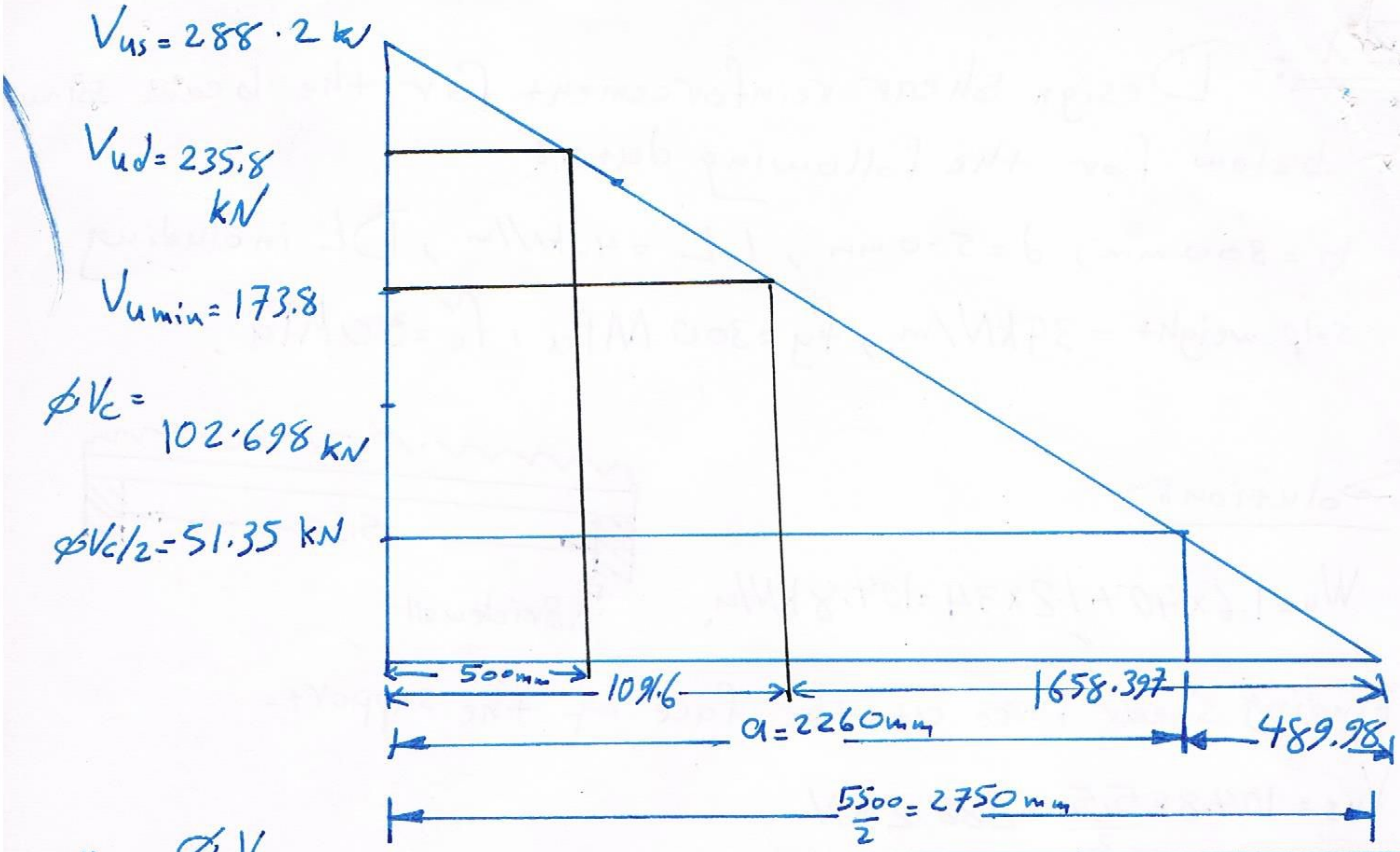


* $\frac{\phi V_c}{2} =$

$\frac{102.698}{2} = 51.35\ kN$

$\because \phi V_s < 4\phi V_c$

* $\therefore S_{max} \leqslant \begin{cases} d/2 = 250\ mm \checkmark \\ 600\ mm \\ \frac{3 A_v f_y}{b_w} = \frac{3\times 2\times 79\times 300}{300} = 474\ mm \\ \frac{16 A_v f_y}{\sqrt{f'_c}\, b_w} = \frac{16\times 2\times 79\times 300}{\sqrt{30}\times 300} = 461\ mm \end{cases}$

