STRENGTH OF MATERIALS (9324866015)

CBSGS

Q.P. CODE. 27319

DOE 07-12-2013

MAX MARKS- 80

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Q.P. Solution (Model Answer with marking)

Q 1 Compulsory (5×4 = 20)

(a) (i) Pure bending ——— 2m } 5m
(ii) Beam of uniform strength —— 3m
(Explanation + figures)

(b) $E = \dfrac{9KG}{3K+G}$ ——— 2m } 5m

Explaining terms with unit —— 3m

(c) Assumption theory of simple torsion
(Min 4 Assumption) —— 1.25×4 = 5m

(d) ev for cylindrical shell

$e_1 = e_d = \dfrac{f_1}{E} - \dfrac{f_2}{mE}$ or $\dfrac{f_1}{E} - \nu\dfrac{f_1}{2E}$ — 1

$e_2 = e_L = \dfrac{f_2}{E} - \dfrac{f_1}{mE}$ or $\dfrac{f_1}{2E} - \nu\dfrac{f_1}{E}$ — 1

——— 1

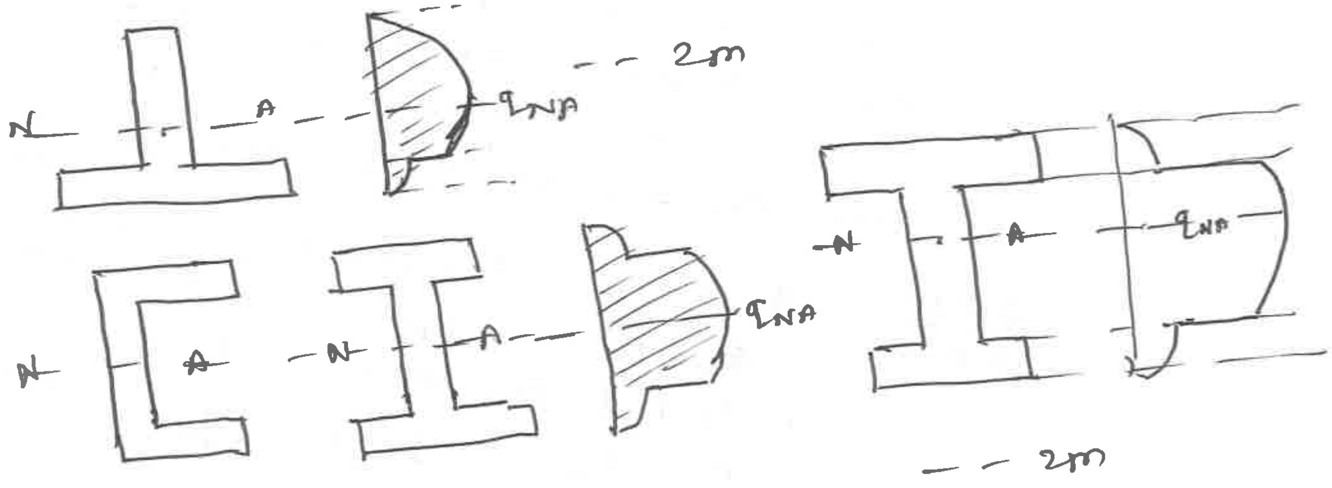
$e_v = e_L + 2e_d$ ——— 1

$e_v = \dfrac{f_1}{2E}(5-4\nu)$ ——— 1

$$\boxed{e_v = \dfrac{pd}{4tE}(5-4\nu)}$$

= 5 marks

(e) shear stress diagram (2+1+2 = 5 marks)



