- \text{Check } \mu_{min} = \frac{0.4}{F_y} = \frac{0.4}{240} = 0.0016$$

$$, \quad \mu = \frac{n A_s}{b\,S} = \frac{4 * 50.3}{250 * 125} = 0.0064 > \mu_{min} \ \therefore \text{o.k.}$$

Point of min Shear RFT.



عندما نحدد عدد الكانات الموضوعه فى المتر الطولى مثلاً $8\phi10\backslash m'$
توضع الكانات بهذه القيمه حتى طول محدد (Z) و بعدها يقل
ال Shear Stress حتى يصل إلى قيمه q_{cu}
فلا نحتاج بعدها إلى أكثر من $5\phi8\backslash m'$ min. Shear RFT.

$$q_{cu} = \frac{Q_{max} - w_a Z}{b\ d} \longrightarrow \text{Get } Z$$

Example.

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

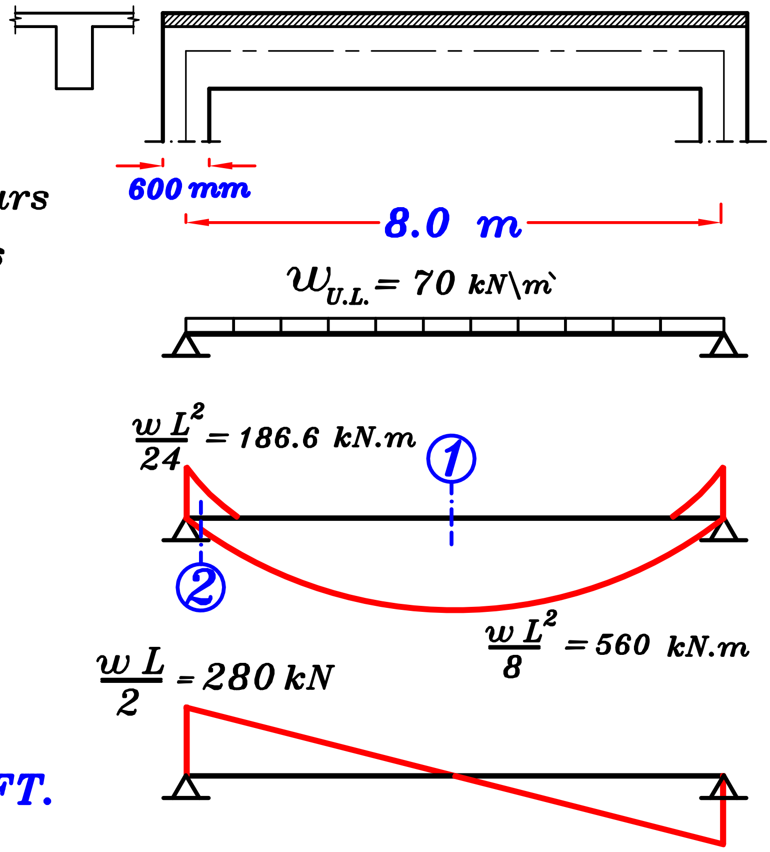
st. 360/520 → Steel Bars

st. 240/350 → Stirrups

$t_s = 120\ mm$

C.L. _ C.L. = 5.0 m

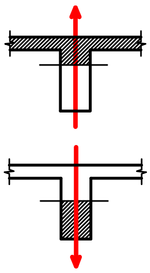
Column (300* 600)



Req:

1. Design the Beam.
2. Check Shear.
3. Draw Details of RFT.

Solution :



Sec. ① $M_{U.L.} = 560$ kN.m T–Sec.

Sec. ② $M_{U.L.} = 186.6$ kN.m R–Sec.

