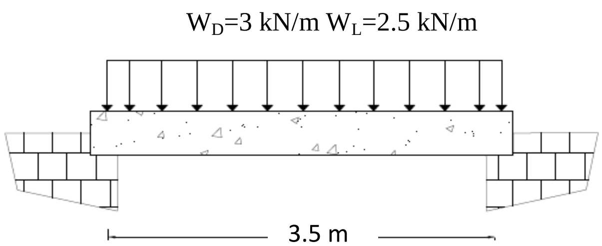
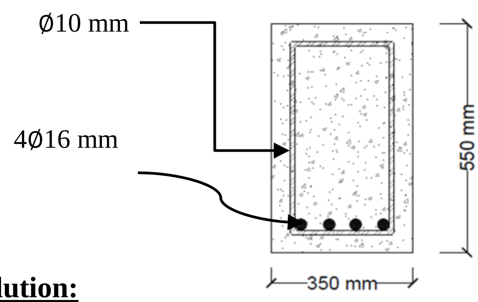
Typical Solutions

Note: use fc`=25 MPa and fy=420 Mpa for all questions

Provide enough drawings to illustrate your answer for steel reinforcement.

Q1 (50%): check the adequacy of the beam shown below according to ACI requirement. Neglect the self-weight.





Solution:

1. Calculate $\rho = \frac{As}{bd}$

   As = $4 \times \frac{\pi}{4} \times 16^2 = 804.24$ mm^2

   $d = 550 - 40 - 10 - \frac{16}{2} = 492$ mm

   $\rho = \frac{804.24}{350 \times 492} = 4.67 \times 10^{-3}$

   $\rho_{max} = 0.85\beta_1 \frac{fc`}{fy} \frac{\epsilon u}{\epsilon u + 0.004} = 0.0184$

   $\rho < \rho_{max}$ O.k

2. Calculate Ø

   $a = \frac{As*fy}{0.85fc`*b} = \frac{804.24*420}{0.85*25*350} = 45.11$ mm

   $c = \frac{a}{\beta 1} = \frac{45.11}{0.85} = 53.42$ mm

   $\epsilon_t = \frac{dt - c}{c}\epsilon_u = \frac{492 - 53.42}{53.42} \times 0.003 = 0.0246 > 0.005$

   ∴ Ø = 0.9

3. Calculate ØMn

   $ØMn = ØAsfy(d - \frac{a}{2})$

   $ØMn = 0.9 \times 804.24 \times 420 \times (492 - \frac{45.11}{2}) \times 10^{-6}$

   ØMn=142.6 kN.m

4. Find Mu and compare it with ØMn

   W_D = 3 kN/m W_L= 2.5 kN/m

   $Wu = 1.2W_D + 1.6W_L = 1.2 \times 3 + 1.6 \times 2.5 = 7.6$ kN/m

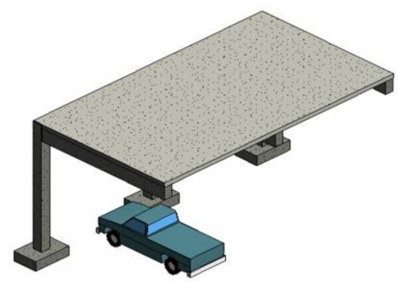
   $Mu = \frac{w_u \times \ell^2}{8} = \frac{7.6 \times 3.5^2}{8} = 11.64$ kN.m < ØMn

   The section is O.k ■

Q2 (50%): Design a cantilever rectangular reinforced concrete beam shown in Figure below.

Assume that the designer intends to use:

- Mu = 220 kN.m
- A width of 400 mm and a height of 500 mm.
- Rebar diameter 25mm for longitudinal reinforcement.
- Rebar diameter 10mm for stirrups.
- Two layers of reinforcement.



Solution:

1. Compute required factored applied moment Mu

   Mu =220 kN.m

2. Compute the effective depth (d)

   $d_{\text{for two layer}}$ = h- cover-stirrups- bar diameter-$\frac{\textbf{spacing between layers}}{\textbf{2}}$

   d = 500 – 40 – 10 – 25 – 12.5 = 412.5 mm

3. Compute ρ_{max}, ρ_{min}

   $\rho_{max} = 0.0184$ & $\rho_{min} = 3.33 \times 10^{-3}$

4. Compute ρ

   $m = \frac{fy}{0.85fc`} = 19.76$, $R = \frac{M_u \times 10^6}{\varphi b d^2} = 3.59$

   $\rho = \frac{1}{m}(1 - \sqrt{1 - \frac{2Rm}{fy}}) = 9.425*10^{-3}$

   $\rho_{min} < \rho < \rho_{max}$ O.K

5. Compute the required steel area (As):

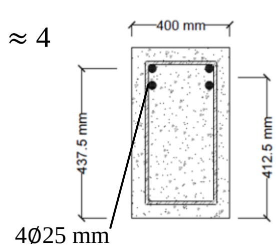
   $As = \rho \times b \times d = 9.425 \times 10^{-3} \times 400 \times 412.5 = 1555.88$ mm^2

6. Compute required Number of rebars:

   No. of rebars = $\frac{As}{Abar} = \frac{1555.88}{\frac{\pi}{4}*25^2} = 3.16 \approx 4$

   Use 4 Ø25 mm

   $As_{provided} = 4 \times 491 = 1964$ mm^2



7. Check if the available width "b"

   $b_{required}$ = 175 mm < 400 mm O.k

8. Check the assumption of Ø = 0.9

   a = 97 mm, c =114 mm, dt=437.5mm $\epsilon_t = 8.5 \times 10^{-3} > 0.005$

   ∴ Ø=0.9

9. Draw your final detail section ■