

Invullen in blokletters/To be completed by student

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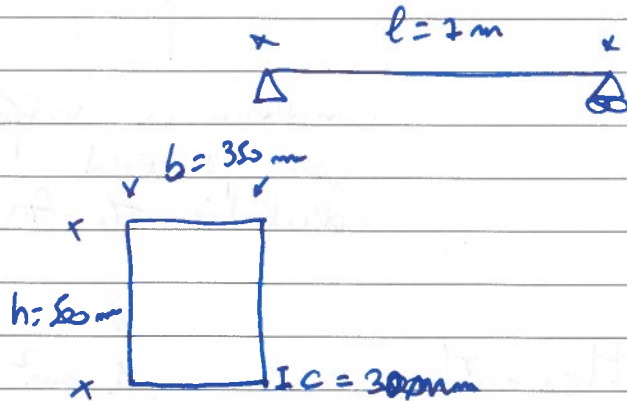
Exercise 1 45

INPUT

C30/32
BS00

$$q_k = 20 \text{ kN/m} \quad 0,25$$

$$q_{ik} = 25,32 \text{ kN/m} \quad 0,27$$



SOLUTION

① BENDING REINFORCEMENT

$$\textcircled{A} \quad w_d(\text{ULS}) = 1,35 \cdot 20 \frac{\text{kN}}{\text{m}} + 1,5 \cdot 25,32 \frac{\text{kN}}{\text{m}} = 65 \text{ kN/m} \quad 1$$

$$\textcircled{B} \quad \eta_{Rd} = 0,162 f_{ck} b \cdot d^2 \quad 1$$

$$d = ?$$

Assume $\phi_{\text{stirrup}} = 12 \text{ mm}$; $\phi = 20 \text{ mm}$

$$d = h - c - \phi_s - \frac{\phi}{2} = 408 \text{ mm} \quad 1$$

$$\eta_{Rd} = (0,162) \left(30 \frac{\text{N}}{\text{mm}^2} \right) (350 \text{ mm}) (408^2) \text{ mm}^2 = 351934469 \text{ Nmm} \quad 1$$

$$\textcircled{C} \quad M_{Ed} = \frac{w_d l^2}{8} = \frac{65 \frac{\text{N}}{\text{mm}} \cdot 7000^2 \text{ mm}^2}{8} = 398002500 \quad 1$$

$$\textcircled{D} \quad M_{Ed} > \eta_{Rd} \Rightarrow \text{We need double reinforcement at the tension \& compression's fibers.} \quad 1$$

to be calculated:

$$\textcircled{E} \quad d_2 = c + \frac{\phi}{2} + \phi_s = 30 + 10 + 12 = 52 \text{ mm}$$

$$x = d - z / 0.4 = (448 - 362.5) / 0.4 = 21.2$$

$$z = d \left[0.5 + \sqrt{0.25 - \frac{3 \cdot 0.167}{3.4}} \right] = 362.5 \text{ mm}$$

$$\textcircled{F} \quad \text{condition} \quad \frac{d_2}{x} \leq 0.38 \rightarrow \frac{52}{21.2} = 0.26$$

condition is satisfied so we can proceed with calculating the Area of reinforcement.

$$\textcircled{G} \quad A_{s.2} = \frac{M_{Ed} - M_{Rd}}{0.87 f_{yk} (d - d_2)} = 262.4 \text{ mm}^2 \rightarrow 2 \phi 16$$

$$\textcircled{H} \quad A_{s.1} = \frac{M_{Rd}}{0.87 f_{yk} z} + A_{s.2} = 2468.7 \text{ mm}^2 \rightarrow 8 \phi 20$$

$\textcircled{I}$

spacing check:

$$\text{Twelve bars } 8 \cdot 20 + 9 \cdot 20 = 340 < b \quad \checkmark$$

The space needed is 340 mm which is smaller than b so this reinforcement choice works.

But we are assuming that we have stirrups so the spacing needed is:

$$8 \cdot 20 + 2 \phi_s + 11 s_p = 8 \cdot 20 + 2 \cdot 12 + 11 \cdot 20$$

Spacing needed is: 404 so it is too small, so potentially we go back in the design loop & increase the width.

② SRA2 REINFORCEMENT.