$\because M_T > 2\,M_R \quad \therefore$ Design T–Sec. at First

Sec. ①

$M_{U.L.} = 560$ kN.m T–Sec.

$$B = \begin{cases} C.L.-C.L. = 5.0\ m = 5000\ mm \\ 16\,t_s + b = 16*120+250 = 2170\ mm \\ K\,\frac{L}{5} + b = 1.0*\frac{8000}{5} + 250 = 1850\ mm \end{cases}$$

B = 1850 mm

Take the value of $C_1 = (5.0 \longrightarrow 7.0)$

Take $C_1 = 6.0 \longrightarrow J = 0.826$

$$d = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\, B}} = 6.0 \sqrt{\frac{560 * 10^6}{25 * 1850}} = 660.2 \text{ mm}$$

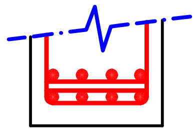
Take $d = 700 mm$ $t = 750 mm$

$$A_s = \frac{M_{U.L.}}{0.826\, F_y\, d} = \frac{560 * 10^6}{0.826 * 360 * 660.2} = 2852.5 \text{ mm}^2$$ **8 ϕ22**

– Check $A_{s_{min.}} = \frac{1.1}{F_y} b\, d = \frac{1.1}{360} (250)(700) = 534.7 \text{ mm}^2$

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

$$\therefore n = \frac{b - 25}{\phi + 25} = \frac{250 - 25}{19 + 25} = 5.113 = 5.0$$



Stirrup Hangers $= (0.1 \rightarrow 0.2)\, A_s = (0.1 \rightarrow 0.2)\; 2852.5$

$= (285 \rightarrow 570)\; mm^2$ **3 ϕ 12**

shrinkage Bars $= \frac{750 - 100}{300} = 2.16 = 3.0$ Spacing

Sec. ②

$M_{U.L.} = 186.6$ kN.m R–Sec.

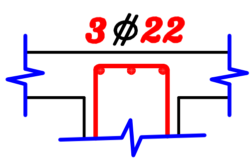
Take $d = 0.70$ m (The same d of Sec. ①)

$$\because d = C_1 \sqrt{\frac{M_{U.L.}}{F_{cu}\, b}} \quad \therefore 700 = C_1 \sqrt{\frac{186.6 * 10^6}{25 * 250}} \longrightarrow C_1 = 4.05 \longrightarrow J = 0.805$$

$$\therefore A_s = \frac{M_{U.L.}}{J\, F_y\, d} = \frac{186.6 * 10^6}{0.805 * 360 * 700} = 919.8 \text{ mm}^2$$

– Check $A_{s_{min.}} = \frac{1.1}{F_y} b\, d = \frac{1.1}{360} (250)(700) = 534.7 \text{ mm}^2$

$\therefore A_s > A_{s_{min.}}$ ∴ o.k. $A_s = 919.8 \text{ mm}^2$ **3 ϕ22**



Check Shear.

– Allowable shear stress.

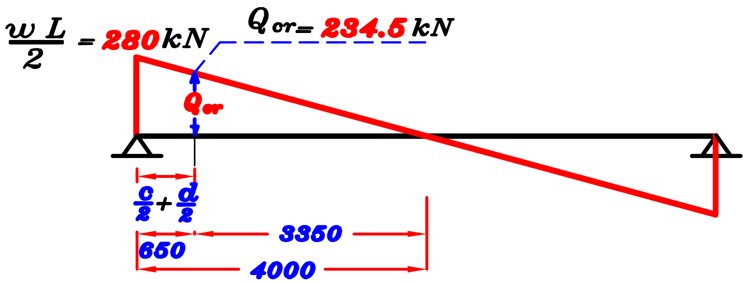
– $q_{cu} = 0.24\sqrt{\frac{F_{cu}}{\gamma_c}} = 0.24\sqrt{\frac{25}{1.5}} = 0.979 \ N\backslash mm^2$

– $q_{max.} = 0.7\sqrt{\frac{F_{cu}}{\gamma_c}} = 0.7\sqrt{\frac{25}{1.5}} = 2.85 \ N\backslash mm^2$

Critical Sec. at $(\frac{c}{2}+\frac{d}{2})$

$= \frac{600}{2} + \frac{700}{2} = 650 \ mm$

$Q_{cr} = \frac{3325}{4000} * 280 = 232.75 \ mm$



– Actual shear stress.

