UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA

DEPARTEMENT SIVIELE INGENIEURSWESE
DEPARTMENT OF CIVIL ENGINEERING

STERKTELEER SWK 210 – SEMESTERTOETS 2
STRENGTH OF MATERIALS SWK 210 – SEMESTER TEST 2

26 April 2008 / *26 April 2008*

Dosente/*Lecturers*: *Prof L Maree* *Dr E Chaparanganda* *Mnr F van Graan*

Volpunte/*Full Marks* : 60
Tyd/*Time* : 1½ uur/*hrs*

Memorandum

Van en voorletters / *Surname and initials*
Studentenommer / *Student number*
Klastaal / *Class Language*: Afrikaans ☐ English ☐
Studierigting / Study d*iscipline:* *[Mech / Civil / Metal / Mining / Geol]* [Meg / Siviel / Metal / Mynbou / Geol]

Vraag Question	Punt Mark	
1	10	
2	12	
3	10	
4	8	
5	8	
6	12	
Σ =	**60**	

SIGNATURE **HANDTEKENING**

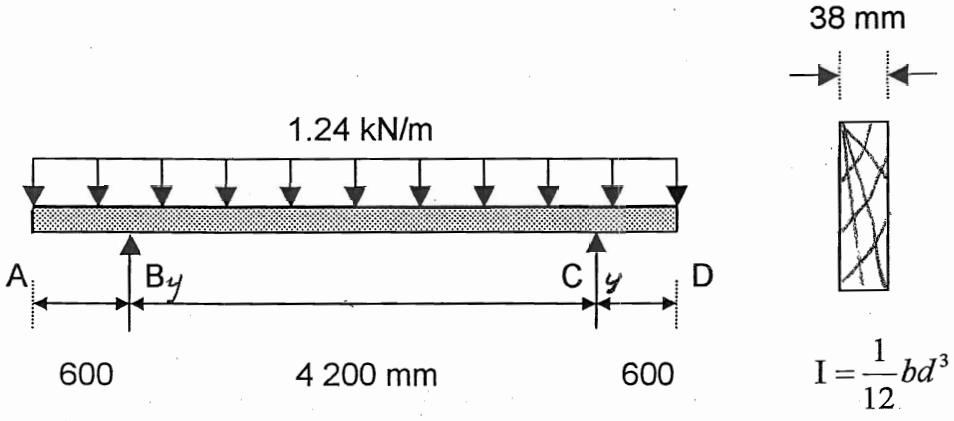
NB ▸ **All answers must be substantiated by the relevant units.**
LW **Alle antwoorde moet deur die nodige eenhede bevestig word.**

▸ **All aspects as described in the EXAMINATION REGULATIONS are applicable.**
Alle aspekte soos vervat in die EKSAMENREGULASIES is van toepassing.

QUESTION 1 / VRAAG 1 [12]

Roof beam AD rests on two walls at B and C and carries a distributed load of 1.24 kN/m. The weight of the beam is included in this value.
The following sizes SAPine are available:
38 mm x 38 mm; 38 mm x 76 mm; 38 mm x 114 mm; 38mm x 152 mm and 38 mm x 228 mm.
The allowable bending stress of SAPine is 32 MPa and the allowable shear stress of SAPine is 2 MPa.

Dakbalk AD rus op twee mure by B en C en dra 'n verspreide las van 1.24 kN/m. Die eie gewig van die balk is hierby ingesluit.
Die volgende groottes SADen is beskikbaar :
38 mm x 38 mm; 38 mm x 76 mm; 38 mm x 114 mm; 38mm x 152 mm en 38 mm x 228 mm.
Die toelaatbare buigspanning van SADen is 32 MPa en die toelaatbare skuifspanning van SADen is 2 MPa.



1(a) Determine the reactions at B and C. **[2]**
Bepaal die reaksies by B en C.

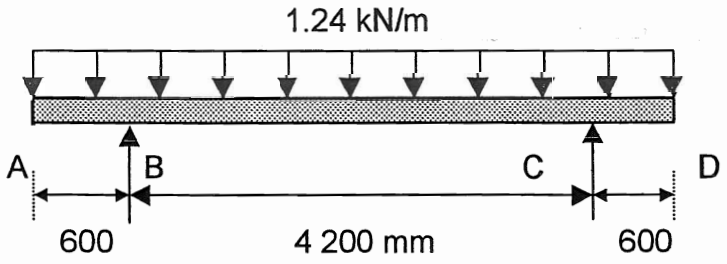
$\circlearrowleft \sum M_C = 0 : -By(4.2) + 5.4(1.24)(2.1) = 0 \quad \therefore By = 3.348\ kN \rightarrow$

$\sum M_B = 0: \quad Cy(4.2) - 1.24(5.4)(2.1) = 0 \quad Cy = 3.348\ kN$

Test: $\sum FP = 2(3.348) = 6.696\ kN \quad \sum F\downarrow = 1.24(5.4) = 6.696\ kN \rightarrow$

1(b) Determine the maximum shear force. **[2]**
Bepaal die maksimum skuifkrag.