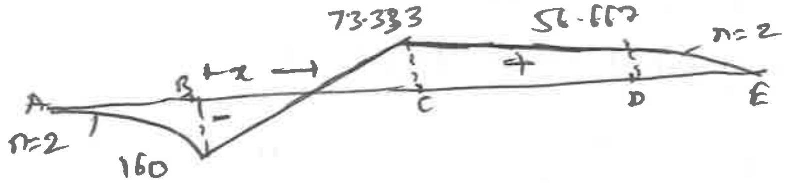
-- 1m

27

Q.2(a)
8 marks

$V_B = 126.667$ kN (↑)
$V_E = 53.333$ kN (↑) — 2m

— 3m



— 3m

Q2(b)
6 marks

$E = \frac{PL}{\Delta A} = 188.628 \times 10^3$ N/mm² — 1m

$e_{long} = 4.5 \times 10^{-4}$ — 1m

$e_{lat} = 1.3 \times 10^{-4}$ — 1m

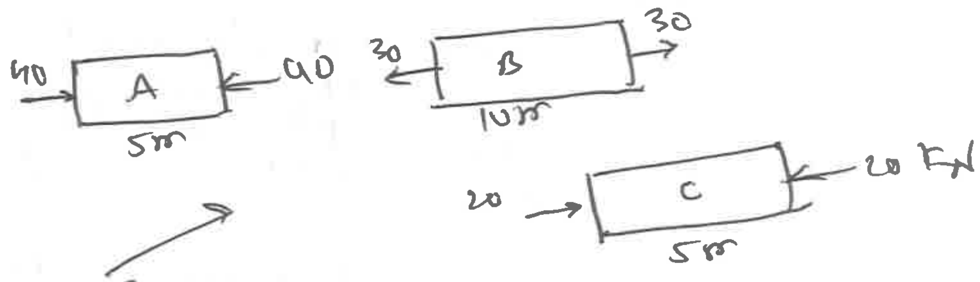
$\nu = \frac{e_{lat}}{e_{long}} = 0.289$ — 1m

$E = 2G(1+\nu)$ $G = 73.188 \times 10^3$ N/mm² — 1m

$E = 3K(1-2\nu)$ $K = 148.995 \times 10^3$ N/mm² — 1m

06

Q 2(c)
6 mark



FBD — 2m

$\Delta_1 = 2.5$ mm (Contraction) — 1

$\Delta_2 = 3.75$ mm (Extension) — 1

$\Delta_3 = 1.25$ mm (Contraction) — 1

final ~~Δ = 2.5~~ $\Delta = -2.5 + 3.75 - 1.25 = 0$ — 1

6 mark

Q 3(a)
8 mark

$A_s = 225\pi$ $A_c = 324\pi$ } + figure — 2 marks

$P_s + P_c = 100$ kN

$f_s A_s + f_c A_c = 100 \times 10^3$ (N) — ① — 2 mark

$e_c = e_s$ $\therefore f_s = 1.818 f_c$ — ② — 2 mark

Solving ① & ② $f_c = 43.423$ MPa $f_s = 78.942$ MPa — 2 marks

= 8 marks

Q 3(b)
6 marks

$\bar{y} = y_{top} = 55.23$ mm
$y_{bottom} = 144.77$ mm } — 2 mark

$I_{NA} = 12.068 \times 10^6$ mm^4 — 2 mark

$\frac{M}{I} = \frac{f}{y}$

$M.R = \frac{I}{y_{max}} \times f_{max}$ } — 1 m

$MR = 12.504$ kN m

$(BM)_{max} = \frac{Wl^2}{8}$

$\therefore \frac{Wl^2}{8} \leq M.R$

$\therefore W \leq 4.001$

Say $W = 4$ kN/m — Ans — 1 m

06 marks

Q 3(c) figure + $\frac{f}{y} = \frac{E}{R}$ — 2 m

N.A. passes through CG — — — 1 m (No derivation)

figure + $\frac{M}{I} = \frac{E}{R}$ — 2 m

final $\frac{M}{I} = \frac{f}{y} = \frac{E}{R}$ — 1 m

6 marks

Q 4(a)
8 marks

$\sigma_p = \frac{p_1 + p_2}{2} \pm \sqrt{\left(\frac{p_1 - p_2}{2}\right)^2 + q^2}$

