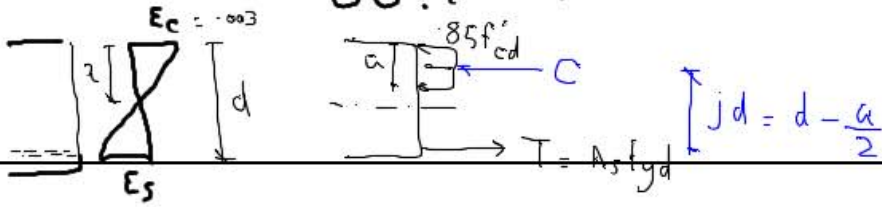


طراحی اعضای خمشی بتن مسلح ✓ روش مقاومت
 ✓ صغیر، صغیر باقی می ماند

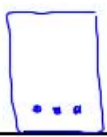


$$\frac{x}{d} = \frac{E_c}{E_c + E_s} = \frac{600}{600 + E_s} \quad C = T$$

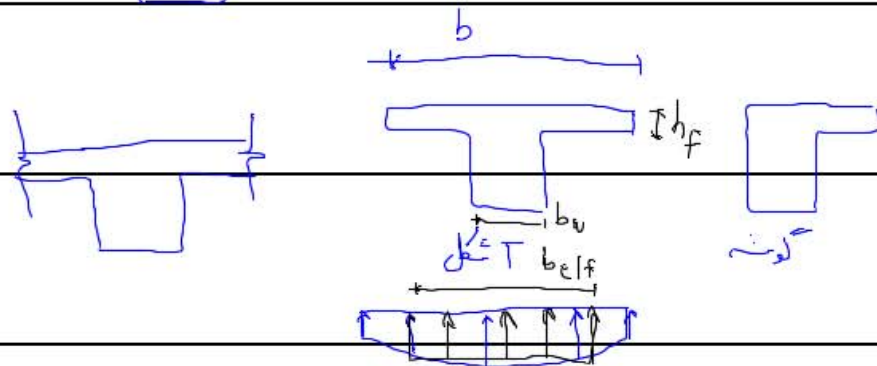
$$M_r = C j d = T j d$$

$$\frac{a_b}{d} = \frac{600}{600 + f_y}$$

مسائل ۱



۱، تحلیل $M_r \leftarrow A_s, d, b, f_y, f_c$
 ۲، طراحی $A_s \leftarrow M_u$



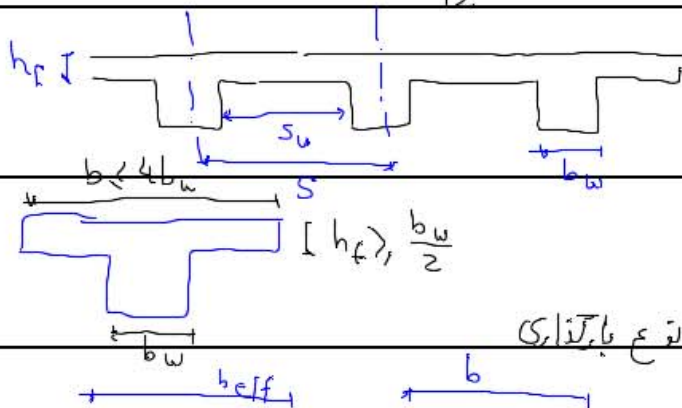
طراحی خمشی تیرکمان بالدار

عرض مؤثر

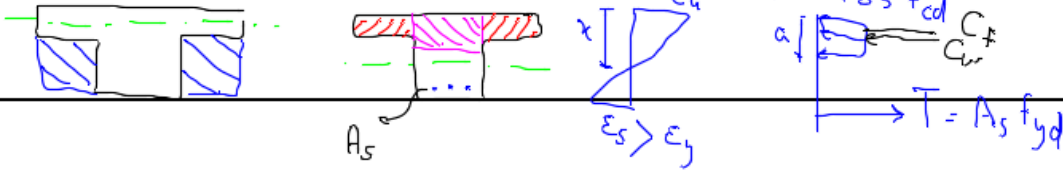
T بالدار

$$b_{eff} = \min \left(\frac{l_u}{4} \text{ ساده} \text{ و } b_w + 16 h_f, S \right)$$

$$b_{eff} = \min \left(\frac{l_u}{12} + b_w, b_w + 6 h_f, b_w + \frac{S_u}{2} \right)$$



