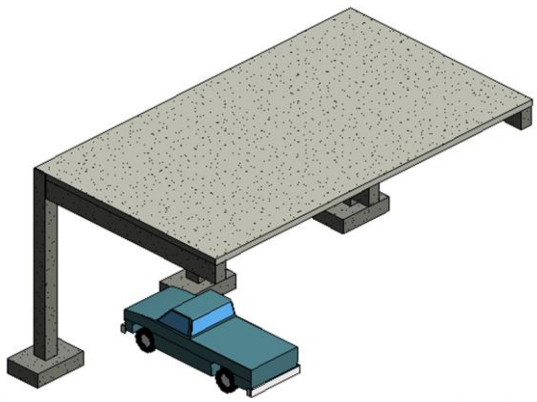
Madent Al-Elem University College | **Reinforced concrete design I** | **Monthly Exam**
College Of Engineering | **Subject: Analysis& Design of Singly beam** | **Time: 1 hr and 15 min**
Civil Engineering Department | | **Stage: 3rd**

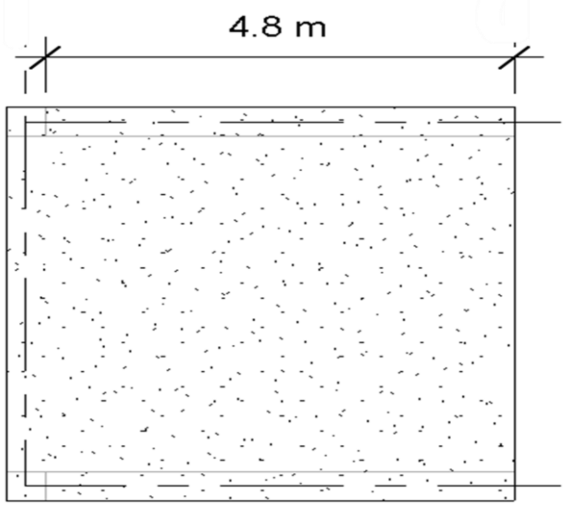
Typical Solutions

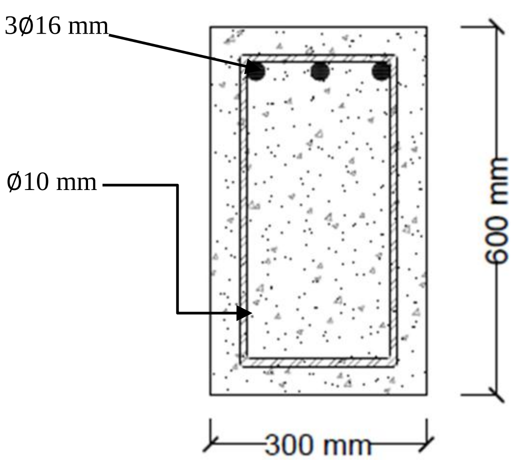
Note: use fc`=25 MPa and fy=420 Mpa for all questions

Provide enough drawings to illustrate your answer for steel reinforcement.

Q1 (50%): check the adequacy of the beam shown below according to ACI requirement. W_D=2.5 kN/m (including self-weight) and W_L=2.5 kN/m







Solution:

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

$As = 3 \times \frac{\pi}{4} \times 16^2 = 603.2\ mm^2$

$d = 600 - 40 - 10 - \frac{16}{2} = 542\ mm$

$\rho = \frac{603.2}{300 \times 542} = 3.7 \times 10^{-3}$

$\rho_{max} = 0.85\beta_1 \frac{fc`}{fy} \frac{\epsilon u}{\epsilon u + 0.004} = 0.018$

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

2. Calculate Ø

$a = \frac{As*fy}{0.85fc`*b} = \frac{603.2*420}{0.85*25*300} = 39.74\ mm$

$c = \frac{a}{\beta 1} = \frac{39.74}{0.85} = 46.75\ mm$

$\epsilon_t = \frac{dt-c}{c}\epsilon_u = \frac{542-46.75}{46.75} \times 0.003 = 0.0317 > 0.005$

$\therefore Ø = 0.9$

3. Calculate ØMn

$ØMn = ØAsfy(d - \frac{a}{2}) = 0.9 \times 603.2 \times 420 \times (542 - \frac{39.74}{2}) \times 10^{-6}$