$\therefore q_U = \frac{Q_{cr.}}{b\,d} = \frac{234.5 * 10^3}{250 * 700} = 1.34 \ N\backslash mm^2$

$\therefore q_{cu} < q_U < q_{max.}$ ∴ We need Stirrups more Than $5\phi 8\backslash m$

$\therefore$ Use $q_s = q_u - \frac{q_{cu}}{2} = \frac{n\,A_s (F_y\backslash\gamma_s)}{b\ \ S}$

* Take $n = 2$, $\phi\ 8 \longrightarrow A_s = 50.3 \ mm^2$

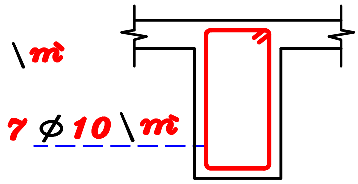
$1.34 - \frac{0.979}{2} = \frac{2 * 50.3\ (240\backslash 1.15)}{250 * S} \longrightarrow S = 98.7 \ mm < 100 \ mm$

* Take $n = 2$, $\phi\ 10 \longrightarrow A_s = 78.5 \ mm^2$

$1.34 - \frac{0.979}{2} = \frac{2 * 78.5\ (240\backslash 1.15)}{250 * S} \longrightarrow S = 154.1 \ mm > 100 \ mm$ ∴ o.k.

∴ No. of stirrups\m` $= \frac{1000}{S} = \frac{1000}{154.1} = 6.48 = 7 \ \backslash m$

∴ Use Stirrups **$7\phi 10\backslash m$** 2 branches



– Check $\mu_{min} = \frac{0.4}{F_y} = \frac{0.4}{240} = 0.0016$

$\therefore \ S = \frac{1000}{No.\ of\ st\backslash m} = \frac{1000}{7.0} = 142.8 \ mm$

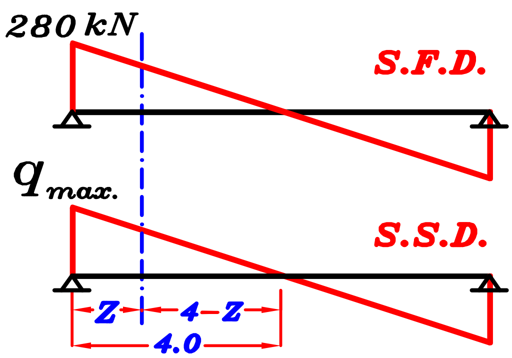
, $\mu = \frac{n\,A_s}{b\,S} = \frac{2 * 78.5}{250 * 142.8} = 0.0044 > \mu_{min}$ ∴ o.k.

Point of min. Stirrups.

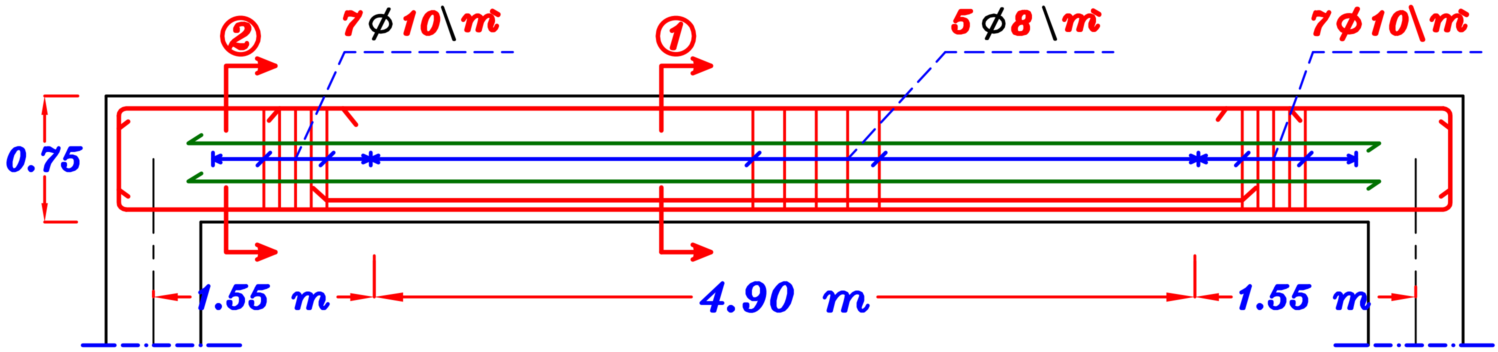
$q_{max.} = \frac{280 * 10^3}{250 * 700} = 1.60 \ N\backslash mm^2$

