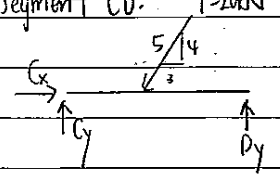
Yes, U can!

11-12 Sem 2 CV1011 Mechanics of Material

1 (a) Segment CD:



$\Sigma F_x = 0$

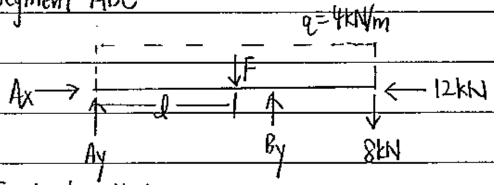
$C_x - 20\left(\frac{3}{5}\right) = 0$

$C_x = 12\,kN$

Due to symmetry, $C_y = D_y = \frac{1}{2} \times 20 \times \left(\frac{4}{5}\right)$

$C_y = D_y = 8\,kN$

Segment ABC:



$F = 4 \times 6 = 24\,kN$

$l = \frac{1}{2} \times 6 = 3\,m$

$\Sigma F_x = 0$

$A_x = 12\,kN$

$\Sigma M_A = 0$

$-24 \times 3 + B_y \cdot 4 - 8 \times 6 = 0$

$B_y = 30\,kN$

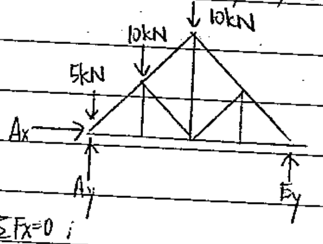
$\Sigma F_y = 0$

$A_y - 24 + 30 - 8 = 0$

$A_y = 2\,kN$

Yes, U can!

1.b) Zero force member: BH, DJ, CJ



$\Sigma F_x = 0$;

$A_x = 0$

$\circlearrowleft + \Sigma M_A = 0$

$-10 \times 3 - 10 \times 6 + E_y \cdot 12 = 0$

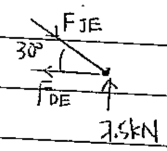
$E_y = 7.5\,kN$

$\Sigma F_y = 0$

$A_y + 7.5 - 5 - 10 - 10 = 0$

$A_y = 17.5\,kN$

Joint E:



$\Sigma F_y = 0$

$F_{JE} \sin 30° - 7.5 = 0$

$F_{JE} = 15\,kN\ (C)$

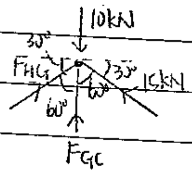
$\therefore F_{GJ} = 15\,kN\ (C)$

$\Sigma F_x = 0$.

$F_{DE} - 15 \cos 30° = 0$

$F_{DE} = 13\,kN\ (T)$

Joint G:



$\Sigma F_x = 0$

$F_{HG} \cos 30° - 15 \cos 30° = 0$

$F_{HG} = 15\,kN\ (C)$

$\Sigma F_y = 0$

$15 \times \sin 30° + 15 \times \sin 30° - 10 + F_{GC} = 0$

$F_{GC} = -5$

$F_{GC} = 5\,kN\ (T)$

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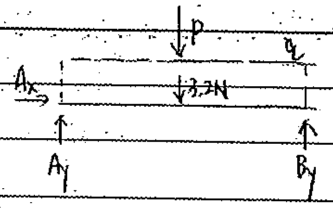
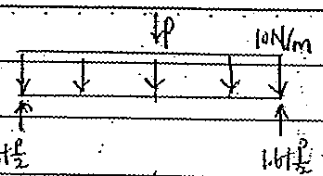
3 (a)





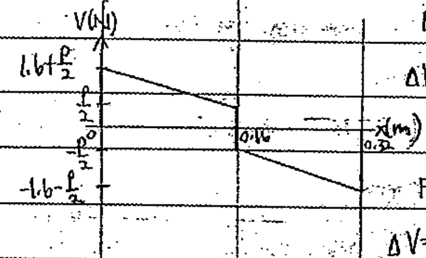
$\Sigma F_x = 0$

$A_x = 0$

Due to symmetry,

$A_y = B_y = \frac{3.2+P}{2} = 1.6 + \frac{P}{2}$

$\therefore q = \frac{3.2}{0.32} = 10$ N/m



For $0 \le x < 0.16$m,

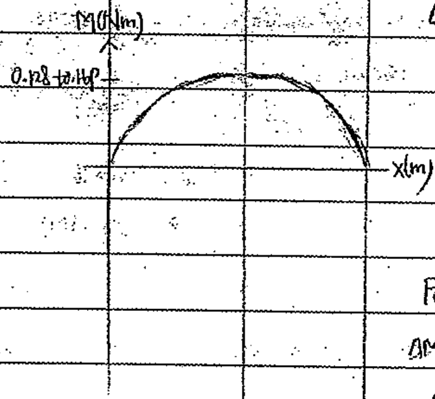
$\Delta V = \int -w\,dx = -10 \times 0.16$