$SF_{max} = -0.6(1.24) + 3.348 = 2.604\ kN \rightarrow$



1(c) Determine the maximum bending moment. **[2]**
Bepaal die maksimum buigmoment.

⊙ $M_{max} = -2.7(1.24)\left(\frac{2.7}{2}\right) + 3.348(2.1)$

$= 2.511\ kN.m$ →

1(d) What size roof beam will you recommend? Support your answer by means of the necessary calculations. **[6]**
Watter grootte dakbalk sal u voorskryf? Ondersteun u antwoord deur middel van die nodige berekenings

⊙ $\sigma = \frac{My}{I}$ $\therefore 32 = \frac{2.511(10^6) * \frac{d}{2}}{\frac{1}{12}(38)(d^3)}$

$\therefore d^2 = \frac{2.511(10^6) * 12}{2(38)(32)}$ $\therefore d = 111.3\ mm$

⇒ Use 38 mm * 114 mm SA Pine →

⊙ Check shear: $\tau = \frac{VQ}{It} = \frac{2604 * (38)\left(\frac{114}{2}\right) * \frac{114}{4}}{\frac{1}{12}(38)(114)^3 * 38}$

$= 0.9\ MPa < 2\ MPa$ ⇒ ok →

OR

⊙ $\tau = \frac{VQ}{It} = 2\ MPa$: $2 = \frac{2604 * \frac{d}{2} * 38 * \frac{d}{4}}{\frac{1}{12}(38)(d^3) * 38}$

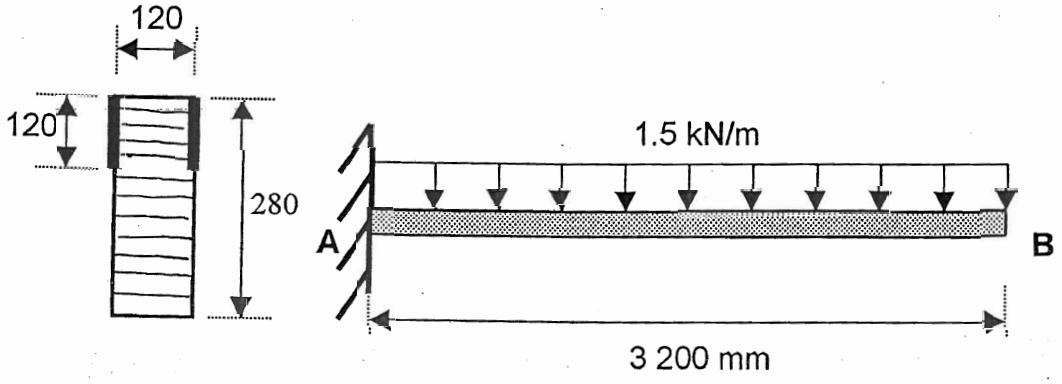
$\therefore d = 52\ mm$ ok

QUESTION 2 / VRAAG 2 [12]

The figure shows a 3.2 metre long cantilever laminated timber beam with a 1.5 kN/m distributed load.
The weight of the beam is included in this value.
The depth of the beam is 280 mm and the width is 120 mm.
A flat steel bar, 3 200 x 120 x 3 mm, is fixed to both sides of the beam at the top of the section.

Die figuur toon 'n 3.2 meter lange gelamineerde hout kantelbalk met 'n 1.5 kN/m verspreide belasting.
Die gewig van die balk is ingesluit by hierdie waarde.
Die balkdiepte is 280 mm en die breedte is 120 mm.
'n Plat staalplaat, 3 200 x 120 x 3 mm, is aan beide kante van die balk aan die bokant van die snit aangebring.

