$A_{st} = 577.66 mm^2$

Cl. 26.5.1.1. a

$$\frac{A_{st\,min}}{bd} = \frac{0.85}{f_y}$$

$$A_{st\,min} = \frac{0.85 \times 175 \times 500}{415}$$

$$= 179.219\ mm^2$$

Cl. 26.5.1.1. b

$A_{st\,max} = 0.04\ bD$

$D = d + c + \frac{\phi}{2}$ Assumption

$= 500 + 30 + \frac{16}{2}$

$= 538$

$= 0.04 \times 538 \times 175$

$= 3766\ mm^2$

$A_{st\,min} < A_{st} < A_{st\,max}$

179.219 577

Ast safe.

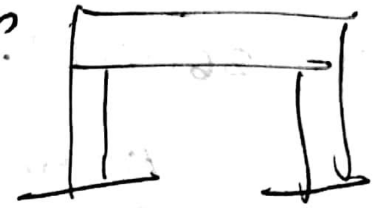
$$\text{No. of bars} = \frac{A_{st}}{\text{Area of 1 bar}} = \frac{577}{\frac{\pi}{4} \times 16^2} = 2.86$$

$= 3$ No.s

Q: A RC beam is supported on 2 walls 750 mm thick spaced at a clear distance of 6m the beam carries a superimposed load of 9.8 KN/m Design the beam using M20 concrete & HYSD bars of Fe415 steel

$l = 6m = 6000\,mm$

width of support = 750 mm



Live load = 9.8 kN/m

$f_y = 415\ N/mm^2$

$f_{ck} = 20\ N/mm^2$

<u>Soln</u>

1* Computation of beam dimension

$\frac{l}{d} = 12 \qquad \frac{6000}{12} = d$ $\qquad \frac{l}{d}$ max 20

(max 20) $\qquad d = 500\ mm$ $\qquad$ slab

Assume clear cover = 30 mm

$\phi \qquad \phi_{bar} = 20\,mm$ (assumptn)

$D = d + c + \phi/2$

$= 500 + 30 + 10 = 540$ → safe to round to 550 always round up.

$D = 540\,mm$

$b = 0.5 \times 540$

$= 270\,mm \qquad b = (0.5 \text{ to } 0.6)D$

cl. 22.2 of IS 456 : 2000

$l_{effective}$ (I) c/c distance = 6000 + 750

$= 6750\ mm$

(II) l clear span + d = 6000 + 500

$= 6500\ mm$

$\therefore\ l_{eff} = 6500\ mm$ or $6.5\,m$

$d = 500\,mm \qquad \phi = 20\,mm \qquad D = 540\,mm$

$l_{eff} = 6.5\,m \qquad b = 270\,mm$

<u>Step 2</u> Load & B.M

Unit wgt of concrete $= 25\,kN/m^3$

$LL = 9.8\,kN/m$

$D.L = b \times D \times 25$

$= 0.27 \times 0.54 \times 25$

$= 3.645\,kN/m$

load & BM കണ്ടുപിടിക്കുമ്പോൾ kN/m വയ്ക്കുക

$TL = LL + DL = 9.8 + 3.645$

$= 13.445\,kN/m$

$$B.M = \frac{w l^2_{effective}}{8} = \frac{13.445 \times 6.5^2}{8}$$

$= 71.006\,kNm$

$M_u = 71.006 \times 1.5 = 106.509\,kNm$

$= 106.509 \times 10^6\,Nmm$

<u>Step 3</u> check Singly / Doubly.

cl. G.1.1.c

$$M_{u\,limit} = 0.36 \frac{x_{umax}}{d}\left[1 - 0.42 \frac{x_{umax}}{d}\right] b d^2 f_{ck}$$

$= 0.36 \times 0.48 \left[1 - 0.42 \times 0.48\right] 270 \times 500^2 \times 20$

$= 186250752$

$= 186.25$

$M_u < M_{u\,limit} \rightarrow$ Singly.