$\Delta V = -1.6$N

For $0.16 < x \le 0.32$m,

$\Delta V = \int -w\,dx = -10 \times 0.16$

$\Delta V = -1.6$N



For $0 \le x < 0.16$m,

$\Delta M = \int V dx = \frac{1}{2} \times (1.6+P) \times 0.16$

$\Delta M = 0.128 + 0.16P$

For $0.16 < x \le 0.32$m,

$\Delta M = \int V dx = \frac{1}{2} \times (-1.6-P) \times 0.16$

$\Delta M = -0.128 - 0.16P$

$\therefore V_{max} = 1.6 + \frac{P}{2}$

$M_{max} = 0.128 + 0.16P$

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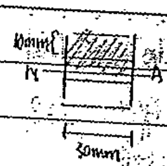


Neutral axis (measured from top)

$\bar{y} = 15mm$

$I = \left[\frac{1}{12} \times (30) \times (10)^3 + (10)(30)(15-5)^2\right] + \frac{1}{12}(30)(10)^3 + \left[\frac{1}{12} \times (30)(10)^3 + (10)(30)(25-15)^2\right]$

$I \doteq 67500\ mm^4$

As maximum bending stress occurs the farthest from neutral axis

$c = \bar{y} = 15mm$

allowable bending stress $\sigma_b = 8 = \frac{M_{max}\, c}{I}$

$8 \times 10^6 \times 67500 \times 10^{-12} \times \frac{1}{15 \times 10^{-3}} = 0.128 + 0.16P$

$P = 224.2 (N)$

∵ Maximum transverse shear stress occurs at neutral axis

$t = 30mm$

$Q = \bar{y}' A' = (15 \times 30) \times (15 - 7.5)$

$Q = 3375 (mm^3)$

$\tau = \frac{V_{max} Q}{I t}$

$0.3 \times 10^6 = \frac{(1.6 + \frac{P}{2})(3375 \times 10^{-9})}{67500 \times 10^{-12} \times 30 \times 10^{-3}}$

$P = 356.8 (N)$

∴ maximum permissible load $P = 224.2 (N)$

2) b) $L_{AB} = L$

$D_{AB} = d_1$

$T = T_0$

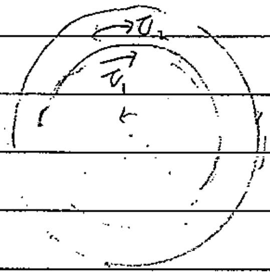
$J_{AB} = \frac{1}{2}\pi d_1^4$

i) $\phi = \frac{TL}{GJ}$

$= \frac{T_0 \times L}{G \times \frac{1}{2}\pi d_1^4}$

$= \frac{2 T_0 L}{G \pi d_1^4}$

ii) When T_0 are removed, the sleeve will stop twisting when stress on the sleeve is equal to the stress on the flange.



$J_1 = \cancel{J_{AB}}\ \frac{1}{2}\pi d_2^4$, $J_2 = \frac{1}{2}\pi(d_3^4 - d_2^4)$

$\tau_1 = \tau_2$

$\frac{T_1 d_2}{\frac{1}{2}\pi d_2^4} = \frac{T_2 d_2}{\frac{1}{2}\pi(d_3^4 - d_2^4)}$

$T_1(d_3^4 - d_2^4) = T_2 d_2^4$

$T_1 = \frac{d_2^4}{d_3^4 - d_2^4} T_2$

$\because T_1 + T_2 = T_0$

$\frac{d_2^4}{d_3^4 - d_2^4} T_2 + T_2 = T_0$

$\frac{d_3^4}{d_3^4 - d_2^4} T_2 = T_0$

$T_2 = \frac{d_3^4 - d_2^4}{d_3^4} T_0$

$\therefore$ Angle of twist of the sleeve $= \frac{T_2 L}{G J_2}$

$= \frac{\frac{d_3^4 - d_2^4}{d_3^4} T_0 \times L}{G \frac{1}{2}\pi(d_3^4 - d_2^4)}$

