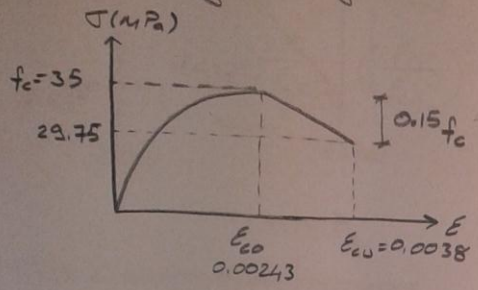
CE 382 Reinforced Concrete Fundamentals

HOMEWORK 1

1) According to Hognestad mathematical model:



$$\varepsilon_{co} = \frac{2 f_c}{E_c} \quad \text{where } E_c = 12680 + 460 f_c$$

$f_c = 35 MPa \Rightarrow E_c = 28780 MPa$

$\varepsilon_{co} = 0.00243$

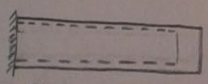
$$\sigma_c = f_c \left[\frac{2\varepsilon_c}{\varepsilon_{co}} - \left(\frac{\varepsilon_c}{\varepsilon_{co}} \right)^2 \right]$$

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

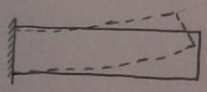
For $\sigma = 30$ MPa $\rightarrow \varepsilon_c = 0.001511$

For $\sigma = 15$ MPa $\rightarrow \varepsilon_c = 0.000593$

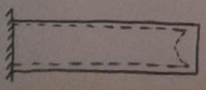
2)



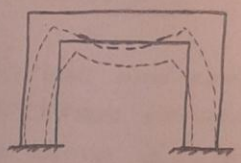
Plain Concrete



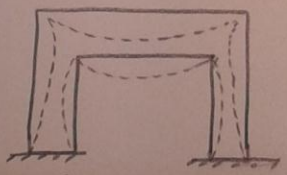
rebars at the bottom



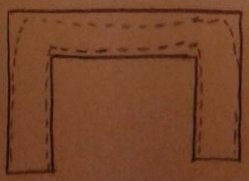
rebars at top & bottom



Plain concrete

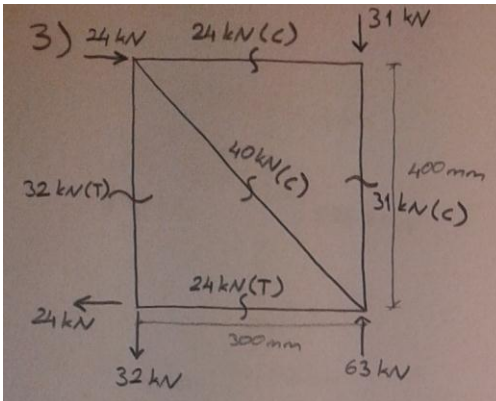


Rebars at one face



Rebars at both faces

3)



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

$f_c = 30\ MPa$

Direct tensile $\longrightarrow f_{ct} = 0.35\sqrt{f_c}$ (According to TS-500)

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

Check compression members,

$$\sigma_c = \frac{40000\ N}{40 \times 40\ mm^2} = 25\ MPa < f_c \quad \text{O.K.}$$

Check tension members,

$$\sigma_{ct} = \frac{32000\ N}{120 \times 120\ mm^2} = 2.22\ MPa \quad \sigma_{ct} > f_{ct} \quad \text{NOT OK}$$

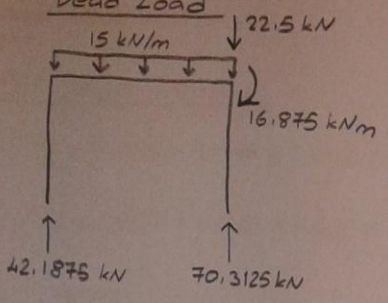
Structure can not carry the applied load.

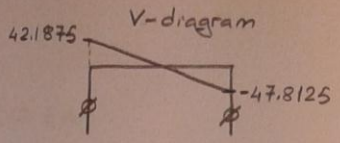
4) a) Thermal expansion coefficients of concrete and steel are the same. They shorten same amount. No stresses developed.

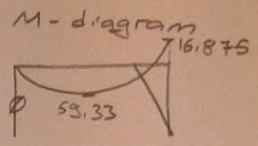
b) For humid environment and adequate curing $\varepsilon_{cs} = 0.00025$.