$E_{\text{staal / steel}}$ = 210 GPa $E_{\text{timber / hout}}$ = 3 GPa



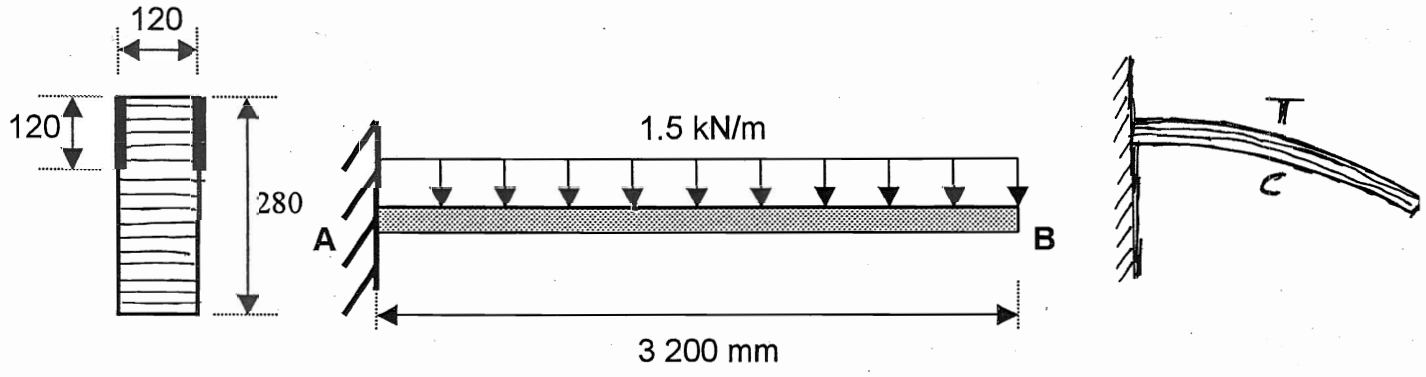
Calculate the maximum bending stress in the steel and in the timber, indicate whether these maximum values are compression or tension and also indicate (on a cross section of the beam) where these maximum values occur.

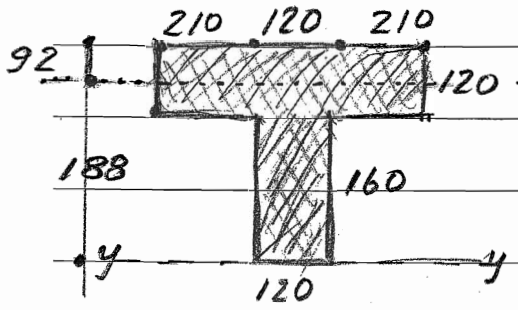
Bereken die die maksimum buigspanning in die staal en in die hout, dui aan of hierdie maksimum waardes drukspannings of trekspannings is en dui ook aan (op 'n dwarssnit van die balk) waar hierdie maksimum waardes voorkom.

$\odot n = \frac{210}{3} = 70$

$\therefore b_{\text{steel} \rightarrow \text{timber}} = 3\,mm * 70$

$= 210\,mm \rightarrow$





⊙ $\bar{y} = \dfrac{540(120)(220) + 160(120)(80)}{540(120) + 160(120)}$

$= \dfrac{15\,792\,000}{84000} = 188 \text{ mm}$ →

① $\bar{I} = \frac{1}{12}(540)(120)^3 + 120(540)(32)^2 \quad (= 144\,115\,200)$

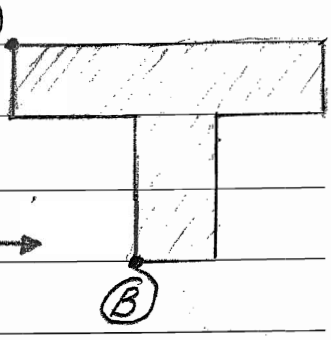
$+ \frac{1}{12}(120)(160)^3 + 120(160)(108)^2 \quad (= 264\,908\,800)$

$= 409 * 10^6 \text{ mm}^4$ →

⊙ $M_{max} = -3.2(1.5)\left(\frac{3.2}{2}\right) = -7.68 \text{ kN.m}$ →

⊙ $\sigma_{t_{timber}}$ at (A): $= \dfrac{My}{I} = \dfrac{7.68 * 10^6 * 92}{409 * 10^6}$