$= \frac{2 T_0 L}{G \pi d_3^4}$

Maximum shear stress $=$ $\tau = \frac{T_1 d_1}{J_{AB}}$

$= \frac{T_1 \times d_1}{\frac{1}{2}\pi d_1^4}$

$= \frac{\frac{d_2^4}{d_3^4 - d_2^4} \times \frac{d_3^4 - d_2^4}{d_3^4} T_0 d_1}{\frac{1}{2}\pi d_1^4}$

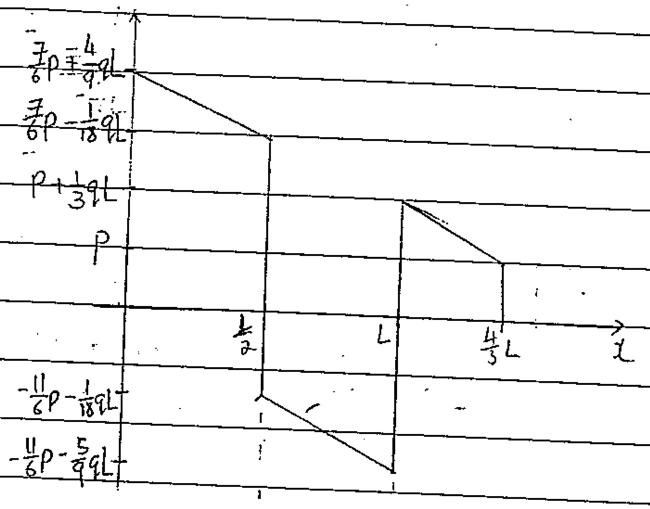
$= \frac{2 T_0 d_2^4}{\pi d_1^3 d_3^4}$

2) a) $\Sigma M_A = -3P \times \frac{L}{2} - P \times \frac{4}{3}L + F_B \times L - q \times \frac{4}{3}L \times \frac{2}{3}L = 0$

$\therefore F_B = \frac{17}{6}P + \frac{8}{9}qL$

$\Sigma F_y = F_A + \frac{8}{9}qL + \frac{17}{6}P - 4P - q \times \frac{4}{3}L = 0$

$F_A = \frac{7}{6}P + \frac{4}{9}qL$



For $0 \leq x \leq \frac{L}{2}$

$\Sigma F_y = \frac{7}{6}P + \frac{4}{9}qL - qx - V = 0$

$\therefore V = -qx + \frac{7}{6}P + \frac{4}{9}qL$

$\Sigma M = -(\frac{7}{6}P + \frac{4}{9}qL)x + qx \cdot \frac{x}{2} + M = 0$

$\therefore M = -\frac{q}{2}x^2 + (\frac{7}{6}P + \frac{4}{9}qL)x$

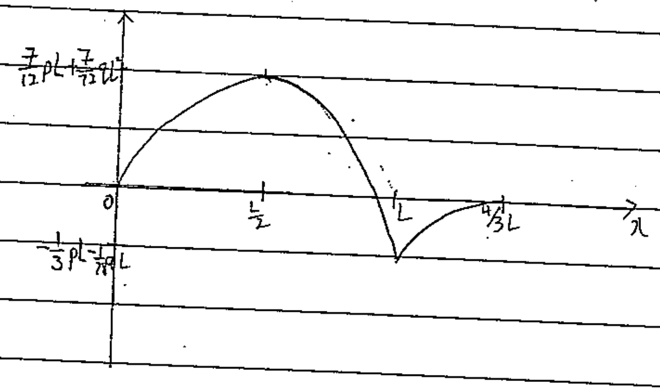
For $\frac{L}{2} \leq x \leq L$

$\Sigma F_y = \frac{7}{6}P + \frac{4}{9}qL - qx - 3P - V = 0$

$V = -qx + \frac{7}{6}P + \frac{4}{9}qL - 3P$

$\Sigma M = -(\frac{7}{6}P + \frac{4}{9}qL)x + qx \cdot \frac{x}{2} + 3P(x - \frac{L}{2}) + M = 0$

$\therefore M = -\frac{q}{2}x^2 + (\frac{7}{6}P + \frac{4}{9}qL)x - 3P(x - \frac{L}{2})$