5)

Dead Load







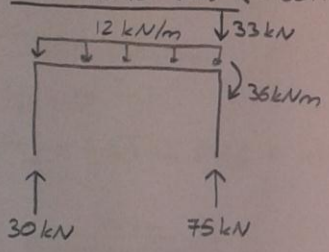
$V = 42.1875 - 15x$

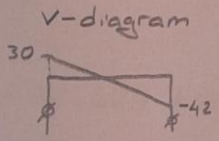
$M = 42.1875x - \frac{15x^2}{2}$

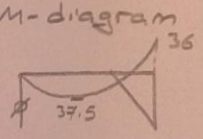
$\frac{dM}{dx} = 0 \rightarrow$ Max. moment at $x = 2.8125$

$M_{max} = M_{2.8125} = 59.33\ kNm$

Live Load (1) (Distributed Load is on both beam and overhang)





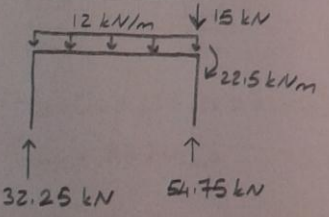


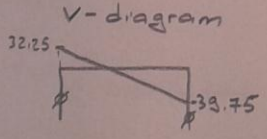
$V = 30 - 12x$

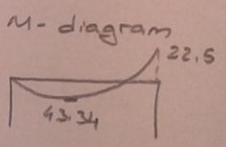
$M = 30x - 6x^2$

$M_{max} = M_{2.5} = 37.5\ kNm$

Live Load (2) (Distributed Load is on only beam)





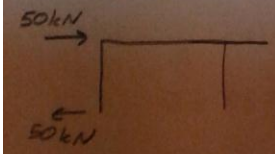


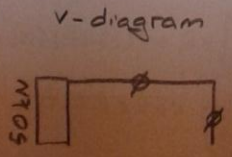
$V = 32.25 - 12x$

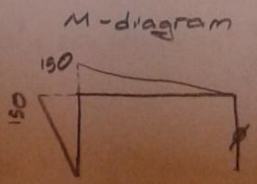
$M = 32.25x - 6x^2$

$M_{max} = M_{2.6875} = 43.34\ kNm$

Earthquake







We have to consider 1.4G+1.6Q and 1.0G+1.0Q+1.0E as load combinations.

For left column

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

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

For beam

$V_d = 1.4 \times 47.8125 + 1.6 \times 42 = 134.1375\ kN$

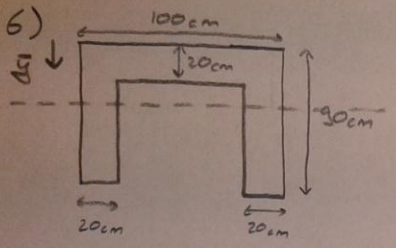
$M_d = 1.4 \times 59.33 + 1.6 \times 43.34 = 152.406\ kNm$

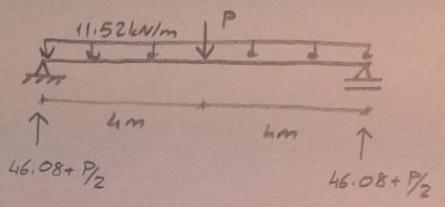
For right column

$V_d = 0$

$M_d = 1.4 \times 16.875 + 1.6 \times 36 = 81.225\ kNm$

6)





Area = $(1 \times 0.2) + (2 \times 0.7 \times 0.2) = 0.48\ m^2$

$\gamma_{conc.} = 24\ kN/m^3$

} Distributed Load = 11.52 kN/m

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

$\bar{y} = \frac{(100 \times 20 \times 10) + (2 \times 20 \times 70 \times 55)}{4800} = 36.25\ cm$

$I = \frac{1}{12}(100)(20^3) + (100 \times 20)(26.25)^2 + 2 \times \left[\frac{1}{12} \times 20 \times 70^3 + 20 \times 70 \times 18.75^2\right]$

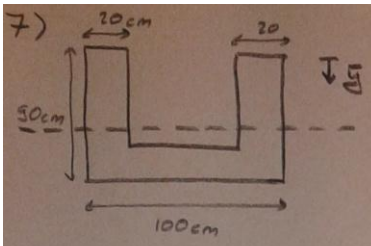
$I = 3572500\ cm^4 = 0.035725\ m^4$

Flexural Tensile (Single Load) $\rightarrow$ $f_{ct} = 0.7\sqrt{f_c} = 4.14\ MPa$ (Tension occurs at bottom)

$\sigma_{ct} = \frac{My}{I} \rightarrow 4.14 \times 10^3 = \frac{(92.16 + 2P) \times 0.5375}{0.035725}$

$P = 91.5\ N$

7)



$\bar{y} = 90 - 36.25 = 53.75$ from the top.

M_{max} and I are the same with the previous question.

$$4.14 \times 10^3 = \frac{(92.16 + 2P) \times 0.3625}{0.035725} \quad \Rightarrow \quad \boxed{P = 157.9\ N}$$

Concrete is weak in tension. Since tension is perceived at the bottom in beams, the second cross-section gives larger P value due to the impendence of neutral axis to the bottom.