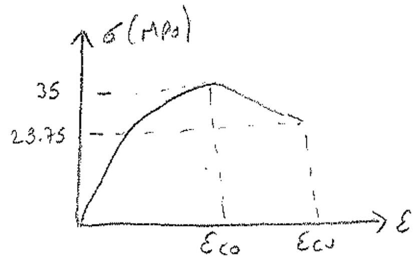
CE382 – Homework I

1) By using Hognestad mathematical model:



$$\varepsilon_{co} = \frac{2f_c}{E_c} \longrightarrow E_c = 12680 + 460 f_c$$

$$f_c = 35 \text{ MPa} \longrightarrow E_c = 28780 \text{ MPa}$$

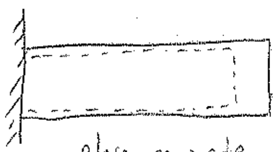
$$\varepsilon_{co} = 0.00243$$

$$\sigma_c = f_c\left[\frac{2\varepsilon_c}{\varepsilon_{co}} - \left(\frac{\varepsilon_c}{\varepsilon_{co}}\right)^2\right] = 35\left[\frac{2\varepsilon_c}{0.00243} - \left(\frac{\varepsilon_c}{0.00243}\right)^2\right]$$

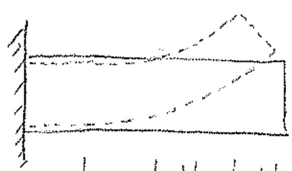
$$\sigma = 30 \text{ MPa} \longrightarrow \varepsilon_c = 0.001511$$

$$\sigma = 15 \text{ MPa} \longrightarrow \varepsilon_c = 0.000533$$

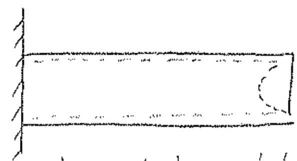
2)



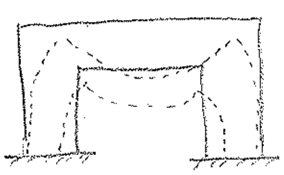
plain concrete



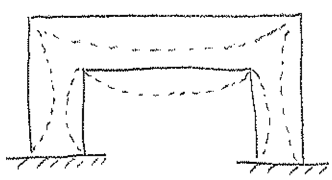
rebars at the bottom



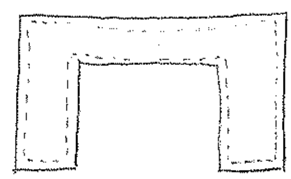
rebars at top and bottom



plain concrete

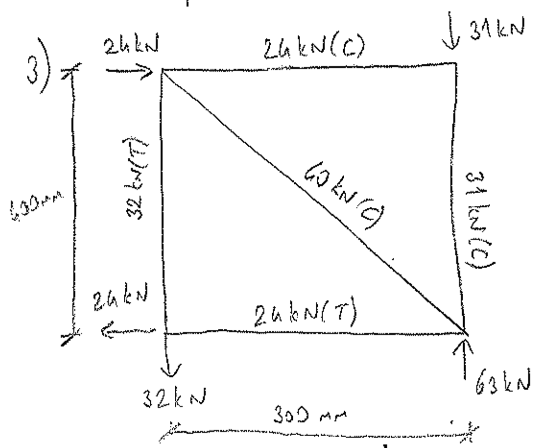


rebars at one face



rebars at both faces

3)



$f_c = 30$ MPa

40x40 mm members are in compression, also two 120x120 mm members are in tension.

direct tensile : $f_{ct} = 0.35\sqrt{f_c}$

$$f_{ct} = 0.35\sqrt{30}_{\text{MPa}} = 1.92 \text{ MPa}$$

checking compression members:

$$\sigma_c = \frac{40000\text{N}}{40 \times 40 \text{mm}^2} = 25 \text{ MPa} < f_c \qquad \text{it is OK.}$$

checking tension members:

$$\sigma_{ct}: \frac{32.000\text{N}}{120 \times 120 \text{mm}^2} = 2.22 \text{ MPa} > f_{ct} \qquad \text{not OK!}$$

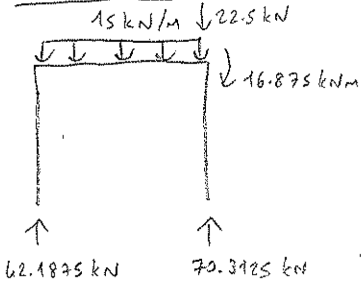
it cannot carry the applied load, it will FAIL!