$\therefore$ Use $S_{max} = 250\ mm$

* Find spacing of reinforcement at critical section.

$S_o = \frac{A_v f_y d}{V_s} \Longrightarrow$ use ϕ 10mm for stirrups.

$\therefore A_v = 2 * \frac{\pi}{4} \times 10^2 = 157.0\ mm^2$

$S_o = \frac{157 * 300 * 500}{177.47 * 10^{-3}} = 132.7\ mm < S_{max} = 250\ mm$

$\therefore$ use $S_o = 130$ mm c/c

* Finding the distance in which there is no need for reinf.

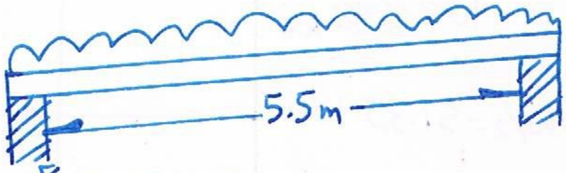
$\frac{x}{51.35} = \frac{2750}{288.2} \Rightarrow x = 489.98\ mm$

$a = 2750 - 489.98 = 2260\ mm$

E.X.:- Design shear reinforcement for the beam shown below for the following data:-

$b = 300mm$, $d = 500mm$, $LL = 40kN/m$, DL including self weight $= 34kN/m$, $f_y = 300 MPa$, $f_c' = 30MPa$.

Solution:-



* $W_u = 1.6 \times 40 + 1.2 \times 34 = 104.8 \; kN/m$

* finding shear force at the face of the support.

$V_{us} = 104.8 * \frac{5.5}{2} = 288.2 \; kN$

* Finding shear force at critical section.

$V_{ud} = V_{us} - W_u d = 288.2 - 0.5 \times 104.8 = 235.8 \; kN$

* $\phi V_c = 0.75 \left(\frac{1}{6} \sqrt{f_c'} \times b \times d\right)$

$= 0.75\left(\frac{1}{6} \sqrt{30} \times 300 \times 500\right) * 10^{-3} = 102.698 \; kN$

Check if there is need for shear reinforcement

$V_{ud} = 235.8 > \phi V_c = 102.698$ ∴ there is a need for shear reinforcement

* $\phi V_s = V_{ud} - \phi V_c = 235.8 - 102.698 = 133.1 \; kN$

$V_s = \frac{133.1}{\phi} = \frac{133.1}{0.75} = 177.47 \; kN$

* $4 * \phi V_c = 4 * 102.698 = 410.792 kN$

∵ $\phi V_s < 4 \phi V_c$

$133.1 \; kN < 410.792 \; kN$

∴ The section is adiquate for shear resistance.

- We can find the distance (a) by other method.

$$V_{us} - W_u * a = \phi V_c / 2$$

$$288.2 - 104.8 * a = 51.35 \Rightarrow a = \frac{51.35 - 288.2}{-104.8}$$

$\therefore a = 2.260$ m

* Determine the distance, which it is after reinforced by minimum reinforcement (shear reinforcement).