⑦ $V_{Ed} = \frac{q l}{2} = 227430 \text{ N}$

⑧ $V_{Ed} = \frac{V_{Ed}}{b \cdot d} = \frac{227430 \text{ N}}{(350 \cdot 408) \text{ mm}^2} = 1,45 \text{ N/mm}^2$

⑨ V_{Rsw} (TABLE 6)

$d = 400$
C30/32

$\rightarrow V_{Rsw} = 0,43 \text{ N/mm}^2$

$f_{cd} = 2 f_{ck} = 1 \cdot \frac{30 \text{ N/mm}^2}{1,5} = 20 \text{ N/mm}^2$

⑩ $V_{Rmax} = \frac{2}{d} V_1 \frac{f_{cd}}{\omega + \theta + \tan \theta} = 2,99 \text{ N/mm}^2$

$\theta = 21,1^\circ$

if from table 10
 $\theta = 21,1^\circ$
C30/32

$V_1 = 0,6 \left(1 - \frac{f_{ck}}{25} \right) = 0,53$

$V_{Rmax} = 3,20 \text{ N/mm}^2$

⑪ $V_{Rsw} < V_{Ed} < V_{Rmax} \Rightarrow$ we need shear reinforcement

⑫ TABLE 11

$b = 350$ $V_{Ed} = 1,45 \text{ N/mm}^2$

$\hookrightarrow \phi 8-150$
or $\phi 6-100$

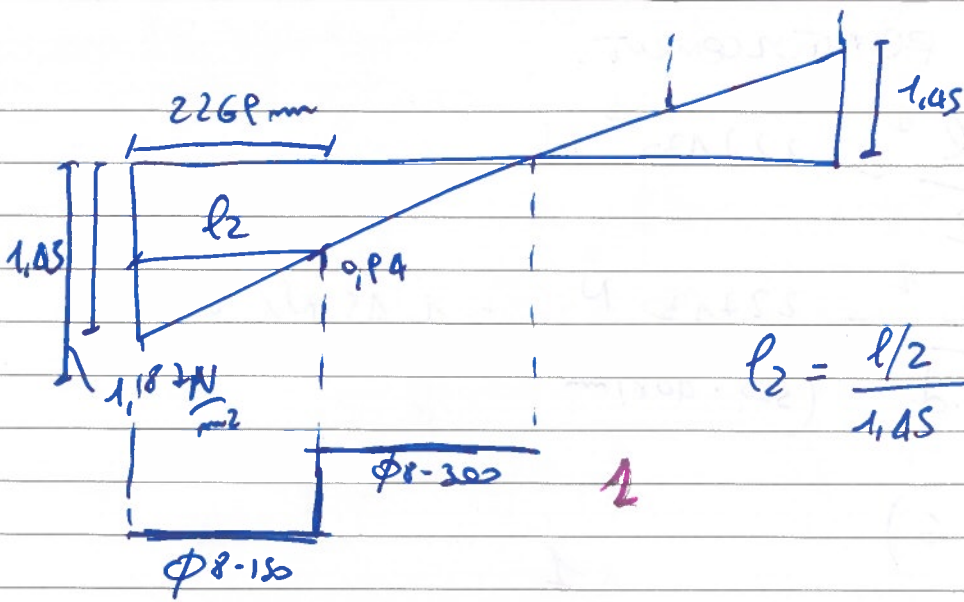
We choose $\phi 8-150$ & $\phi 8-300$

$\downarrow$
1182

$\downarrow$
994

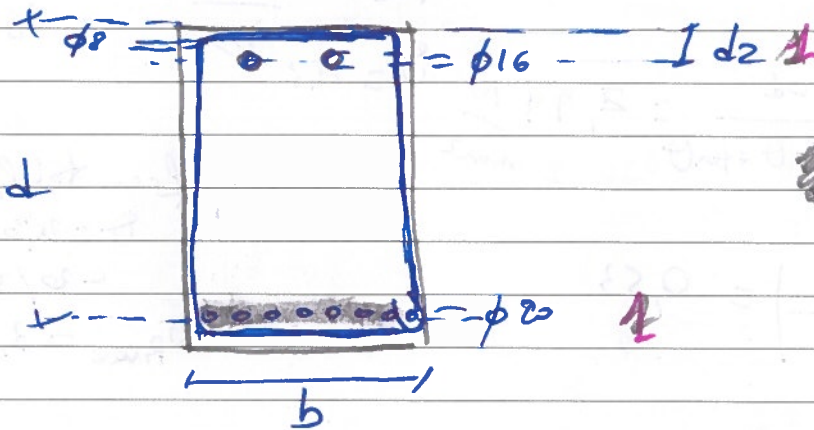
11

2

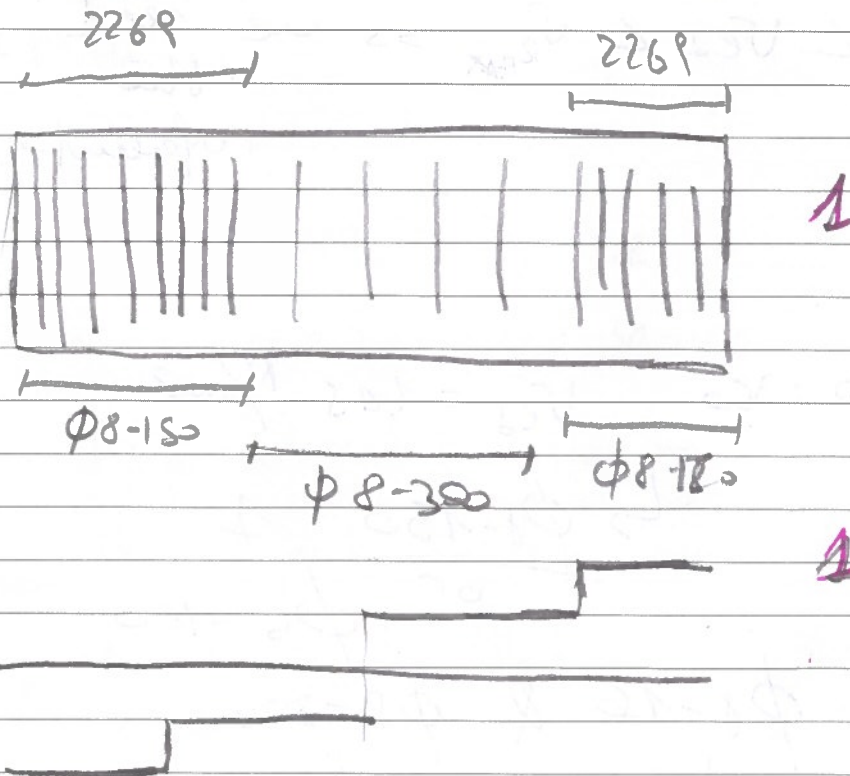


$$l_2 = \frac{l/2}{1.45} \cdot 0.94 = 2269 \text{ mm}$$