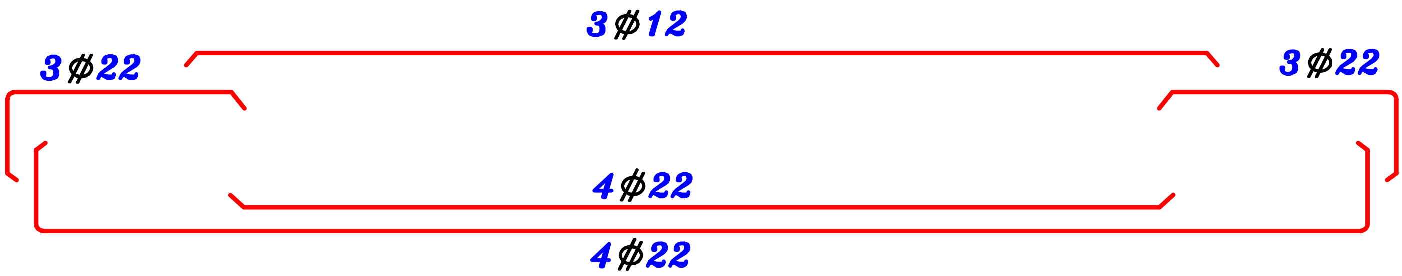
$q_{cu} = 0.979 \ N\backslash mm^2$

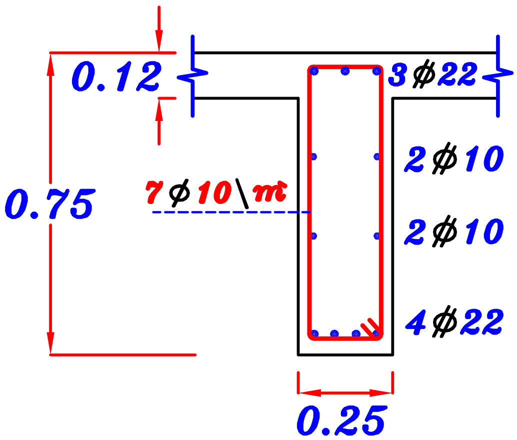
$\frac{0.979}{1.60} = \frac{4 - Z}{4} \longrightarrow$ **$Z = 1.55 \ m$**



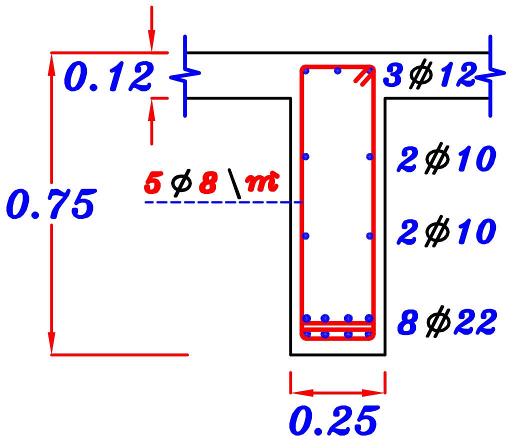
RFT. of Beam.







Sec. (2–2)



Sec. (1–1)