Q1. Given size 300×600 mm

$f_{ck} = 25$ MPa.

Moment of cracking.

$$M_{cr} = \frac{f_{cr}}{y} I.$$

$$\Rightarrow \frac{M}{I} = \frac{\sigma}{y}.$$

$$\Rightarrow f_{cr} = 0.7\sqrt{f_{ck}}$$

Modulus of fracture (f_{cr})

$$\Rightarrow f_{cr} = 0.7 \times \sqrt{25}$$

$$\Rightarrow f_{cr} = 0.7 \times 5$$

$$\Rightarrow f_{cr} = 3.5 \text{ MPa}.$$

3.5×10^3.

$$\Rightarrow y = \frac{D}{2} = \frac{600}{2}\ 300 = 300 \text{ mm}$$

$$I = \frac{BD^3}{12} = \frac{300 \times (600)^3}{12} = 5.4 \times 10^9$$

$$\Rightarrow M_{cr} = \frac{3.5 \times 10^3 \times 5.4 \times 10^9}{300}$$

$$\Rightarrow M_{cr} = 6.3 \times 10^7 \text{ N/mm}$$

$$\Rightarrow M_{cr} = 63 \text{ kN}$$

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Q2. Moment at serine ~~tont~~ level

$M = 63 KN$

At service level $= 63 \times 0.67 = 42.21$

Partial safety factor $= 1.5$

$= \frac{42.21}{1.5}$

$= 28 KN$.

3) Bending stress for 80% for cracked moment

$M = 63 KN$

M for 80% $= \frac{63 \times 80}{100}$

$= 50.4 KN$

Bending stress $\Rightarrow \sigma = \frac{M \cdot y}{I}$

$\Rightarrow \sigma = \frac{50.4 \times 300}{5.4 \times 10^9}$

$\Rightarrow \sigma = 50.4 \times 10^6 N/mm$

$\sigma = \frac{50.4 \times 10^6 \times 300}{}$ $= 2.8 N/mm$

4) Given data.
- Steel grade Fe - 500
- Effective cover : 50mm

Concrete M20

$b = 300mm$

$D = 500mm$

effective depth (d)

$d = D -$ effective cover

$d = 500 - 50 = 450mm$

$x_{u,lim} = 0.46 \times d$

$x_u \, lim = 0.46 \times 450 = 207mm$

$M_{u,lim} = 0.36 f_{ck} \, b \times x_u lim (d - 0.42 \, x_u lim)$

$M_{u,lim} = 0.36 \times 20 \times 300 \times 207 \times (450 - 0.42 \times 207)$

$M_{u,lim} = 0.36 \times 20 \times 300 \times 207 (450 - 86.94)$

$M_{u,lim} = 447120 \times 363.06 \; N mm$

$M_u lim = 162.22 \; KN-m$

Alternative.

for Fe 500

$0.133 f_{ck} \, bd^2$

$M_{u,lim} = 0.133 \times 20 \times 300 \times 450^2$

$M_{u,lim} = 161.745 \times 10^6 \; N-mm$

$M_{u,lim} = 161.75 \; KN m$

So, the max^m factored moment is $M_u lim = 162.22 KNm$ ans

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5. Concrete M20 $f_{ck} = 20 N/mm^2$

$\Rightarrow b = 300 mm$

$\Rightarrow D = 500 mm$

$\Rightarrow d' = 50 mm$ (Effective cover for tension)

$\Rightarrow d_c = 50 mm$ (Effective cover for compression)

$\Rightarrow$ Steel grade = Fe 500

$\Rightarrow$ Area of compression reinforcement = 2 bar of 16mm

$= 2 \times \frac{\pi}{4} \times \cancel{16}^{4} \times 16$

$= 402.12 mm^2$

$\Rightarrow$ Area of tension reinforcement 4 bar 20 mm

$= 4 \times \frac{\pi}{4} \times 20^2$

$\Rightarrow \pi \times 20^2 = 1256.64 mm^2$

Step 1 :→ Effective depth.

$d = D - d' = 500 - 50 = 450 mm$

Step 2 :→ Limiting N.A depth.

$\Rightarrow x_u, lim/d = 0.46$

$\Rightarrow x_u, lim = 0.46 \times d$

$\Rightarrow x_u\ lim = 0.46 \times 450 = 207 mm$

Step 3 :→ $M_u\ lim = 0.36 f_{ck}\ b\ x_u\ lim(d - 0.42\ x_u\ lim)$

$\Rightarrow M_u\ lim = 0.36 \times 20 \times 300 \times 207 \times (450 - 0.42 \times 207)$

$\Rightarrow M_u\ lim = 162.22 \times 10^6$ N-mm

$\Rightarrow M_u\ lim = 162.22$ KN m.

Step 4. $A_{st}\ lim = \frac{0.36 f_{ck}\ b\ x_u\ lim}{0.87 f_y}$

$\Rightarrow A_{st,lim} = \frac{0.36 \times 20 \times 300 \times 207}{0.87 \times 500}$

$\Rightarrow A_{st,lim} = 1026.83 \, mm^2$

$\Rightarrow A_{st_2} = 1256.64 - 1026.83$

$\Rightarrow A_{st2} = 229.81 \, mm^2$

Step 5 Stress in compression steel

$\epsilon_{sc} = 0.0035 \times \left(1 - \frac{d_c}{x_{u\,lim}}\right)$

$\epsilon_{sc} = 0.0035 \times \left(1 - \frac{50}{207}\right)$

$\epsilon_{sc} = 0.00265$

for fe 500

$f_{sc} = 412 \, N/mm^2$ from stress - strain curve

Step 6

$\Rightarrow M_{u_2} = f_{sc} \times A_{sc} (d - d_c)$

$\Rightarrow M_{u_2} = 412 \times 402.12 (450 - 50)$

$\Rightarrow M_{u_2} = 66.21 \times 10^6 \, N-mm$

$\Rightarrow M_{u_2} = 66.21 \, KN-m$

Step 7.

$M_u = M_{u\,lim} + M_{u2}$

$M_u = 162.22 + 66.21$

$M_u = 228.43 \, KN-m$ (maximum)