ØMn = 119 kN.m

4. Find Mu and compare it with ØMn

W_D = 2.5 kN/m, W_L = 2.5 kN/m

$Wu = 1.2W_D + 1.6W_L = 1.2 \times 2.5 + 1.6 \times 2.5 = 7$ kN/m

$Mu = \frac{w_u \times \ell^2}{2} = \frac{7 \times 4.8^2}{2} = 80.64$ kN.m < ØMn

The section is O.k ■

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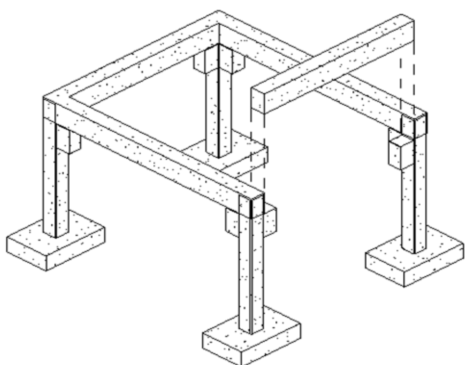
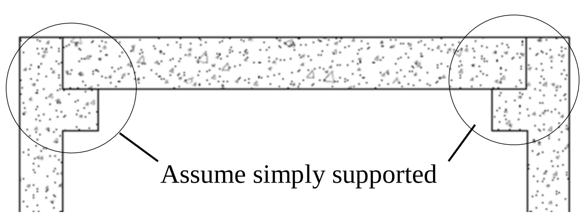
Q2 (50%): Design a simply supported rectangular reinforced concrete beam shown in Figure below.

Assume that the designer intends to use:

- Mu = 350 kN.m
- Use $\rho = 0.5\ \rho_{max}$ and $\frac{d}{b} = 3$
- Rebar diameter 20mm for longitudinal reinforcement.
- Rebar diameter 10mm for stirrups.
- Two layers of reinforcement.





Solution:

1. Compute required factored applied moment Mu

   Mu = 350 kN.m

2. $Mu = \emptyset Mn = \emptyset \rho f_y bd^2 (1 - 0.59 \frac{\rho fy}{fc`})$

   As it was mentioned in question $\rho = 0.5\rho_{max}$ & $\frac{d}{b} = 3$

   $\rho_{max} = 0.85 \times \beta_1 \frac{fc`}{fy} \frac{\epsilon u}{\epsilon u + 0.004}$ and $\epsilon_u = 0.003$

   $\rho_{max} = 0.85 \times 0.85 \times \frac{25}{420} \frac{0.003}{0.003+0.004} = 0.0184$

   $\rho = 0.5\rho_{max} = 0.5 \times 0.0184 = 9.2 \times 10^{-3}$

3. Substitute both of selected $\boldsymbol{\rho}$ and ration of $\frac{d}{b}$ in the main equation:

   $Mu = \emptyset Mn = \emptyset \rho f_y bd^2 (1 - 0.59 \frac{\rho fy}{fc`})$

   $350 \times 10^6 = 0.9 \times 9.2 \times 10^{-3} \times 420 \times bd^2\ (1 - 0.59 \times \frac{9.2\times10^{-3}\times420}{25})$

   $350 \times 10^6 = 3.16 \times bd^2$

   $bd^2 = 110.75 \times 10^6\ mm^2$

   As $\frac{d}{b} = 3$ ► d = 3b

   b = 230.87 mm ≈ 250 mm ∴ d = 3 × 250 = 750 mm

4. Compute required steel area

   $As_{required} = \rho \times (bd) = 9.2 \times 10^{-3} \times 250 \times 750 = 1725\ mm^2$

5. Compute the required number of bars (n)

   No. of bars (n) $= \frac{As}{Abar} = \frac{1725}{\frac{\pi}{4}20^2} = \frac{1725}{314} = 5.49 \approx 6$

6. Check if rebars can in be put in single layer

   $b_{required}$ = 2 × cover +2 × stirrups diameter + No. of rebars × bar diameter + (No. of rebars-1) × spacing between rebars

   $b_{required} = 2 \times 40 + 2 \times 10 + 3 \times 20 + 2 \times 25 = 210$ mm

   $b_{required} = 210 < b_{provided} = 250$ O.K

7. Compute the depth (h)

   $h_{\text{for two layer}} = 750 + 40 + 10 + 12.5 + 20 = 832.5 \approx 835$ mm

   Use (250 ×750) mm with 6Ø20 mm

8. Check the assumption of Ø =0.9

   $a = \frac{As*fy}{0.85fc`*b} = \frac{1884.9*420}{0.85*25*250} = 149$ mm

   $c = \frac{a}{\beta1} = \frac{149}{0.85} = 175.32$ mm

   dt = 835 – 40 – 10 – 10 = 775 mm

   $\epsilon_t = \frac{dt - c}{c} \epsilon_u = \frac{775-175.32}{175.32} \times 0.003 = 0.0102 > 0.005 \therefore \emptyset = 0.9$

9. Draw final detailed section ■