4) a) Since the thermal expansion coefficients of concrete and steel are same, they will not occur stress developed. (shortening with same amount)

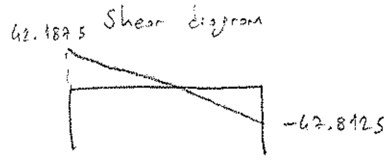
b) From the text book, for humid environment and adequate curing $\varepsilon_{cs} = 0.00025$.

5)

Dead Load



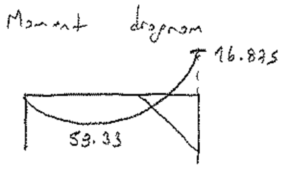
Shear diagram



$V = 62.1875 - 15x$

$M = 62.1875x - \frac{15x^2}{2}$

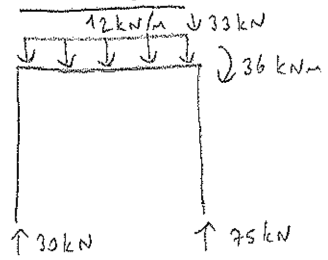
Moment diagram



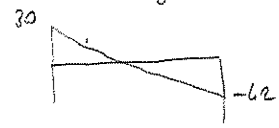
$\frac{dM}{dx} = 0 \rightarrow$ max. moment at $x = 2.8125m$

$M_{max} = M_{2.8125} = 53.33\ kN.m$

Live Load 1



Shear diagram

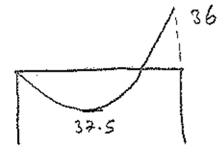


$V = 30 - 12x$

$M = \int V dx = (30-12x)dx$

$M = 30x - 6x^2$

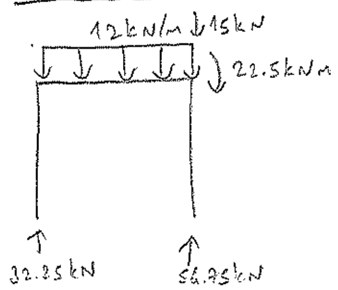
Moment diagram



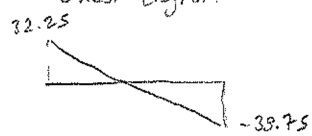
$\frac{dM}{dx} = 0 \rightarrow$ max. moment at $x = 2.5m$

$M_{max} = 37.5\ kNm$

Live Load 2



Shear diagram

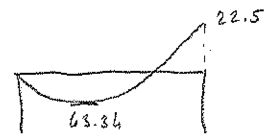


$V = 32.25 - 12x$

$M = \int V dx = (32.25 - 12x)dx$

$M = 32.25x - 6x^2$

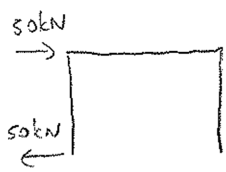
Moment diagram



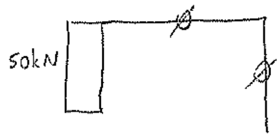
$\frac{dM}{dx} = 0 \rightarrow$ max. moment at $x = 2.6875m$

$M_{max} = 43.36\ kN.m$

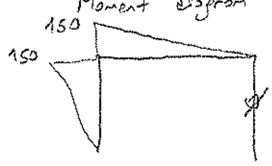
Earthquake



Shear diagram



Moment diagram



We take into consideration load combinations that create the most critical situation:
$1.4G + 1.6Q$ and $1.0G + 1.0Q + 1.0E$