$$\phi V_{s\,min} = \frac{\phi A_v f_y d}{S_{max}} = \frac{0.75 * 157 * 300 * 500 * 10^{-3}}{250} = 70.650 \text{ kN}$$

$$V_{u\,min} = \phi V_{s\,min} + \phi V_c = 71.1 + 102.7 = 173.8 \text{ kN}$$

$$V_{us} - W_u b = 173.8$$

$$288.2 - 104.8 * b = 173.8 \Rightarrow b = \frac{173.8 - 288.2}{-104.8}$$

$b = 1.0916$ m

$$x = 1658.397 \Rightarrow x_1 = 2750 - 1658.397$$

or $\frac{x}{173.8} = \frac{2750}{288.2} \Rightarrow x_1 = 1091.6$ mm

* Distribution of shear reinforcement along the beam

a- Put the first stirrups at a distance equal to $\frac{S_o}{2} = \frac{130}{2} = 65$ mm

$\therefore$ Put the first Stirrups at a distance equal to 60mm from the face of the support.

b- Number of the stirrups (130mm)

$$n = \frac{1092 - 60}{130} = 7.938$$ Use 8 ϕ10 stirrup @ 130mm

c- So, the distance from the face of the support which reinforced for shear until now equal to:-

$60 + 8 * 130 = 1100$ mm

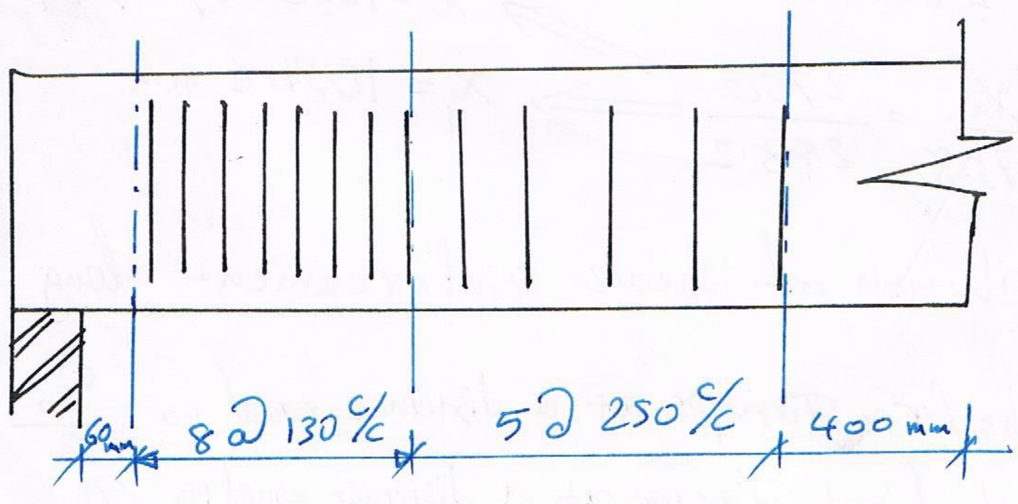
$\therefore$ No of stirrups of 250mm c/c $= \frac{2260 - 1100}{250}$

$= 4.64$

$\therefore$ use $5 \phi 10$ mm stirrups @ 250 c/c

So, the space which reinforced to shear equal to $1100 + 5(250) = 2350$ mm

So, the region which not reinforced for shear is equal to $2750 - 2350 = 400$ mm



or from equilibrium

$V_{us} = W_u a = \phi V_c/2$

$288.2 - 104.8a = 51.35\ kN \Longrightarrow a = 2260\ mm$

finding the distance which after this distance the shear reinforcement in minmun magnitude

$$\phi V_{s\,min} = \frac{\phi A_v f_y d}{S_{max}} = \frac{0.75 \times 2 \times 79 \times 300 \times 500 \times 10^{-3}}{250}$$

$= 71.1\ kN$

$V_{u\,min} = \phi V_{s\,min} + \phi V_c = 71.1 + 102.7 = 173.8\ kN$

$V_{us} - W_u b = 288.2 - 104.8b = 173.8 \Rightarrow b = 1092\ mm$

the distance between critical Section & the point of minmum shear reinf. is small

$e = b - 500 = 1092 - 500 = 592\ mm$

So use the same shear reinf. for critical section