$= 1.73 \text{ MPa (T)}$ →



$\sigma_{t_{steel}}$ at (A) $= \frac{210}{3} * 1.73 = 120.93 \text{ MPa (T)}$ →

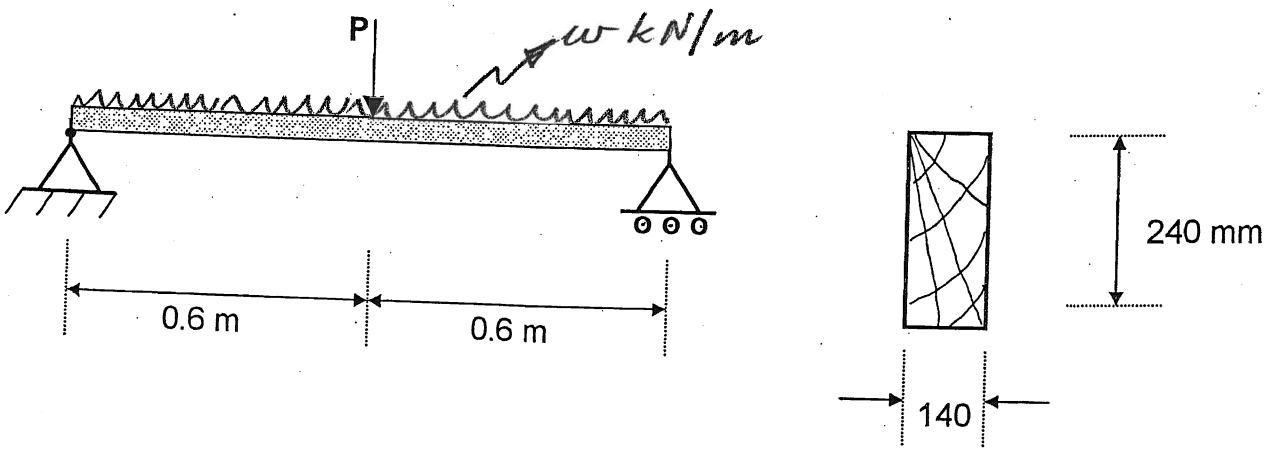
$\sigma_{c_{timber}}$ at (B) $= \dfrac{7.68 * 10^6 * 188}{409 * 10^6} = 3.53 \text{ MPa (C)}$ →

QUESTION 3 / VRAAG 3

[10]

The figure shows a timber beam. The weight density of timber is 5.4 kN/m^3.

Die figuur toon 'n hout balk. Die gewigsdigtheid van hout is 5.4 kN/m^3.



3(a) Calculate the maximum permissible value of the load **P** if the allowable bending stress is equal to 8.5 MPa. **[5]**

Bereken die maksimum toelaatbare waarde van **P** indien die toelaatbare buigspanning gelyk is aan 8.5 MPa.

◎ $w = 0.14 * 0.24 * 5.4$

$= 0.181\ kN/m$ →

◎ $M_{max} = (P/2 * 0.6) - 0.181 * 0.6 * 0.3$

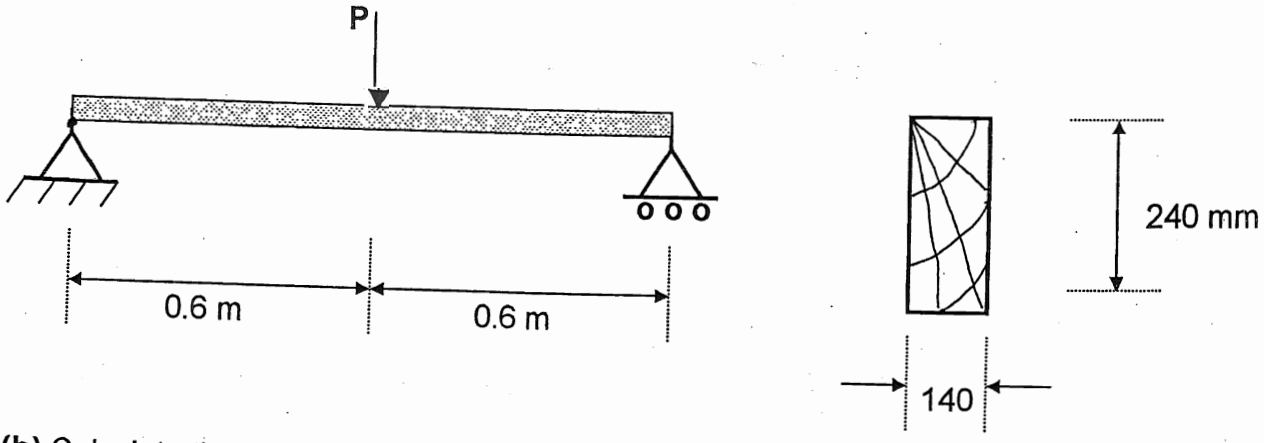
$= (0.3P - 0.03266)\ kN.m$ →

◎ $I = \frac{1}{12}(140)(240)^3 = 161.3 * 10^6\ mm^4$ →

◎ $\sigma = \frac{My}{I}$ $\therefore 8.5 = \frac{(0.3P - 0.03266)(10)^6 * 120}{161.3 * 10^6}$

$\therefore 0.3P = 11.457$

$P = 38.2\ kN$ →



3(b) Calculate the maximum permissible value of the load **P** if the allowable shear stress is equal to 0.8 MPa. **[5]**

Bereken die maksimum toelaatbare waarde van **P** indien die toelaatbare skuifspanning gelyk is aan 0.8 MPa.