$\frac{p_1 + p_2}{2} = 30$ MPa

$\frac{p_1 - p_2}{2} = 50$ MPa $q = 25$ MPa

$\sigma_{p_1} = 85.902$ N/mm^2

$\sigma_{p_2} = -25.902$ N/mm^2 } — 2 m

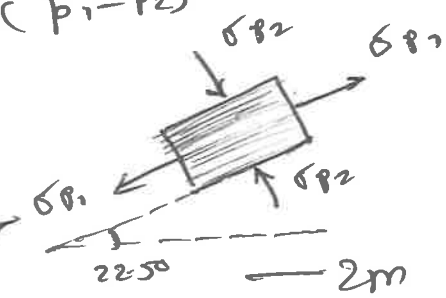
Principal planes $\tan 2\theta = \frac{2q}{(p_1 - p_2)}$

$\tan 2\theta = 1$

$2\theta_1 = 45°$

$\theta_1 = 22.5°$

$\theta_2 = 22.5 + 90° = 112.5°$



— 2 m

Element orientation for σ_p

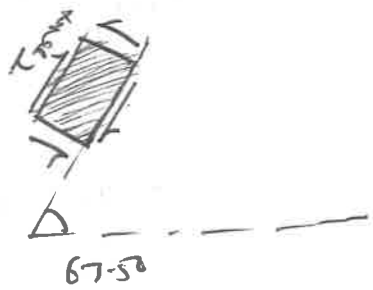
maximum shear stress

$$\tau_{max} = \frac{\sigma_{P_1} - \sigma_{P_2}}{2} = 55.902 \text{ N/mm}^2$$

$\alpha_1 = 22.5 + 45 = 67.5^\circ$

$\alpha_2 = 67.5 + 90^\circ = 157.5^\circ$

Element orientation for τ_{max}



4 marks

Total - 8 marks

Q 4 (b) 6 marks ★ point 'c' shall be assumed on mid span point

$M_{max} = M_c = \frac{w l^2}{8} = 14.4$ kNm — 1m

$\bar{y} = y_{top} = 48.182$ mm — 1m

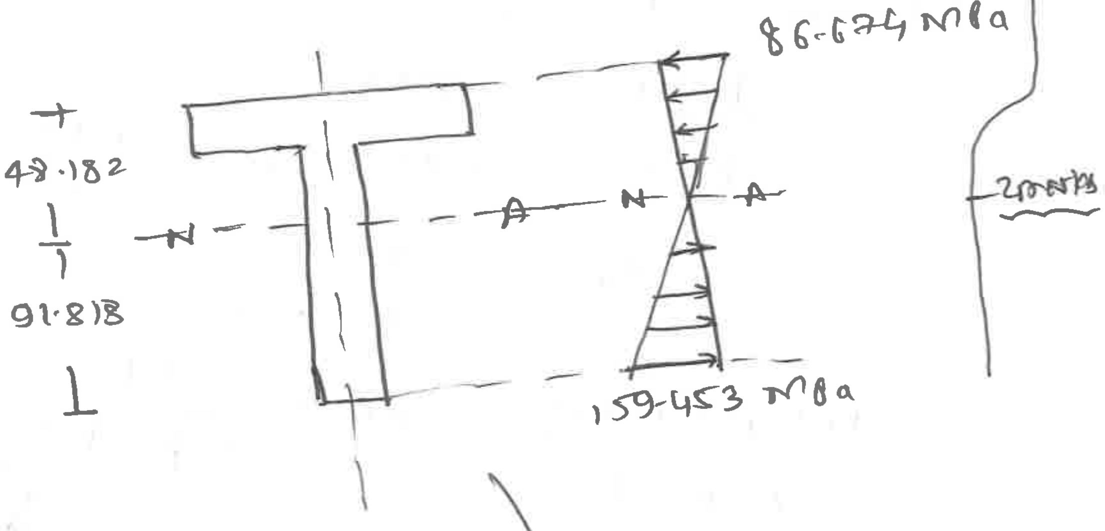
$y_{bottom} = 91.818$ mm

$I_{NA} = 8.292 \times 10^6$ mm⁴ — 2m

Use $\frac{M}{I} = \frac{f}{y}$ $\therefore f = \frac{M}{I} \cdot y$

$f_{top} = 83.674$ N/mm² (Compression)