Left column

$V_d = 1.0G + 1.0Q + 1.0E = 50kN$

$M_d = 1.0G + 1.0Q + 1.0E = 150kNm$

Beam

$V_d = 1.4G + 1.6Q$
$= 1.4 \times 67.8125 + 1.6 \times 62 = 194.1375\ kN$

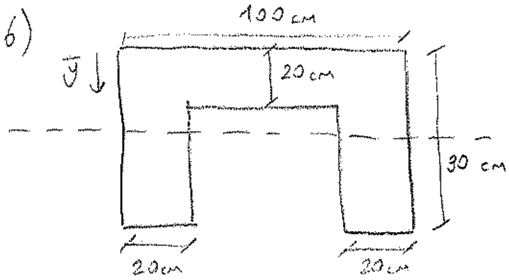
$M_d = 1.4G + 1.6Q$
$= 1.4 \times 53.33 + 1.6 \times 43.34 = 144.0\ kNm$

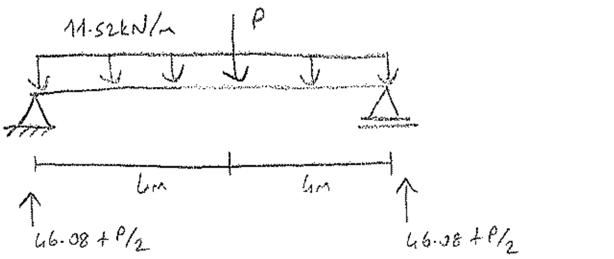
Right column

$V_d = 0$

$M_d = 1.4G + 1.6Q$
$= 1.4 \times 16.875 + 1.6 \times 36 = 81.225\ kN.m$

6)





$$\left.\begin{array}{l} \text{Area} = (1\times0.2) + (2\times0.7\times0.2) = 0.48\,m^2 \\ \gamma_{conc} = 24\ kN/m^3 \end{array}\right\}\ \text{distributed load} = 24\times0.48 = 11.52\ kN/m$$

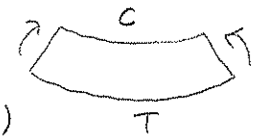
$$M_{max} = 4\times\left(46.08+\frac{P}{2}\right) - \frac{11.52\times4^2}{2} = 184.32 + 2P - 92.16 = (92.16+2P)\ kNm$$

$$\bar{y} = \frac{(100\times20\times10)+(2\times20\times70\times55)}{4800} = 36.25\,cm$$

$$I = \frac{1}{12}(100)(20^3) + (100\times20)(26.25)^2 + 2\times\left[\frac{1}{12}\times20\times70^3 + 20\times70\times18.75^2\right]$$

$$I = 3572500\ cm^4 = 0.035725\ m^4$$

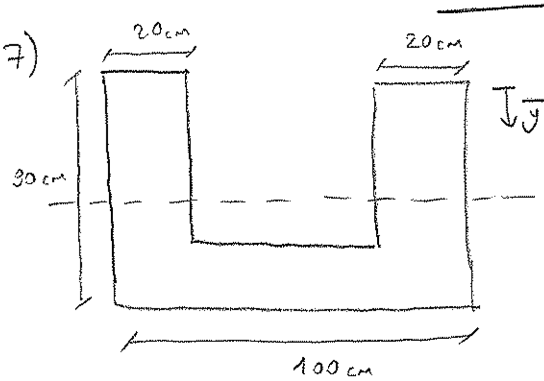
flexural tensile : $f_{ctf} = 0.7\sqrt{f_c} = 4.14\ MPa$ (MPa)



$$\sigma_{ct} = \frac{My}{I} \longrightarrow 4.14\times10^3 = \frac{(92.16+2P)\times(0.9-0.3625)}{0.035725}$$

$$\underline{P = 91.5\ N}$$

7)



$\bar{y} = 90 - 36.25 = 53.75\ cm$

$$\left.\begin{array}{l} M_{max} = (92.16+2P)\ kN.m \\ I = 0.035725\ m^4 \end{array}\right\}\ \text{they are taken from answer 6, because they are same.}$$

$$4.14\times10^3 = \frac{(92.16+2P)\times0.3625}{0.035725} \Longrightarrow \underline{P = 157.3N}$$