$$\odot \quad V_{max} = P/2 + 0.6(0.181)$$

$$= (P/2 + 0.1086)\ kN \rightarrow$$

$$\odot \quad \tau = \frac{VQ}{It} :$$

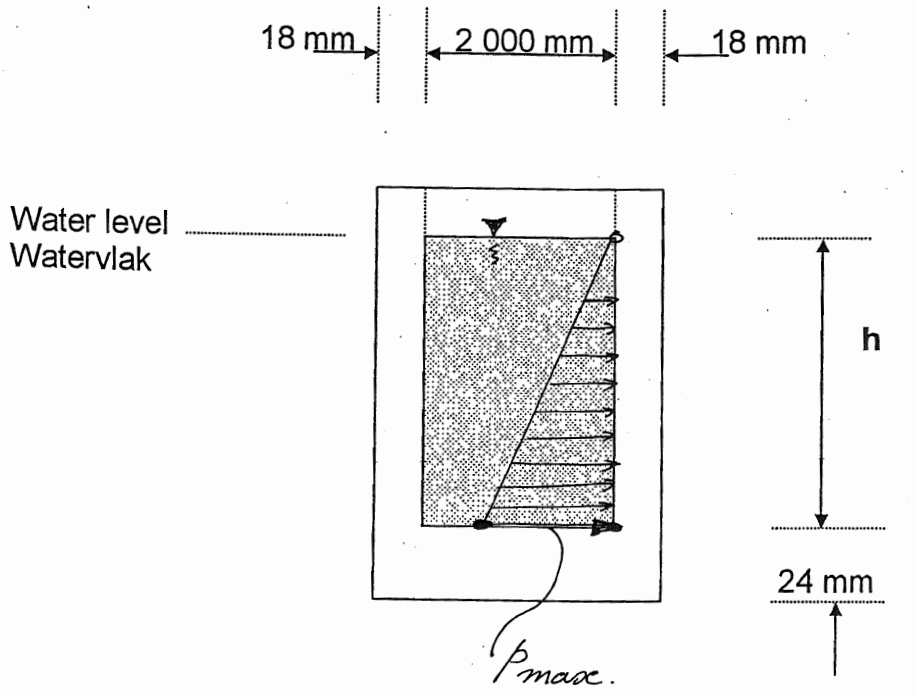
$$\therefore \quad 0.8 = \frac{(P/2 + 0.1086) * 10^3 * [120 * 140 * 60]}{161.3 * 10^6 * 140}$$

$$P = 35.6\ kN \rightarrow$$

QUESTION 4 / VRAAG 4 [8]

The figure shows a vertical section through a tall standpipe with an open top, an inner diameter of 2 m, a wall thickness of 18 mm and a base thickness of 24 mm.

Die figuur toon 'n vertikale snit deur 'n lang staanpyp met 'n oop bokant, 'n binnediameter van 2 m, 'n wanddikte van 18 mm en 'n bodemdikte van 24 mm.



4(a) What height of water **[h]** will produce a circumferential normal stress of 10.9 MPa in the pipe wall? **[6]**

Watter waterhoogte [h] sal 'n omtreknormaalspanning van 10.9 MPa in die wand van die pyp ontwikkel?

$\odot\ p_{max} = \gamma_w * h = 9.8h\ kN/m^2$

$= \frac{9.8h}{10^3}\ N/mm^2 \rightarrow$

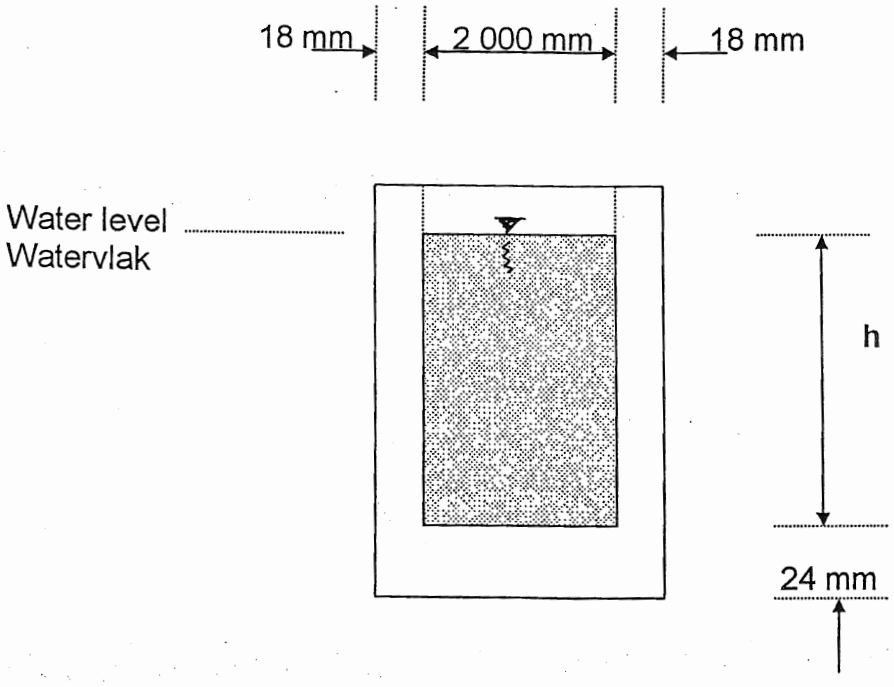
$\odot\quad \sigma_1 = \frac{pr}{t}$:

$\therefore\ 10.9 = \frac{9.8h}{10^3} * \frac{1000}{18}$

$\therefore\ h = 20.02\ m \rightarrow$

4(b) Calculate the axial normal stress in the wall of the pipe due to the pressure of the water [water level at **h**]. **[2]**

Bereken die aksiale normaalspanning in die pypwand as gevolg van die druk van die water [watervlak by **h**].



$$\textcircled{1} \quad \sigma_2 = \frac{pr}{2t}$$

$p = 0$: vessel open at the top

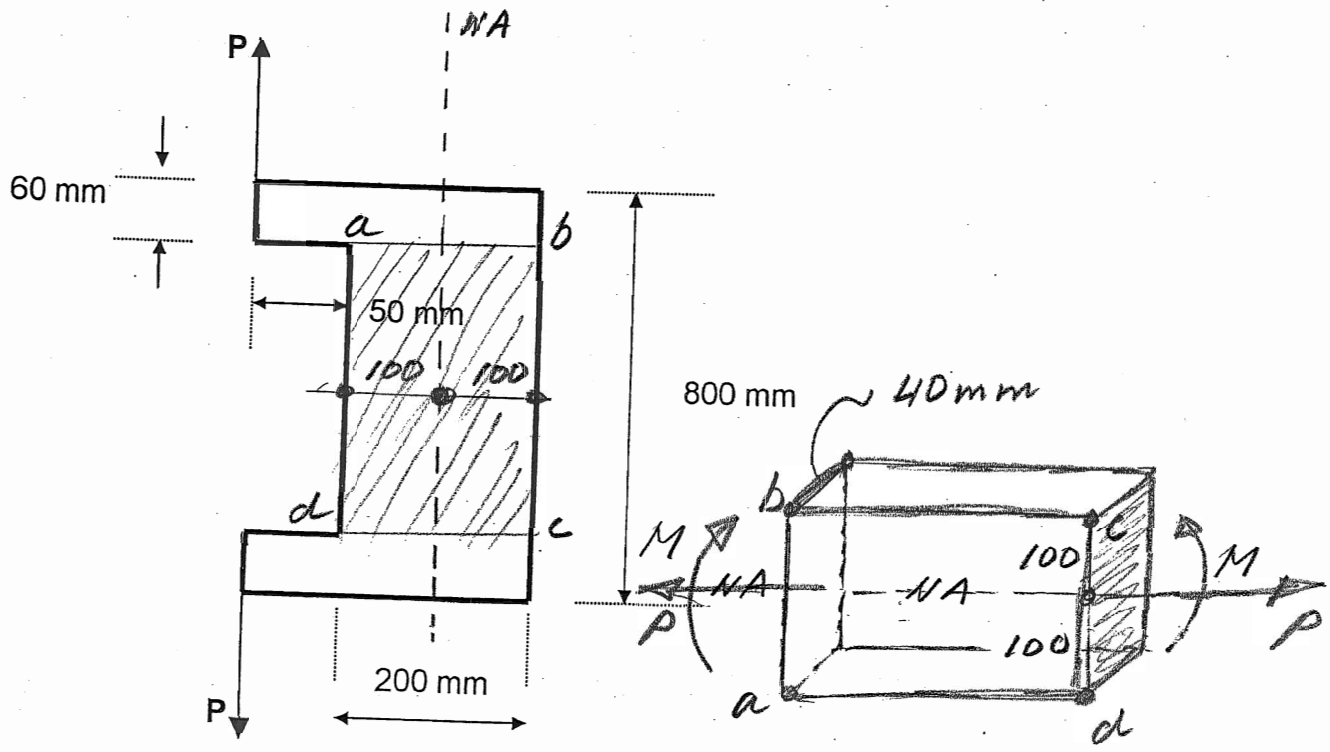
$\Rightarrow \sigma_2 = 0$ $\rightarrow$

QUESTION 5 / VRAAG 5

[8]

The figure shows an offset link with a width of 40 mm.
If the allowable normal stress of the material is 75 MPa, determine the maximum load **P** that can be applied to the cables.

