Answer- 1

Reinforced Concrete beams are structural elements that designed to carry transverse external loads. The loads caused bending moment, shear forces and in some case torsion across their length.

The design of concrete beam includes the estimation of cross section dimension and reinforcement area to resist applied loads.

There are two approaches for the design of beams.

→ Firstly, begin the design by selecting depth and width of the beam that compute reinforcement area.

→ Secondly, assume reinforcement area, then calculate cross-section sizes.

first approach :- Initially, select beam effective depth (d) and width (b). Effective depth can be computed using beam depth (h)

- Then Calculate the required flexural resistance factor assume $\phi = 0.9$

$$R = \frac{Mu}{\phi bd^2} \quad eq^2$$

- After that, find reinforcement ratio corresponding to the computed flexural resistance compute above.

$$R = \rho F_y \left(1 - 0.588 \frac{\rho F_y}{f'c}\right) MPa \quad eq(3)$$

- The reinforcement ratio shall be less than maximum reinforcement ratio and greater than minimum reinf. ratio.
- Minimum reinf. ratio.

$$\rho_{min} = 025 \sqrt{\frac{f'c}{F_y}} \geq \frac{1.4}{f_y} \quad eq(4)$$

- Max. reinf. ratio

$$\rho_{0.004} = 0.85 \beta_1 \frac{f'c}{f_y} \frac{\varepsilon_u}{\varepsilon_u + 0.004} \quad eq(5)$$

$$\rho_{0.004} = 0.85 \beta_1 \frac{F'c}{f_y} \frac{\varepsilon_u}{\varepsilon_u + 0.005} \quad eq(6)$$

- Either reinf. ratio can be employed but the latter will ensure that the strain in steel is at least 0.005.
- Thereafter, Compute reinf. area

$A_s = \rho bd$ eq 7

- Then find no. of bar by dividing reinforcement area over the area of a single bar.

- Lastly, check whether the bar can be placed within selected width of the cross-section.

$$S = b - \frac{(2 \text{ conc. cover} + 2 \text{ Stirrup dia} + n \times \text{bar dia})}{n-1} \quad \text{eq (8)}$$

- The value of S shall not be less than 25 mm which the minimum required spacing between adjacent bars.

where, R = Flexural Resistance factor
ρ = reinforcement ratio
M_u = factored load moment
ϕ = strength reduction factor
b = cross section width
S = Spacing blw adjacent bars.