For $L \leq x \leq \frac{4}{3}L$

$\Sigma F_y = \frac{7}{6}P + \frac{4}{9}qL - qx - 3P + \frac{17}{6}P + \frac{8}{9}qL - V = 0$

$V = P + \frac{1}{3}qL - qx$

$\Sigma M = -(\frac{7}{6}P + \frac{4}{9}qL)x + qx \cdot \frac{x}{2} + 3P(x - \frac{L}{2}) - (\frac{17}{6}P + \frac{8}{9}qL)(x - L) + M = 0$

$M = -\frac{q}{2}x^2 + (\frac{7}{6}P + \frac{4}{9}qL)x - 3P(x - \frac{L}{2}) + (\frac{17}{6}P + \frac{8}{9}qL)(x - L)$

* ∴ For maximum shear force,

when $x = L$, $V = -\frac{11}{6}P - \frac{5}{9}qL$,

- maximum bending moment,

when $x = \frac{L}{2}$, $M = \frac{7}{12}PL + \frac{7}{72}qL^2$,

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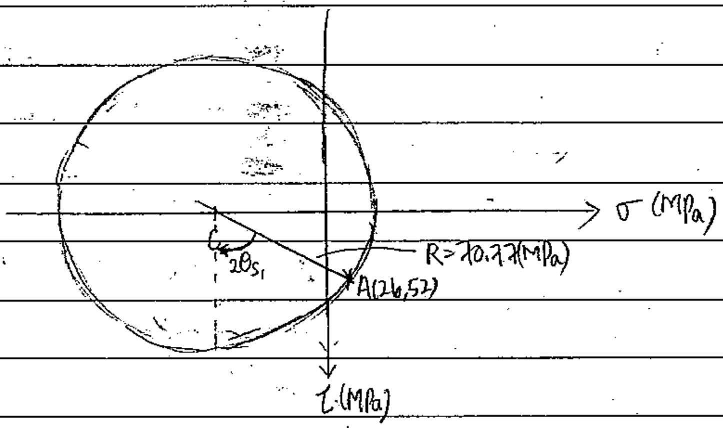
3(b) (i) $\sigma_x = 26\,MPa$, $\sigma_y = -70\,MPa$, $\tau_{xy} = 52\,MPa$

$\sigma_{ave} = \frac{\sigma_x + \sigma_y}{2} = \frac{26-70}{2} = -22\,MPa$

$A(26, 52)$

$C(-22, 0)$

$R = \sqrt{[26-(-22)]^2 + (52)^2} = 70.77\,MPa$



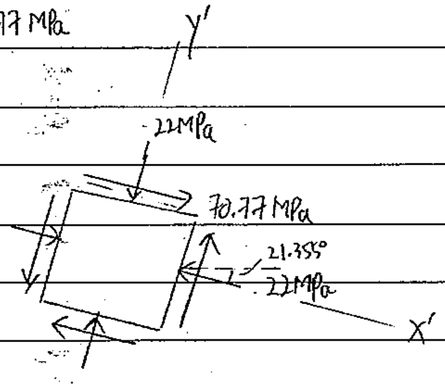
$\tan 2\theta_{s_1} = \frac{26-(-22)}{52}$

$2\theta_{s_1} = 42.71°$

$\theta_{s_1} = 21.355°$

$\tau_{max} = R = 70.77\,MPa$

$\sigma_{ave} = -22\,MPa$



p.g11 -

internal - opposite in direction

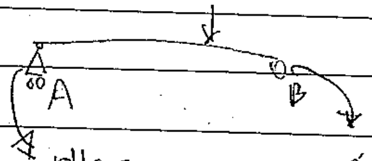
At A, external force (E.R.)

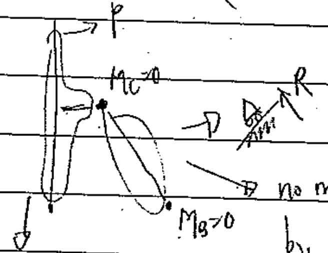
At B, D, w_1, w_2, E.I external Imposed force

p.g 12

at a point *

p.g17 ((0-0) am)





no moment, can be replaced by roller

p.g18 read-

p.g19 read- (internal force)

skeleton è7

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3(b) (ii) $\sigma_x = 26\,MPa$, $\sigma_y = -70\,MPa$, $\tau_{xy} = 70.77\,MPa$