Die figuur toon 'n knikskakel met 'n 40 mm breedte.
Indien die toelaatbare normaalspanning in die materiaal 75 MPa is, bepaal die maksimum waarde van **P** wat op die kabels toegepas kan word.



⊙ $M = P * 150 = 150P$ N.mm →

⊙ $I = \frac{1}{12} bd^3 = \frac{1}{12}(40)(200)^3 = 26.67 * 10^6$ mm^4 →

⊙ $\sigma = \frac{P}{A} + \frac{My}{I}$

$\therefore 75 = \frac{P}{200 * 40} + \frac{150P * 100}{26.67 * 10^6}$

$\therefore P = 109\,102$ N

$= 109.1$ kN →

QUESTION 6 / VRAAG 6 [12]

A propeller shaft is designed to resist a shear stress of 63 MPa and a compressive stress of 90 MPa.

'n Aandryfas is ontwerp om 'n skuifspanning van 63 MPa en 'n drukspanning van 90 MPa te weerstaan.

$C = (\sigma_{avg}; 0)$

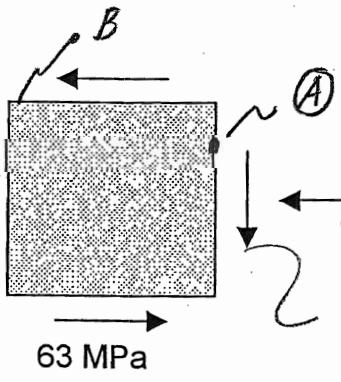
$= \left(\frac{\sigma_x + \sigma_y}{2}; 0\right)$

$= \left(\frac{-90}{2}; 0\right)$

$= (-45; 0)$

$R = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$

$= \sqrt{45^2 + 63^2} = 77.4$



$\sigma_x = -90$

$\tau_{xy} = -63$

$\sigma_y = 0$

6(a) Determine the principal stresses and show them on a properly orientated stress element. [4]

Bepaal die hoofspannings en toon hulle op 'n korrek georiënteerde spanningselement.

$\sigma_1 = -45 + 77.4 = 32.4$ MPa

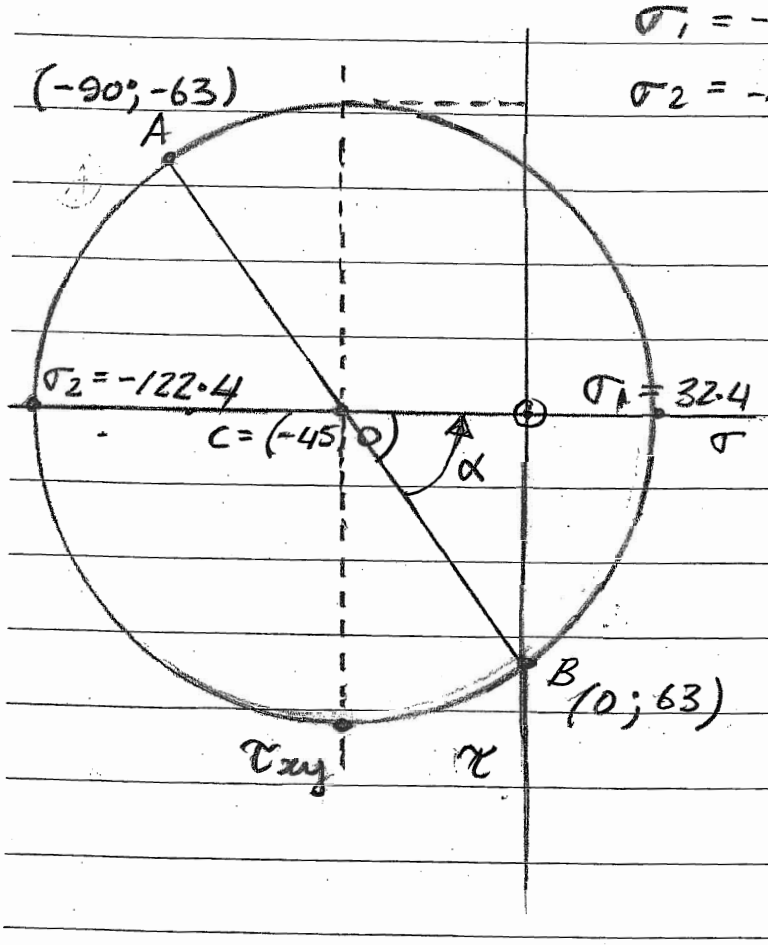
$\sigma_2 = -45 - 77.4 = -122.4$ MPa.