3



4



Exercise #2

30

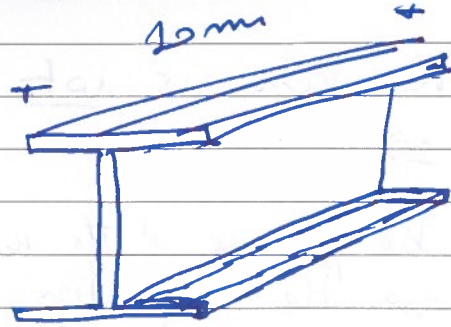
INPUT

UB S33x210 x 101 kg/m →

S275

$$EI_x = 1.29 \cdot 10^5 \text{ kNm}^2$$

$$\rightarrow 1.29 \cdot 10^{14} \text{ N/mm}^2$$



$$q_k = 10 \text{ kN/m} \quad \text{self weight} = 1 \text{ kN/m} \quad q_k = 7 \text{ kN/m}$$

check at Bending & Deflection

Solution

Bending

$$\begin{aligned} \textcircled{1} \quad M_{PRd} &= \frac{W_{pl,y} \cdot f_y}{\gamma_m} = \frac{400 \text{ cm}^3 \cdot 275 \text{ N/mm}^2}{1} = \\ &= \frac{400000 \text{ mm}^3 \cdot 275 \text{ N/mm}^2}{1} = 110000000 \text{ Nmm} \end{aligned}$$

$$M_{Ed} = w_d \cdot \frac{l^2}{8}$$

$$\begin{aligned} \textcircled{2} \quad w_d &= 1.35 (q_k + s_k) + 1.5 \cdot q_k = 1.35 (10 + 1) \frac{\text{kN}}{\text{m}} + 1.5 \cdot 7 \frac{\text{kN}}{\text{m}} = \\ &= 25 \text{ kN/m} \end{aligned}$$

$$\textcircled{3} \quad M_{Ed} = \frac{25 \text{ kN/m} \cdot (10000)^2}{8} = 31625000 \text{ Nmm}$$

$$\textcircled{4} \quad M_{PRd} < M_{Ed}$$

NOT verified 2

Bigger section is needed.