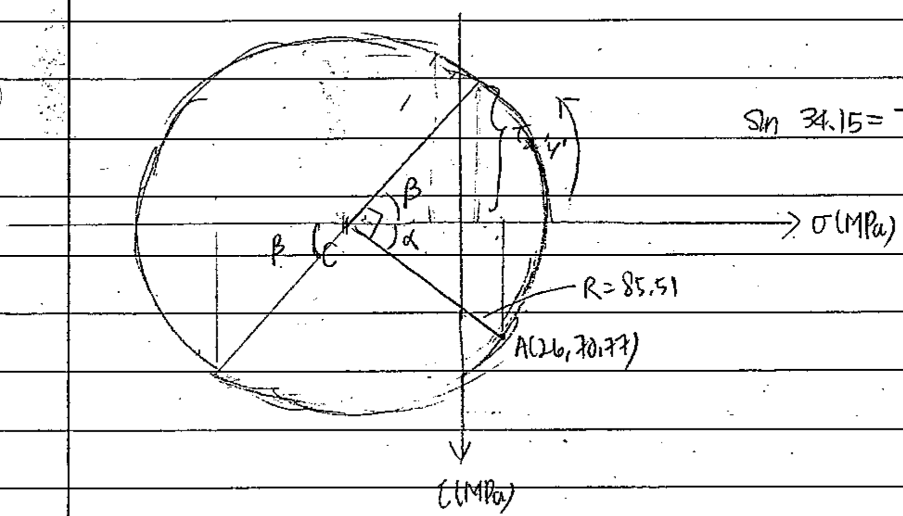
$\sigma_{ave} = \frac{\sigma_x + \sigma_y}{2} = \frac{26-70}{2}$

$\sigma_{ave} = -22\,MPa$

$A(26, 70.77)$

$C(-22, 0)$

$R = \sqrt{[26-(-22)]^2 + (70.77)^2} = 85.51\,MPa$



$\sin 34.15 = \frac{0}{R}$

$\tan\alpha = \frac{70.77}{22+26}$

$\alpha = 55.85°$

$\beta = 90 - 55.85° = 34.15°$

$\sigma_{x'} = -22 + 85.51 \times \cos 34.15°$

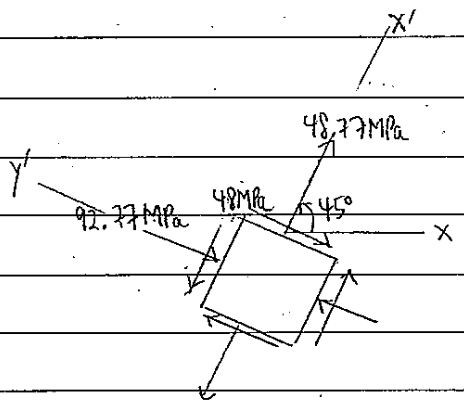
$\sigma_{x'} = 48.77\,MPa$

$\tau_{x'y'} = -85.51 \times \sin 34.15°$

$\tau_{x'y'} = -48\,MPa$

$\sigma_{y'} = -85.51 \times \cos 34.15° - 22$

$\sigma_{y'} = -92.77\,MPa$



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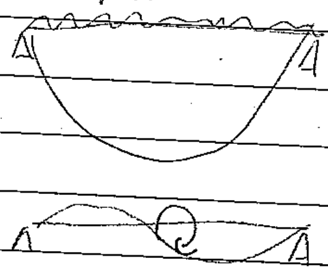
bending moment depends on deflection profile.

Tut 1 Q2. deflection profile



Q3. 75.833 kN = F_B

A_y = 50kN

A_x = 20.833 kN

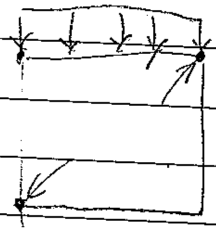
Q4. AC - need support from CB (dependent structure)

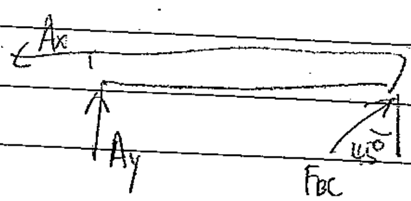
CB - can sustain itself

remove distributed on AC, internal force in AC = 0

" " " CB, CB will still have internal force to sustain AC.

