week 4

Assignment # VI

Harajli

Given:

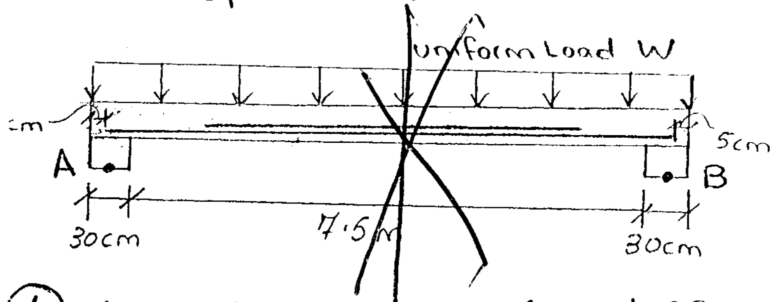
$W_{DL+S} = 0.8\ T/m$

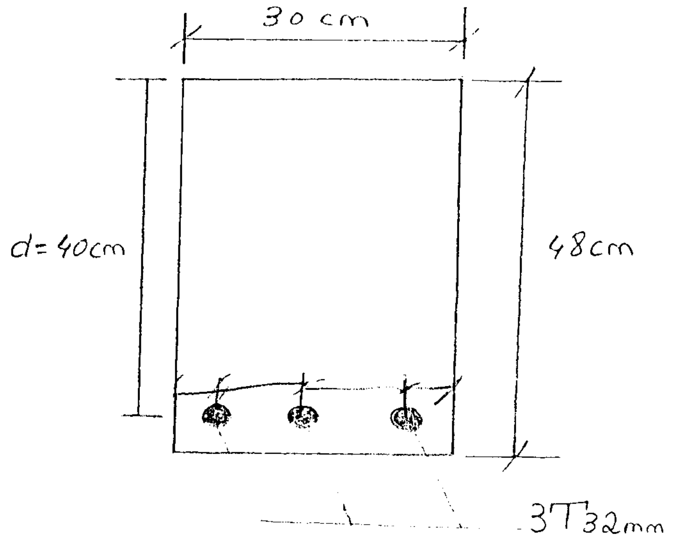
$W_{LL} = 1.6\ T/m$

$f'_c = 280\ kg/cm^2$

$f_y = 4200\ kg/cm^2$

Clear span = 7.5 m





(1) Locate flexural cutoffs of the center Bar:

- **Equation of Mu @ a distance x from A:**

$W_u = 1.4\, W_{DL+S} + 1.7\, W_{LL} = 3.84\ T/m$

$$\Rightarrow M_u = \frac{W_u L}{2}(x) - \frac{W_u (x)^2}{2} = \frac{(3.84)(7.8)}{2} x - \frac{3.84}{2} x^2$$

(center to center)

$$\Rightarrow \boxed{M_u = 15x - 1.92x^2}$$

- **Flexural Capacity of the remaining Bars:**

$A_s = \frac{2\pi(3.2)^2}{4} = 16\ cm^2$ (cross-sectional area of the 2 remaining Bars)

$T = C_c$

$A_s f_y = 0.85 f'_c \times b \times a \Rightarrow a = \frac{(16)(4200)}{(0.85)(280)(30)} = \boxed{9.41\ cm}$

$\Rightarrow c = \frac{a}{\beta} = \frac{9.41}{0.85} = 11.07\ cm$

Check if Tensile steel yielded as assumed

$$\varepsilon_s = \varepsilon_{cu}\left[\frac{d-c}{c}\right] = 0.003\left[\frac{40-11.07}{11.07}\right] = 0.0078 > 0.002$$

$\Rightarrow$ steel yielded and assumption is correct.

$= A_s f_y \left(d - \frac{a}{2}\right) = (16)(4200)\left(40 - \frac{9.41}{2}\right) = 2371824$ kg-cm
$= \boxed{23.718 \text{ T-m}}$

$\Rightarrow M_u = \phi M_n = 0.9 M_n = \boxed{21.34 \text{ T-m}}$

Flexural cutoff points occur when: (Theoretical cutoff points)

$$15x - 1.92x^2 = 21.34$$

$\Rightarrow x = 1.87$ m and $x = 5.94$ m

$\Rightarrow$ Theoretical cutoff points occur @ $\boxed{1.87 \text{ m}}$ away from center of each support.

Actual Cutoff points: (positive Moment Reinforcement shall be extended by the greatest of d or 12db)

$\Rightarrow x_{actual} = 1.87\text{m} - \underbrace{(d \text{ or } 12d_b)}_{\text{whichever is greater}}$

d = 40cm ← governs
12db = 38.4cm

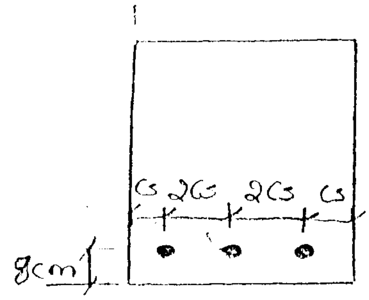
$\Rightarrow x_{actual} = 1.87\text{m} - 0.4\text{m} = \boxed{1.47\text{m}}$

2) check if adequate development length is provided for the continued and the discontinued bars:

- **calculate the developement length:**

$$\frac{l_d}{d_b} = \frac{3}{40} \frac{f_y}{\sqrt{f'_c}} \frac{\alpha \cdot \beta \cdot \gamma \cdot \lambda}{\left(\frac{C + K_{tr}}{d_b}\right)}$$

$K_{tr} = 0$ → no Transverse Reinforcement
$\alpha = 1.0$ → for bottom cast Bars.
$\beta = 1.0$ → uncoated Bars
$\gamma = 1.0$ → for T'22 Bars and Larger
$\lambda = 1.0$ → Normal weight concrete.