2

Deflection.

If the section is not verified at ULS, the verification at SLS is not needed.

For the purpose of the exercise here is how to solve the deflection in case the verification would have been needed.

⑥

$$\sigma_{max} < \sigma_{lim}$$

⑦

$$\sigma_{lim} = \ell / 360 \quad \leftarrow \text{Because it is not a cantilever and it has brittle finishes.}$$

$$\sigma_{lim} = 27,8 \text{ mm}$$

⑧

$$\sigma_{max} = \frac{5}{384} \frac{w \ell^4}{EI_x} = \frac{5}{384} \cdot \frac{18 \text{ N} \cdot (10000)^4 \text{ mm}^4}{1,28 \cdot 10^{14} \text{ N/mm}^2} = 18,2 \text{ mm}$$

⑨

$$w(SLS) = g_k + s_w + q_k = 10 + 1 + 7 \frac{\text{kN}}{\text{m}} = 18 \frac{\text{N}}{\text{mm}}$$

$$\sigma_{max} < \sigma_{lim} \rightarrow \text{verified}$$

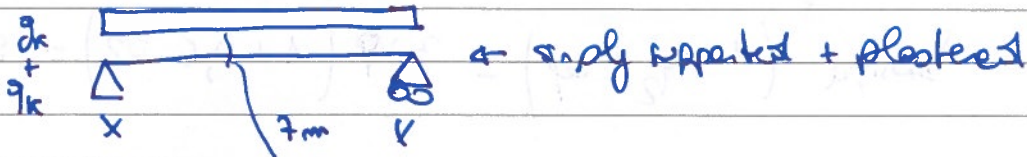
if the beam would have been safe at bending then it would have been safe also at deflection.

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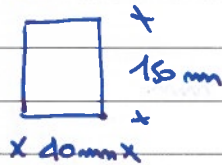
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Exercise 3 (25)

INPUT



C24
SC 2



$$q_k = 20 \text{ kN/m} ; q_k = 1,5 \text{ kN/m} ; E_{\text{mean}} = 11 \text{ kN/mm}^2 ; \psi_2 = 0,6$$

$$= 10 \text{ N/mm} \quad = 1,5 \text{ N/mm}$$

check at deflection

Solution

$$w_{f,n} = w_{f,n,g} + w_{f,n,q} < w_{f,n} \quad 1+1$$

$$\textcircled{1} w_{f,n} \text{ (from table)} : \text{plastered over span} \rightarrow w_{f,n} = l/250 = \frac{7000 \text{ mm}}{250} = 28 \text{ mm}$$

$$\textcircled{2} w_{f,n,g} = w_{\text{inst},g} (1 + k_{\text{def}}) \quad 1$$

$$w_{\text{inst},g} = \frac{5 \cdot g_k L^4}{384 E I_x} \quad 1$$

$$I_x = \frac{b h^3}{12} = \frac{140 \text{ mm} \cdot 150^3 \text{ mm}^3}{12} = 11250000 \text{ mm}^4$$

$$w_{\text{inst},g} = \left(\frac{5 \cdot 10 \frac{\text{N}}{\text{mm}} \cdot 2000^4 \text{ mm}^4}{384 \cdot 11000 \text{ N/mm}^2 \cdot 11250000 \text{ mm}^4} \right) = 2526,3 \text{ mm}$$

$$K_{def} = 0,8 \Rightarrow \textcircled{2}$$

$$\overset{2}{v_{pm,G}} = \overset{1}{v_{inst,G}} (1 + K_{def}) =$$

$$= 2526 \text{ mm} (1 + 0,8) = 4547,3 \text{ mm}$$

$$\overset{2}{v_{inst,Q}} = \frac{\overset{1}{5} \overset{1}{k} \overset{1}{L}^4}{384 \overset{1}{EI_x}} = \frac{(5)(1,5 \frac{N}{mm^2})(2000 \text{ mm})^4}{384 \cdot 11000 \frac{N}{mm^2} \cdot 1125000 \text{ mm}^4} = 328,95 \text{ mm}$$

$$\overset{2}{v_{MN,Q}} = \overset{2}{v_{inst,Q}} (1 + \psi \overset{1}{K_{def}}) = 328,95 (1 + 0,6 \cdot 0,8) = 560,8 \text{ mm}$$

③

$$v_{pm} = v_{pm,G} + v_{pm,Q} = 5108,2 \text{ mm}$$

$$v_{pm} \gg w_{lim}$$

2 NOT SAFE