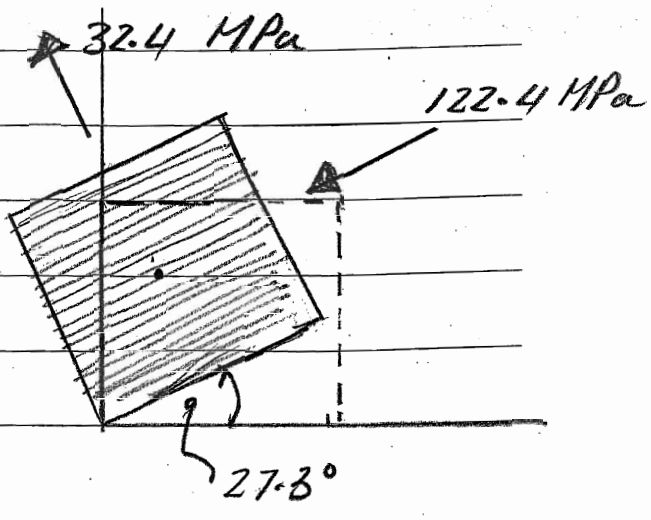
$\alpha = \tan^{-1}\frac{63}{45} = 54.5^\circ$

$\therefore 2\theta_p = 180^\circ + 54.5^\circ$

$\therefore \theta_{p_1} = 117.3^\circ$

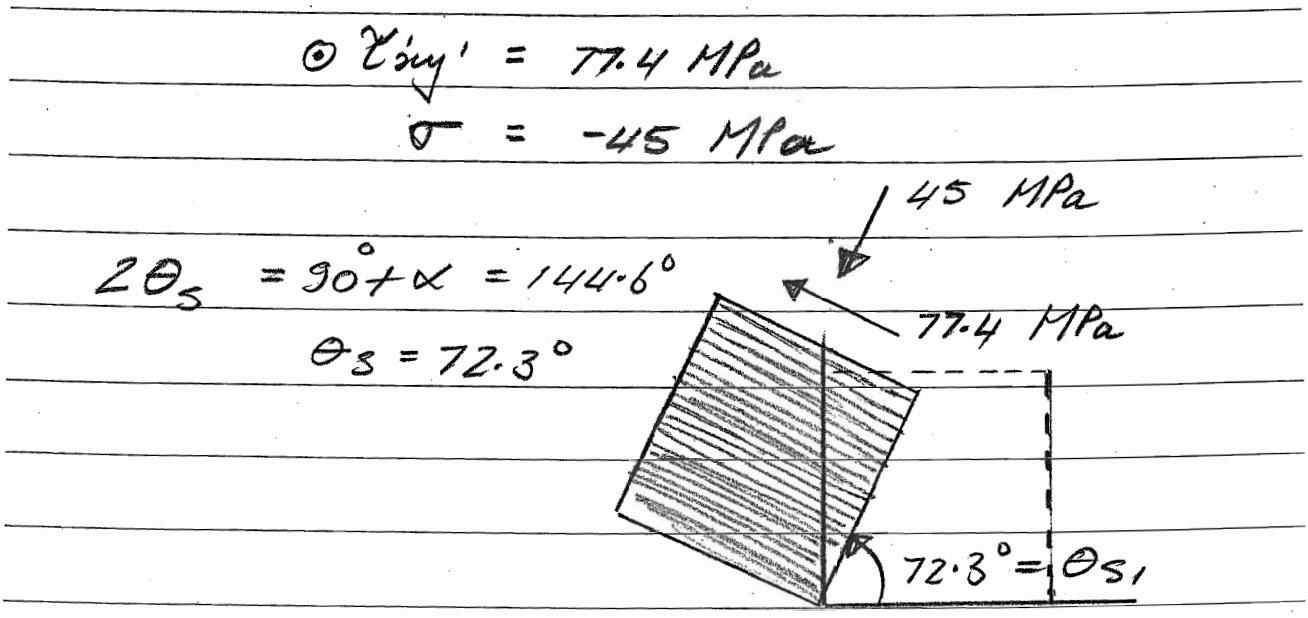
$\theta_{p_2} = 27.3^\circ$





6(b) Determine the maximum shear stresses and associated normal stresses and show them on a properly orientated stress element [4]

Bepaal die maksimum skuifspannings en ooreenkomstige normaalspannings en toon hulle op 'n korrek georiënteerde spanningselement.



6(c) Draw a Mohr diagram [with captions and values] depicting all these stresses. [4]

Teken 'n Mohr diagram [met byskrifte en waardes] wat al hierdie spannings weergee.