Q6. pin-pin connect = roller





4) a) $V = 1000\,kN$

$M_y = 1000 \times 120mm$

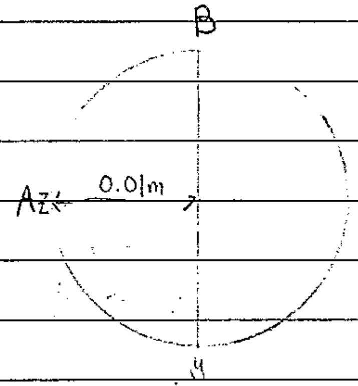
$= 120\,Nm$

$M_x = 1000 \times 120mm$

$= 120\,Nm$

$M_z = 0\,Nm$

$N = 0N$



$I_y = \frac{1}{4}\pi(0.01)^4$

$= 7.85 \times 10^{-9}\,m^4 = I_z$

$J = \frac{1}{2}\pi(0.01)^4$

$= 1.57 \times 10^{-8}\,m^4$

i) - Tensile and Compressive stress :

$$0 + \frac{120 \times 0.01}{7.85 \times 10^{-9}} + 0 = \text{Normal Stress}$$

Normal Stress = 152.87MPa

- Shear Stress :

$$\text{Shear Stress} = \frac{120 \times 0.01}{1.57 \times 10^{-8}} + \cancel{Q}\ \cancel{1000 \times Q}\ \frac{VQ}{It}$$

$= 76.43MPa$

- In plane Shear Stress ,

$$\tau_{max} = \sqrt{\left(\frac{152.87}{2}\right)^2 + 76.43^2}$$

$= 108.09\,MPa$

ii) $V = 1000\,kN$

$M_y = 1000 \times 120mm = 120\,Nm$

$M_x = 1000 \times 120\,\cancel{k}m\,m = 120\,Nm$

$M_z = 0\,Nm$

$N = 0N$

$$Q = \frac{4 \times 0.01}{3\pi} \times \frac{\pi \times 0.01^2}{2}$$

$= 6.67 \times 10^{-7}\,m^3$

· Normal Stress = 0Pa

· Shear Stress $= \frac{120 \times 0.01}{1.57 \times 10^{-8}} - \frac{1000 \times 6.67 \times 10^{-7}}{7.85 \times 10^{-9} \times 0.01}$

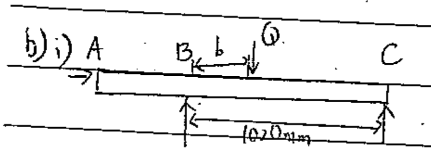
$= 67.94MPa$

· In plane Shear Stress,

$$\tau_{max} = \sqrt{\left(\frac{0}{2}\right)^2 + 67.94^2}$$

$= 67.94MPa$

b) i)



$\Sigma M_B = F_c \times (1020) - Q\,b = 0$

$F_c = \dfrac{Qb}{1020}$

$\Sigma F_y = -Q + \dfrac{Qb}{1020} + F_{AB} = 0$

$F_{AB} = \dfrac{Q(1020-b)}{1020}$

$E = 200GPa$

$K_{BD} = 0.7$, $L_{BD} = 0.89m$

$K_{CE} = 1$, $L_{CE} = 1.15m$

$I = \frac{1}{12}(0.016)^4$

$= 5.46\times10^{-9} m^4$

Critical loading for both column BD, CE

$\hookrightarrow P_{cri_{BD}} = \dfrac{\pi^2 \times 200G \times 5.46\times10^{-9}}{(0.7\times0.89)^2}$

$= 27.77kN$

$\hookrightarrow P_{cri_{CE}} = \dfrac{\pi^2 \times 200G \times 5.46\times10^{-9}}{(1\times1.15)^2}$

$= 8.15kN$

$Q_{CE} = 8.15k \times 1020 \times \frac{1}{250}$

$= 33.25kN$

$Q_{BD} = 27.77k \times 1020 \times \frac{1}{770}$

$= 36.79kN > Q_{CE}$

$\therefore$ The critical load $Q = 33.25kN$

ii) Q value is maximized when $Q_{BD} = Q_{CE}$

$Q_{BD} = Q_{CE}$

$27.77 \times 1020 \times \dfrac{1}{1020-b} = 8.15 \times 1020 \times \dfrac{1}{b}$

$\dfrac{27.77}{1020-b} = \dfrac{8.15}{b}$

$27.77b = 8313 - 8.15b$

$b = 231.43mm$

$\therefore$ when $b = 231.43mm$, Q is maximized

$Q = 8.15 \times 1020 \times \frac{1}{231.43}$

$= 35.92kN.$