$f_{bottom} = 159.453$ N/mm² (Tensile)



Q 4(c) 6 marks

$q_{f/j}$ = $V_A = V_B = \frac{18 \times 8}{4} = 36\ kN$

$q_{w/j}$ = $F = SF_{max} = 36\ kN$

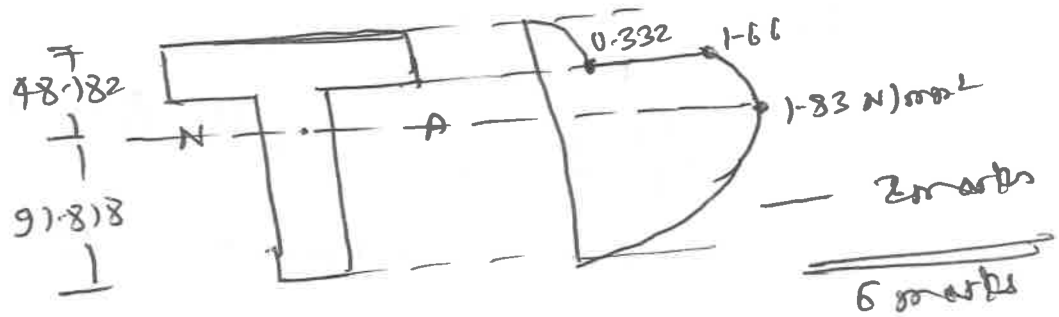
$q = \frac{F A'\bar{y}}{I \cdot b}$

$q_{f/j} = 0.332\ N/mm^2$

$q_{w/j} = \frac{100}{20} \times 0.332 = 1.66\ N/mm^2$

$q_{NA} = 1.83\ N/mm^2$

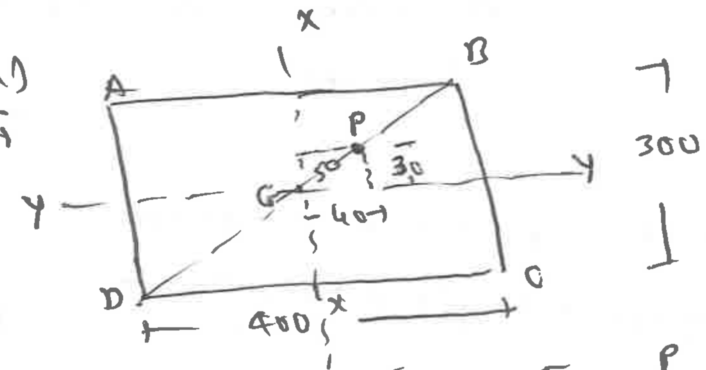
— 4 marks



— 2 marks

6 marks

Q 5(a) 8 marks



$A = 120 \times 10^3\ mm^2$ $\sigma_{axial} = \sigma_a = \frac{P}{A} = \frac{2}{3}\ N/mm^2$