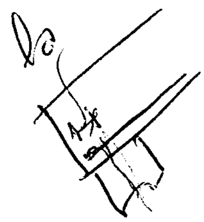
C = smaller of Cs and Cb

Cb = 8cm

Cs = ? → Cs + Cs + 2Cs + 2Cs = 30 ⇒ Cs = 5cm

$\Rightarrow \boxed{C = 5\text{cm}}$

$$\frac{l_d}{d_b} = \frac{3}{40} \frac{(4200)}{(\sqrt{4000}/14.22)} \frac{1}{\left(\frac{5+0}{3.2}\right)}$$



$\Rightarrow l_d = 145.05 \text{ cm} = 1.45 \text{m}$

<u>for the continued Bars:</u>

$$l(\text{available}) = \frac{[7.5 + 0.6 - 2(0.05)]}{2} = 4\text{m} \gg l_d = 1.45\text{m}$$

(↗ cover)

<u>for the discontinued Bars:</u>

$$l(\text{available}) = \frac{(7.5+0.8)}{2} - (1.47) = 2.43\text{m} > l_d = 1.45\text{m}$$

(↗ x_{actual})

$\Rightarrow$ for Both continued and discontinued Bars adequate development length is provided.

3) <u>check Special Requirements @ the support:</u>

$M_n = 27.74$ T-m (ultimate flexural capacity of the 2 continuous Bars)

$V_u = \frac{W_u l}{2} = 15\text{T}$ (@ support)

$l_d \leq \frac{1.3 M_n}{V_u} + l_a$ → anchorage length , $l_a = 15 - 5 = 10\text{cm}$

$$\frac{1.3 M_n}{V_u} + l_a = \frac{(1.3)(27.74)}{(15)} + \frac{(10)}{100} = \boxed{2.5\text{m}}$$

$l_d = 1.45\text{m} \leq 2.5\text{m} \Rightarrow$ Requirements for anchorage @ support are satisfied.

4) <u>Specify special Reinforcing details in the vicinity where the T32 Bar is cutoff.</u> (use T10 Bars as Transverse Reinforcement)

Shear stirrups should be provided over a distance $\frac{3}{4} d = \boxed{30\text{cm}}$ from the Theoretical cut-off point

$$\frac{A_v(\text{additional})}{S} \geq \frac{60\, b_w}{f_y(\text{psi})} \Rightarrow S \leq \frac{(1.57\text{cm}^2)(60000 \text{ Psi})}{(60 \text{ psi})(30)} = 52.3\text{cm}$$

(area of 2T10 bars)

$\Rightarrow$ take $\boxed{S = 50\text{cm}}$

$$S_{max} \leq \frac{d}{8} \cdot \frac{A_{cut\text{-}off}}{A_{Total}} \Rightarrow S_{max} = \left(\frac{40}{8}\right)\left(\frac{32^2}{3 \times 32^2}\right) = \boxed{1.67 \text{ cm}}$$

e S = 1.5cm

refore use T10 @ 1.5cm over a distance 30cm away rom the Theoretical cut-off.

(5) Comment on the practical aspects of the proposed Design. Would you recommend cutting the steel as suggested? Could 2 bars be discontinued rather than one?

- Its not a bad design looking at it from the practical point of View. we have saved approximatly 3m of steel. However, the only inconvinient aspect arises from the fact that there is congestion of stirrups in the vicinity where the T32 bar is cut-off.

- If 2 Bars were discontinued:

$$\phi M_n = (8)(4200)(40 - \frac{a}{2}) = (12.65)(0.9) = 11.385\,T\text{-}m$$

$$a = \frac{A_s f_y}{0.85 f'_c \times b} = \frac{(8)(4200)}{(0.85)(280)(30)} = 4.705\,cm$$

$$\Rightarrow c = \frac{a}{0.85} = 5.53\,cm$$

Check if Tensile steel yielded:

$$\varepsilon_s = (0.003)\left[\frac{40 - 5.53}{5.53}\right] = 0.0187 > 0.002$$

=> steel yielded as assumed.

Theoretical cut-off points occur when:

$$15x - 1.92x^2 = 11.385 \quad \Rightarrow x = 0.85\,m = 85\,cm$$

=> Theoretical cutoff points occur 0.85m away from center of each support.

=> Practical cut-off points occur 0.85 - 0.4 = 0.45m away from center of each support.

=> Developement Length Requirements are also required.

=> Total steel saved in this case is:

$$(0.45)(2)(2) = 1.8\,m < 3\,m$$

Therefore, I may say that 2 bars can be discontinued but its not practical at all since total steel saved is 1.8m and its not worth cutting the Bars.