Step 4 : Under reinforced $x_u < x_{umax}$

Cl. G.1.1.c

$$M_u = 0.36 \frac{x_u}{d} \left[1 - 0.42 \frac{x_u}{d}\right] bd^2 f_{ck}$$

$$106.509 \times 10^6 = 0.36 \frac{x_u}{d} \left[1 - 0.42 \frac{x_u}{d}\right] 270 \times 500^2 \times 2$$

$$-0.42 \frac{x_u^2}{d} + \frac{x_u}{d} - 0.219 = 0$$

$$\frac{x_u}{d} = 0.244 , \quad 2.13$$

$$\frac{x_u}{d} = 0.244 \qquad \frac{x_{umax}}{d} = 0.48$$

$$\frac{x_u}{d} < \frac{x_{umax}}{d}$$

$\therefore$ Under reinforced

Safe section.

Step 5 Reinforcement = ?

A_{st} = ?

Cl. G.1.1.b

$$M_u = 0.87 f_y A_{st} d \left[1 - \frac{A_{st} f_y}{b d f_{ck}}\right]$$

$$06.509 \times 10^6 = 0.87 \times 415 \, Ast \, 500 \left[1 - \frac{Ast \, 415}{270 \times 500 \times 20} \right]$$

$$589.99 = Ast - Ast^2 \times 1.537 \times 10^{-4}$$

$$-1.537 \times 10^{-4} Ast^2 + Ast - 589.99 = 0$$

$$Ast = 656.166 , \; 5850.01$$

$$Ast = \underline{\underline{656.166}}$$

20

cl. 26.5.1.1.a

$$\frac{Ast_{min}}{bd} = \frac{0.85}{fy}$$

$$Ast_{min} = \frac{0.85 \times 270 \times 500}{415}$$

$$= 276.506$$

cl. 26.5.1.1.b

$$Ast_{max} = 0.04 bD$$

$$= 0.04 \times 270 \times 540 = 5832$$

$$Ast_{min} < Ast < Ast_{max}$$

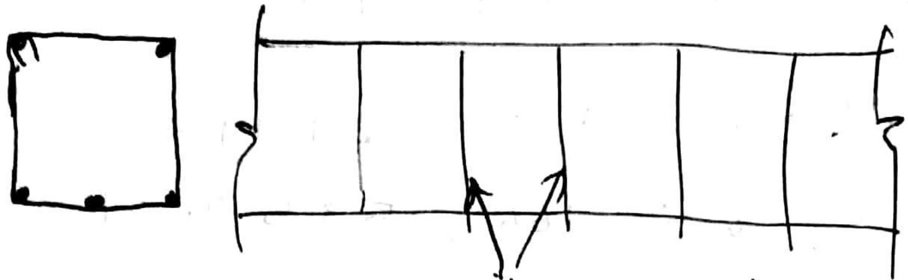
Ast safe

$$\text{No. of bars} = \frac{Ast}{\text{Area of 1 bar}} = \frac{656.166}{\pi/4 \times 20^2} = 2.08$$

3 No.s

Step 6 Check for shear

pg: 72



Stirrups – shear reinforcement

Cl. 40.3

$\tau_v < \tau_c$ 1) Minimum shear reinforcement

$\tau_v > \tau_c$ 2) Design shear – Inclined stirrups / vertical " / Bent up bars

$\tau_v \rightarrow$ Nominal shear $\rightarrow$ loads

$\tau_c \rightarrow$ Design shear $\rightarrow$ Based on % of steel

$$\tau_v = \frac{V_u}{bd}$$

shear force, $V_u = \frac{wl}{2} = \frac{13.445 \times 6.5}{2} \times 1.5$

$= 65.5\,kN$

$$\tau_v = \frac{V_u}{bd} = \frac{65.5 \times 10^3}{270 \times 500}$$

$\tau_v = 0.485\ N/mm^2$

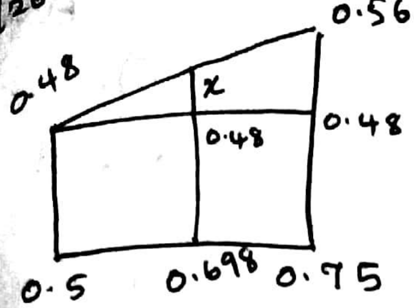
Table 19

$\tau_c \Rightarrow$

$$\frac{100\,A_s}{bd} = \frac{100 \times 3 \times \pi/4 \times 20^2}{270 \times 500} = 0.698$$