عرض مؤثر: طول دهان، ضخامت بال، نوع بارگذاری



تکلیف ظرفیت تیر T شکل (در حالت قرار دارد)

$$M_r \leftarrow A_s, d, b_w, b, f_y, f_c$$

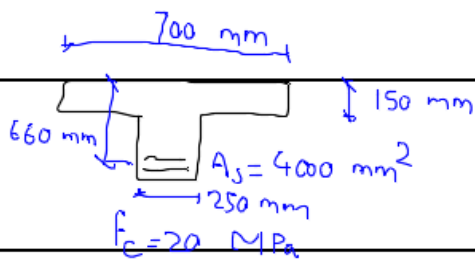
$$A_{sf} f_{yd} - C_f = -0.85 f_{cd} h_f (b - b_w) \rightarrow A_{sf} = \frac{0.85 f_{cd} h_f (b - b_w)}{f_{yd}}$$

$$M_{rf} = A_{sf} f_{yd} \left(d - \frac{h_f}{2} \right)$$

$$A_{sw} = A_s - A_{sf} \rightarrow A_{sw} f_{yd} = -0.85 f_{cd} a b_w \rightarrow a = \frac{A_{sw} f_{yd}}{0.85 f_{cd} b_w}$$

$$M_{rw} = A_{sw} f_{yd} \left(d - \frac{a}{2} \right)$$

$$M_r = M_{rf} + M_{rw}$$



تیر T شکل جزا سوال:

$$150 = h_f \geq \frac{b_w}{2} = \frac{250}{2} = 125 \text{ mm}$$

$$700 = b \{ 4b_w = 4 \times 250 = 1000 \text{ mm} \}$$

$$M_r = ?$$

$$a = \frac{A_s f_{yd}}{0.85 f_{cd} b} = \frac{4000 \times 340}{0.85 \times 12 \times 700} = 190 \text{ mm} > h_f = 150 \text{ mm}$$

فرض: سطح برابری سطح
 سطح T شکل است

$$C_f = T_f \rightarrow A_{sf} = \frac{0.85 f_{cd} (b - b_w) h_f}{f_{yd}} = \frac{0.85 \times 12 \times (700 - 250) \times 150}{340} = 2025 \text{ mm}^2$$

$$M_{rf} = A_{sf} f_{yd} \left(d - \frac{h_f}{2} \right) = 2025 \times 340 \times \left(660 - \frac{150}{2} \right) = 402.7 \text{ kN.m}$$

$$A_{sw} = A_s - A_{sf} = 4000 - 2025 = 1975 \text{ mm}^2$$

$$a = \frac{A_{sw} f_{yd}}{0.85 f_{cd} b_w} = \frac{1975 \times 340}{0.85 \times 12 \times 250} = 263 \text{ mm}$$

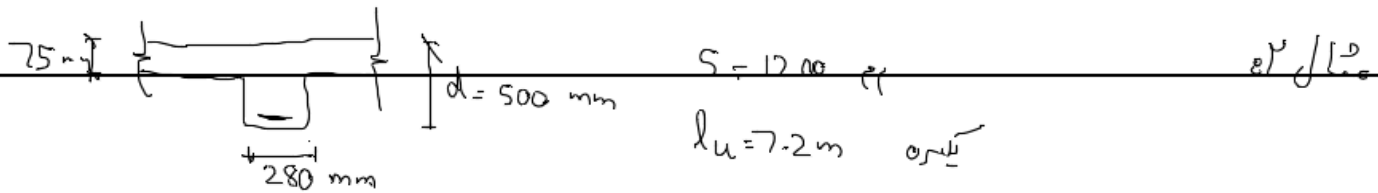
$$M_{rw} = A_{s0} f_{yd} \left(d - \frac{a}{2} \right) = 1975 \times 340 \times \left(660 - \frac{263}{2} \right) = 354.8 \text{ kN}\cdot\text{m}$$

$$M_r = M_{rw} + M_{rf} = 757.6 \text{ kN}\cdot\text{m}$$

$$a = 263 \text{ mm} \rightarrow \alpha = \frac{a}{\beta_1} = \frac{263}{0.85} = 309 \text{ mm}$$

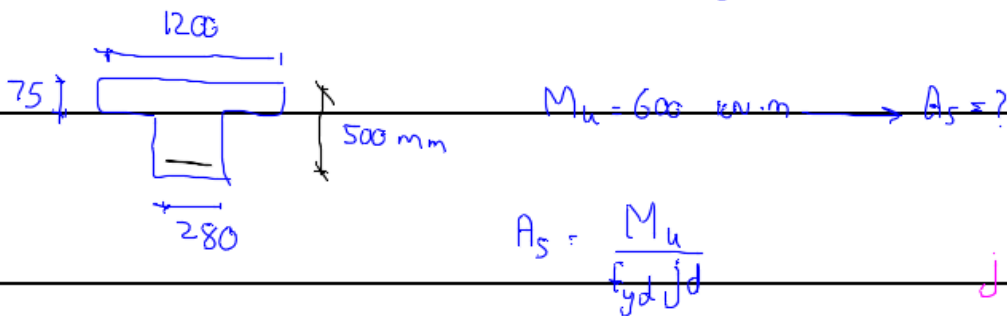
$$\frac{\alpha}{d} = \frac{309}{660} = 0.47 < \left(\frac{\alpha_b}{d} \right) = \frac{600}{600+400} = 0.6$$

