MONDAY.

A beam simply supported over an eff. span of 7m carries a live load of 20 kN/m. Design the beam using M20 concrete & HYSD bars of grade 415. Keep the width of the beam = 1/2 the eff depth. Assume unit wt of concrete 25 kN/m³.

Soln:

L.L = 20 kN/m

f_{ck} = 20 N/mm²

f_y = 415 N/mm²

b = d/2

l_{eff} = 7m

Step 1

Computation of beam dimension

$\frac{l}{d} = 12$

$\frac{7000}{d} = 12$ $\frac{7000}{12} = d$

d = 583.33 mm

Assume clear cover = 30 mm

ϕ_{bar} = 20 mm

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

= 583.3 + 30 + 10

= 623.3 mm

= 650 mm

d = 610

b = 610/2

= 305 mm

Step 2

2. Load & BM

L.L = 20 kN/m

D.L = b × D × 25

0.305 × 0.650 × 25

= 4.95625 kN

Total load = LL + DL

= 20 + 4.95

= 24.95625 kN

$BM = \frac{wl^2}{8}$

$= \frac{24.956 \times 7^2}{8}$

= 152.855 kNm

M_u = 152.855 × 1.5

= 229.283 kNm

$M_u = 229.283 \times 10^6$ Nmm

Step 3

Check singly / doubly

Cl. G.1.1.c

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

$= 0.36 \times 0.48 [1 - 0.42 \times 0.48] \, 305 \times 610^2 \times 20$

= 313150977.3 Nmm

= 313.1509 kNm

$M_u < M_{u\,limit}$

⇒ Singly.

Step 4:

Under reinforced

$x_u < x_{umax}$

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

$229.283\times10^6 = 0.36 \frac{x_u}{d}\left[1-0.42\frac{x_u}{d}\right]$

$= 305\times610^2\times20$

$0.28 = \frac{x_u}{d} - 0.42 \frac{x_u}{d}^2$

$-0.42 \frac{x_u}{d}^2 + \frac{x_u}{d} - 0.28 = 0$

$x = 0.324, 2.05$

If redesign Make d unknown

$\frac{x_u}{d} = 0.324$

$\frac{x_{umax}}{d} = 0.48$

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

∴ under reinforced Safe section.

Step 5

Reinforcement = ?

Ast = ?

cl. G.1.1.b

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

$229.283\times10^6 = 0.87\times415\times A_{st}\times610 \left[1-\frac{A_{st}\times415}{305\times610\times20}\right]$

$1041.057 = A_{st} - 1.115\times10^{-4} A_{st}^2$

$x = 1202.2, 7766.4$

$A_{st} = 1202.2$

cl. 26.5.1.1.a

$\frac{A_{stmin}}{bd} = \frac{0.85}{f_y}$

$A_{stmin} = \frac{0.85\times305\times610}{415}$

$= 381.06$

cl. 26.5.1.1.b

$A_{stmax} = 0.04\, bD$

$= 0.04\times305\times650$

$= 7930$

$A_{stmin} < A_{st} < A_{stmax}$

1202.2

Ast safe

$\text{No. of bars} = \frac{\cancel{\text{Area}}\ A_{st}}{\text{Area of 1 bars}}$

$= \frac{1202.2}{\pi/4\times20^2}$

$= 3.82$

4 Nos

Step 6 : Check for shear

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

shear force,

$V_u = \frac{wl}{2}$

$= \frac{24.956\times7}{2}\times\underbrace{1.5}_{FOS}$

$= 131.019$ KN

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

$= \frac{131.019 \times 10^3}{305 \times 610}$

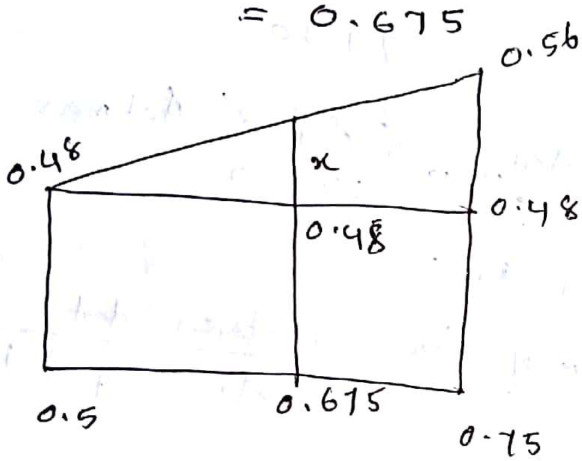
$\tau_v = 0.704$

Table 19 ⇒

τ_c ⇒

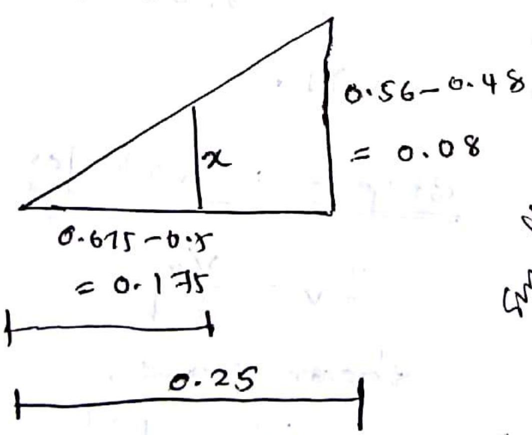
$\frac{100 A_c}{bd} = \frac{100 \times 4 \times \pi/4 \times 20^2}{305 \times 610}$

$= 0.675$



$\tau_c = 0.48 + x$

Similar Δles



$\frac{0.08}{x} = \frac{0.25}{0.175}$

$x = 0.056$

$\tau_c = 0.48 + x$
$= 0.536$

$\tau_v > \tau_c < \tau_{c\,max}$

$\tau_{c\,max} = 2.8$ (Table 20)

∴ Design shear reinforcement in the form vertical stirrups is to be provided.

From cl. 40.4.a

$V_{us} = \frac{0.87 f_y A_{sv} d}{S_v}$?

Assume 2legged stirrups of 8mm ϕ.

$[V_u - \tau_c bd] = \frac{0.87 \times 415 \times 2 \times \frac{\pi}{4} \times 8^2 \times 610}{S_v}$

$\left[131.109 \times 10^3 - 0.536 \times 305 \times 610\right] = \frac{0.87 \times 415 \times 2 \times \frac{\pi}{4} \times 8^2 \times 610}{S_v}$

$S_v = 705.437\text{mm}$

Check for spacing [26.5.15]

Smaller value.

i) 705.437 mm.

ii) $0.75d = 457.5$

iii) 300 mm

∴ So provide 2 legged stirrup of 8mm ϕ @ 300mm c/c.

Step: Check for Deflection

Slendernous ratio $= l/d$

$$= \frac{7000}{610} = 11.475$$

< 20

$\therefore$ section is safe.

Step 8 : Development length

cl. 26.2.1

$$L_d = \frac{\phi \sigma_s}{4 \tau_{bd}} \qquad \sigma_s = 0.87 f_y .$$

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

$= 1504.375\,mm$

9-10-2019