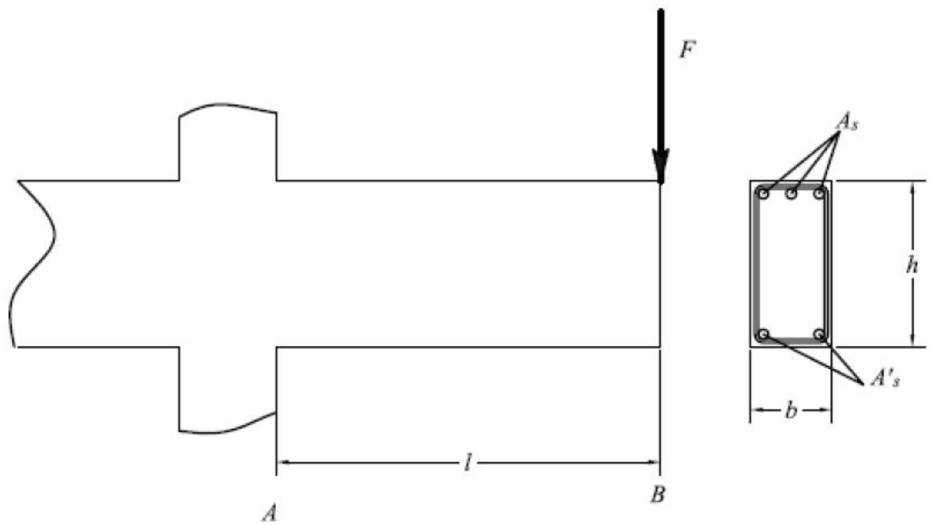
Cemento armato: flessione e taglio, esercizio n.1



Progettare allo stato limite ultimo le armature di flessione e taglio della mensola in cemento armato della figura sovrastante per i seguenti dati:

$l := 2.0 \cdot m$, o $F := 120 \cdot kN$, $h := 65 \cdot cm$ e base $b := 25 \cdot cm$, armatuacompressa: $n_{s1} := 2$ barre $\phi_1 := 16 \cdot mm$, distanza dai bordi $d_1 := 5 \cdot cm$, calcolare:

Calcestruzzo: $f_{cd} := 18 \cdot MPa$

Acciaio $f_{yd} := \frac{440}{1.15} \cdot MPa$ $\quad E_s := 200000 \cdot MPa$

$\varepsilon_{cu} := 3.5 \cdot 10^{-3}$ $\qquad \varepsilon_{yd} := \frac{f_{yd}}{E_s} = 1.913 \times 10^{-3}$

Calcolo delle reazioni vincolari

$Y_A := F = 120 \cdot kN$

$M_A := F \cdot l$ $\qquad M_A = 240 \cdot kN \cdot m$

Sollecitazioni

$V_{AB} := F$ $\qquad V_{AB} = 120 \cdot kN$

$M(x) := -M_A + Y_A \cdot x$ $\qquad M(0) = -240 \cdot kN \cdot m$

Progetto delle armature tese

$d := h - d_1$ $\qquad$ $d = 60 \cdot cm$

$$A_s := \frac{M_A}{0.9 \cdot d \cdot f_{yd}} \qquad A_s = 11.616 \cdot cm^2$$

$\phi_s := 20mm$

$$n_s := ceil\left(\frac{4A_s}{\pi \cdot \phi_s^{\,2}}\right) \qquad n_s = 4$$

$$A_{s1} := n_{s1} \cdot \pi \cdot \frac{\phi_1^{\,2}}{4} \qquad A_{s1} = 4.021 \cdot cm^2$$

$$A_s := n_s \cdot \pi \cdot \left(\frac{\phi_s}{2}\right)^2 = 12.566 \cdot cm^2$$