~~$I_{xx} = 1.6 \times$~~

$I_{xx} = 1600 \times 10^6$ }
$I_{yy} = 900 \times 10^6$ } mm^4

$M_{xx} = 80 \times 10^3 \times 40\ Nmm$

$M_{yy} = 80 \times 10^3 \times 30\ Nmm$

$\sigma_{bx} = \pm \frac{2}{5}\ N/mm^2$ $\sigma_{by} = \pm \frac{2}{5}\ N/mm^2$

— 4 mark

Compⁿ +ve / Tension -ve

$\sigma_A = \frac{2}{3} - \frac{2}{5} + \frac{2}{5} = 0.667\ N/mm^2$

$\sigma_B = \frac{2}{3} + \frac{2}{5} + \frac{2}{5} = 1.467\ MPa$

$\sigma_C = \frac{2}{3} + \frac{2}{5} - \frac{2}{5} = 0.667\ MPa$

$\sigma_D = \frac{2}{3} - \frac{2}{5} - \frac{2}{5} = -0.133\ MPa$

— 4 m

8 marks

6/7

Q 5(b)
8 marks

$P = \frac{2\pi N T}{60}$ $T_{avg} = T_{max} = T$

$= 43.406 \times 10^3$ Nm

$\theta = \frac{Tl}{GJ} \leq 1^\circ \times \frac{\pi}{180}$ $\{ l = 12d \}$

$\frac{GJ}{Tl} \geq \frac{180}{\pi}$ $\{ J = \frac{\pi}{32} \cdot d^4 \}$

$d \geq 32.673$ mm — 5m

$\tau_{max} = \frac{T}{Z_p} \leq 60$ N/mm²

$\frac{Z_p}{T} \geq \frac{1}{60}$ $[Z_p = \frac{\pi}{16} d^3]$

$d \geq 154.451$ mm — 2m

∴ ~~d = 155 m~~ ∴ d = 155 mm — Ans

∴ ~~d = 15 m~~ — 1m

8 marks

Q5(c) Middle third rule — 2 marks
Figure + Explanation — 2 mark } 4 marks

Q6(a)
8 marks

$f_1 = f_c = 150$ N/mm² $[\frac{pd}{2t}]$
$f_2 = f_L = 750$ N/mm² $[\frac{pd}{4t}]$ } —2m

$e_1 = e_d = \frac{150}{E} - 0.3 \times \frac{75}{E} = 6.375 \times 10^{-4}$ — 1m

$e_2 = e_L = \frac{75}{E} - 0.3 \times \frac{150}{E} = 1.5 \times 10^{-4}$ — 1m

$\frac{\delta d}{d} = e_d$ $\delta d = 0.638$ mm — 1m

$\frac{\delta l}{l} = e_L$ - $\delta l = 0.415$ mm — 1m

$e_v = e_L + 2e_d = 8.25 \times 10^{-4}$ — 1m

$e_v = \frac{dv}{V} = 8.25 \times 10^{-4}$ — 1m

$dv = 1943.86$ cm³

08 marks

Q 6(b) — 8 marks

D = 80 mm d = 60 mm $l_e = 0.5L = 2.75$ m

A = 700π mm² $I = 1.374 \times 10^6$ mm⁴

$$P_E = \frac{\pi^2 EI}{l_e^2} = \frac{\pi^2 (2\times10^5)(1.374\times10^6)}{(2750)^2} \text{ N}$$

$P_E = 114.157$ kN ——— 3 m

$$P_R = \frac{f_c A}{1+\alpha(\lambda)^2}$$ $f_c = 350$ N/mm² $\lambda = \frac{l_e}{r_{min}}$