$$0.75 \left(\frac{\alpha_b}{d} \right) = 0.45$$



$$M_u = 600 \text{ kN}\cdot\text{m} \rightarrow A_s = ?$$

$$b_{\text{eff}} = \min \left(\frac{0.25 \times 7200}{1.80}, 280 + 16 \times 75, 1200 \right) = 1200 \text{ mm}$$



$$A_s = \frac{M_u}{f_{yd} j d}$$

$$j = 0.8 - 0.95$$

$$p = 0.75 p_b \quad p_{\text{min}}$$

$$j = \frac{0.87 - 0.9}{0.875 - 0.925}$$

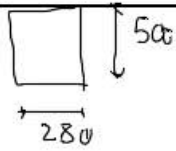
$$A_s = \frac{600 \times 10^6}{340 \times 0.875 \times 500} = 4034 \text{ mm}^2$$

$$a = \frac{4034 \times 340}{0.85 \times 12 \times 1200} = 112 \rightarrow \alpha = \frac{112}{0.85} = 132 > 75 \text{ mm}$$

$$C_f = 0.85 f_{cd} (b - b_w) h_f = 0.85 \times 12 \times (1200 - 280) \times 75 = 703.8 \text{ kN}$$

$$M_f = 703.8 \left(500 - \frac{75}{2} \right) = 325.5 \text{ kN.m}$$

$$M_w = 600 - 325.5 = 274.5 \text{ kN.m}$$



$$A_{sw} = ?$$

$$A_{sw} = \frac{274.5 \times 10^6}{340 \times 0.875 \times 500} = 1845 \text{ mm}^2$$

$$a = \frac{340 \times 1845}{0.85 \times 12 \times 280} = 220 \text{ mm}$$

$$jd = 500 - \frac{220}{2} = 390$$

$$A_{sw} = \frac{274.5 \times 10^6}{340 \times 390} = 2070 \text{ mm}^2$$

$$a = \frac{340 \times 2070}{0.85 \times 12 \times 280} = 246 \text{ mm} \rightarrow jd = 500 - \frac{246}{2} = 377 \text{ mm}$$

$$A_{sw} = \frac{274.5 \times 10^6}{340 \times 377} = 2142 \text{ mm}^2$$

$$a = \frac{2142 \times 340}{0.85 \times 12 \times 280} = 255 \text{ mm} \rightarrow jd = 373$$

$$A_{sw} = 2164 \text{ mm}^2 \rightarrow a = 258 \text{ mm} \rightarrow jd = 371$$

$$A_{sw} = \underline{2176 \text{ mm}^2} \rightarrow a = \underline{259 \text{ mm}} \rightarrow jd = 371$$

$$x = \frac{a}{\beta} = \frac{259}{0.85} = 305 \text{ mm}$$

$$\frac{x}{d} = \frac{305}{500} = 0.61 < \frac{x_b}{d} = 0.6$$

$$A_s = 2176 + 2070 = 4246 \text{ mm}^2$$

$$A_{sf} = \frac{C_f}{f_{yd}} = \frac{703.8 \times 10^3}{340}$$

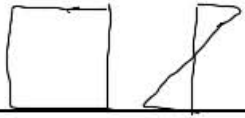
$$8\phi 26 = 4247 \text{ mm}^2$$

$$A_{sf} = 2070$$

حدالة آرمانور : $\epsilon_s > \epsilon_y$

$$\rho_{min} = \frac{25\sqrt{f_c}}{f_y} \gg \frac{14}{f_y} =$$

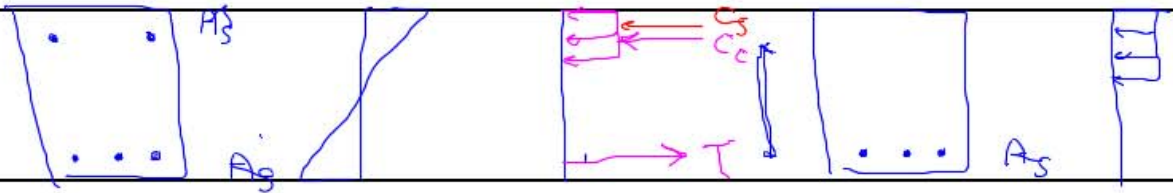
حدال آرمانور



$$f_r = 0.6\sqrt{f_c}$$

$$M_{cr} = f_r \frac{bh^2}{6}$$

12 M_{cr}



T