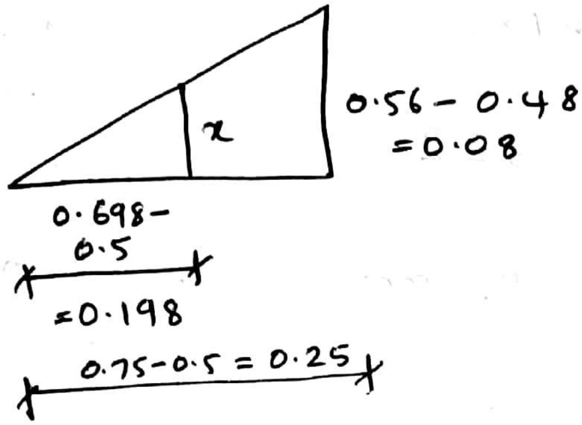
$A_s \rightarrow$ provide ചെയ്ത steel

M20



Similar Δles.

$\tau_c \Rightarrow 0.48 + x$



$$\frac{0.08}{x} = \frac{0.25}{0.198}$$

$$x = \frac{0.08 \times 0.198}{0.25}$$

$$x = 0.063$$

$\tau_v = 0.485\ N/mm^2$

$\tau_c = 0.48 + x$
$= 0.543\ N/mm^2$

$\tau_v < \tau_c$ (cl. 40.3) $< \tau_{cmax}$

Table 20 $\rightarrow$ $\tau_{cmax} = 2.8\ N/mm^2$

$\therefore$ provide minimum shear reinforcement from cl. 26.5.1.6

Area of legs of $\leftarrow$

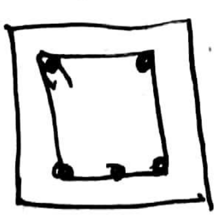
$$\frac{A_{sv}}{b s_v} \geq \frac{0.4}{0.87 f_y}$$

$b \times S_v$

$S_v \rightarrow$ spacing of stirrups

$$\frac{A_{sv}}{b\,s_v} = \frac{0.4}{0.87 f_y}$$

Unkno



Assume 2 legged stirrup of 8mm ϕ

A_{sv} = area of stirrups
$= 2 \times \pi/4 \times 8^2$

$$\frac{A_{sv}}{b \times S_v} = \frac{0.4}{0.87 f_y}$$

$$\frac{2 \times \pi/4 \times 8^2}{270 \times S_v} = \frac{0.4}{0.87 \times 415}$$

$$\cancel{S_v = 1344.322}$$

$$S_v = 336.077 \text{ mm}$$

Stress – N/mm²
Moment KN m
Force KN
Distn mm
Dead Load KN/m

w – KN
M – KN m

Equation of moment
w – N
– mm

Cl. 26.5.1.5

Max spacing shall not exceed 300 mm

Check for Deflection

Slenderness ratio, $\frac{l}{d} = \frac{6500}{500}$

$= 13$

< 20

$\therefore$ section is safe

step 8
Development length

overlapping or bending

Cl. 26.2.1

$$L_d = \frac{\phi \sigma_s}{4 \tau_{bd}} \leftarrow \text{cl. } 26.2.1.1$$

$$\boxed{\sigma_s = 0.87 f_y}$$

$$= \frac{20 \times 0.87 \times 415}{4 \times 1.2} = 1504.375 \text{ mm}$$