$$r = r_{min} = \sqrt{\frac{I}{A}} = 24.996 \text{ mm}$$

$$\lambda = \frac{2750}{24.996} = 110.018$$

∴ $P_R = 294.465$ kN — 3 m

06 mark

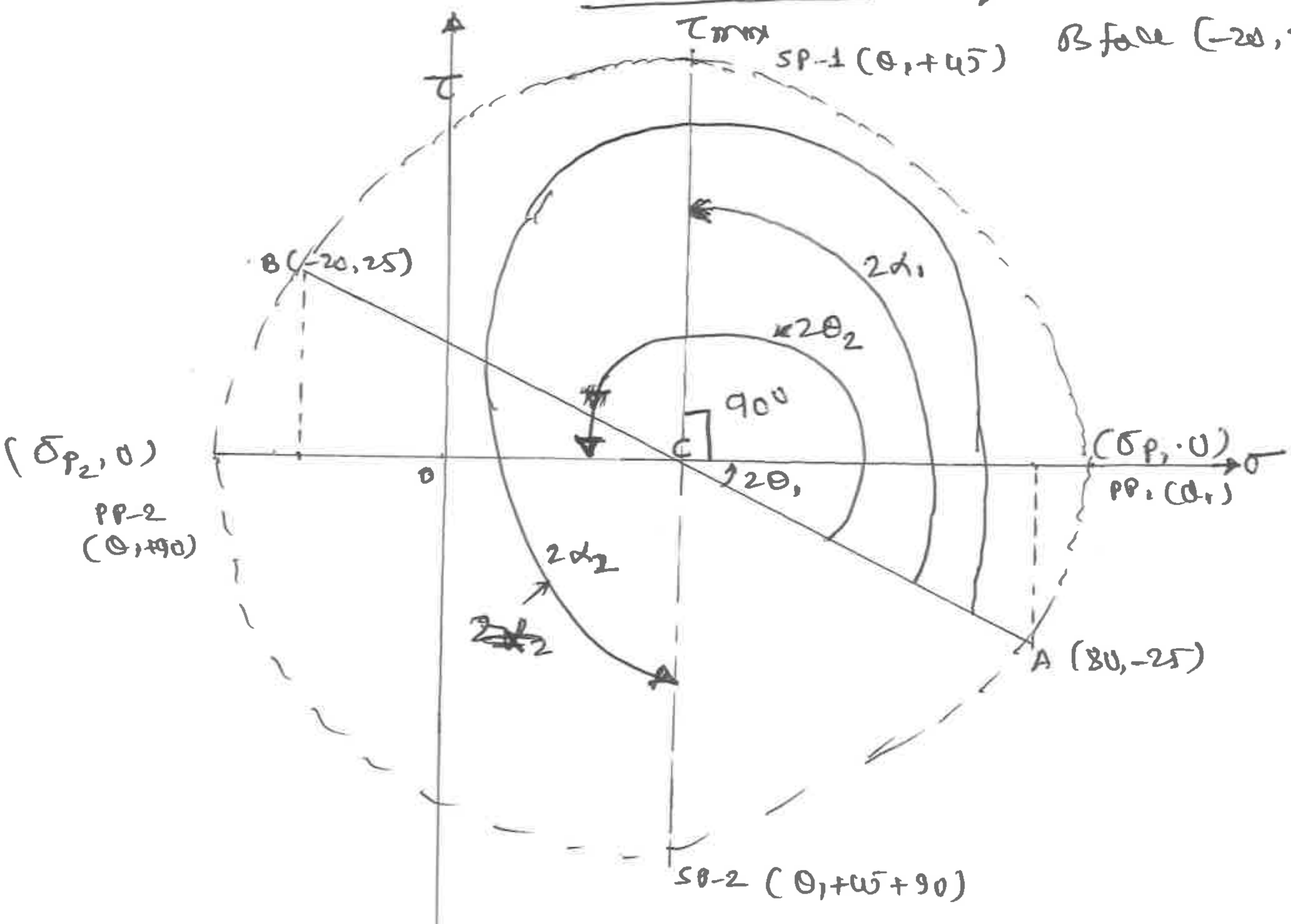
Q 6(c) Definition.
(i) S.R (λ)
(ii) ROG (r)
(iii) Torsional rigidity GJ
(iv) Core (kernel) of section

1×4 = 4 marks

Q 4(a) — 8 marks

Graphical soln (Mohr's Circle)
Scale 1 cm = 10 N/mm²

A face (80, −25)
B face (−20, 25)



— END —

Q 4(a) Graphical solution

A face (80, -25), B face (-20, 25)