Calcolo del momento ultimo

armatura bilanciata

$$z_b := d \cdot \frac{\varepsilon_{cu}}{(\varepsilon_{cu} + \varepsilon_{yd})} = 38.795 \cdot cm \qquad \varepsilon_{s1b} := \varepsilon_{cu} \cdot \frac{(z_b - d_1)}{z_b} = 3.049 \times 10^{-3}$$

$$A_{sb} := \frac{(0.81 \cdot f_{cd} \cdot b \cdot z_b)}{f_{yd}} + A_{s1} \cdot \frac{\min(\varepsilon_{s1b} \cdot E_s, f_{yd})}{f_{yd}} = 40.98 \cdot cm^2 \qquad A_s < A_{sb}$$

$$z_c := \frac{(A_s - A_{s1}) \cdot f_{yd}}{0.81 \cdot f_{cd} \cdot b} = 8.97 \cdot cm$$

$$\varepsilon_{s1} := \varepsilon_{cu} \cdot \frac{(z_c - d_1)}{z_c} = 1.549 \times 10^{-3}$$

$$\beta := \frac{A_s \cdot f_{yd} - A_{s1} \cdot E_s \cdot \varepsilon_{cu}}{0.81 \cdot f_{cd} \cdot b} = 5.468 \cdot cm$$

$$\gamma := \frac{A_{s1} \cdot E_s \cdot \varepsilon_{cu} \cdot d_1}{0.81 \cdot f_{cd} \cdot b} = 38.613 \cdot cm^2$$

$$z_c := \frac{\beta + \sqrt{\beta^2 + 4\cdot\gamma}}{2} = 9.523\cdot cm$$

$$\varepsilon_{s1} := \varepsilon_{cu}\cdot\frac{(z_c - d_1)}{z_c} = 1.662 \times 10^{-3}$$

$$M_u := A_s\cdot f_{yd}\cdot(d - 0.42\cdot z_c) + A_{s1}\cdot\varepsilon_{s1}\cdot E_s\cdot(0.42\cdot z_c - d_1) = 267.913\cdot kN\cdot m$$

$$M_{u1} := 0.9\cdot d\cdot A_s\cdot f_{yd} = 259.632\cdot kN\cdot m$$

Calcolo delle armature di taglio - metodo 1

$$\cot\theta := 2.5$$

$$\omega_{smin1} := 1.5\cdot 10^{-3}\cdot b = 3.75\,\frac{1}{m}\cdot cm^2$$

$$\omega_{smin2} := \frac{V_{AB}}{0.9\cdot d\cdot f_{yd}\cdot\cot\theta} = 2.323\cdot\frac{cm^2}{m}$$

$$\omega_{smin} := \max(\omega_{smin1}, \omega_{smin2}) = 3.75\cdot\frac{cm^2}{m}$$

$$\phi_{st} := 8mm$$

$$A_{sw1} := 2\cdot\pi\cdot\frac{\phi_{st}^2}{4} = 1.005\cdot cm^2$$

$$s_{min1} := \frac{A_{sw1}}{\omega_{smin}} = 26.808\cdot cm$$

$$s_{max} := \min(33cm, 0.8\cdot d, s_{min1}) = 26.808\cdot cm$$

$$s_w := \mathrm{floor}\left(\frac{s_{max}}{cm}\right)\cdot cm = 26\cdot cm$$

$$\mu_w := \frac{A_{sw1}\cdot f_{yd}}{b\cdot 0.5 f_{cd}\cdot s_w} = 0.066$$

$$ct\theta 1 := \sqrt{\frac{1 - \mu_w}{\mu_w}} = 3.769$$

$$ct\theta := \min(ct\theta 1, 2.5)$$

$$V_{Rds} := 0.9 \cdot d \cdot f_{yd} \cdot \frac{A_{sw1}}{s_w} \cdot ct\theta = 199.717 \cdot kN$$

$$V_{Rdc} := 0.9 \cdot d \cdot 0.5 f_{cd} \cdot b \cdot \frac{ct\theta}{1 + ct\theta^2} = 418.966 \cdot kN$$

$$V_{rd} := \min\left(V_{Rds}, V_{Rdc}\right) = 199.717 \cdot kN$$