Model Answer

Highway and airport Engineering

Dr. Sameh El-Gohary

الرابعة بدش

لائحة قديمة

الدرجة لكل سؤال : ٢٠ درجة

- صمم الطريق والمطارات للعام الدراسي

أ.م.د

د/ سامح هلال

Q1-a. (10)

c) $D = 3^\circ$ $\quad R = \frac{1750}{3} = 584m$. $\quad W = \frac{7.5}{2} = 3.75m$

$V = 110$ kph assum $f_{s=0.3}$ & $n = 2$

$$S = 0.278(110) \cdot 2.5 + \frac{110^2}{255(0.3)} \approx 235m$$ 1

$$M = \frac{S^2}{8R} = \frac{(235)^2}{8 \times 584} = 11.82m$$ 1

$$M = y + n(h_w + ey) = 11.82$$

$$y + 2(0.6 + 0.08 \times y) = 11.82$$ 1

$y = 9.16m$

$S = y + W/2$

$S' = 11.04m$ 1

(c) $D = 5^\circ$ $\quad R = \frac{1750}{D} = 350^\circ$ 1

$$M = \frac{S^2}{8R} = 19.72m$$ 1

$$19.72 = y + 2(0.6 + 0.1 \times y)$$

$y = 15.43m$ 1

$S = y + \frac{W}{2} = 17.31m$ 1

$S'' = 17.31m$ 1

b) [2]

$$SSD = 0.278 * 90 * 2.5 + \frac{(90)^2}{255 * 0.3} \simeq 169 \text{ m} \quad (8)$$

for $S < L$

$$L = \frac{AS^2}{120 + 3.5S}$$

$$L = \frac{A(169)^2}{120 + 3.5(169)} = 40.14A$$

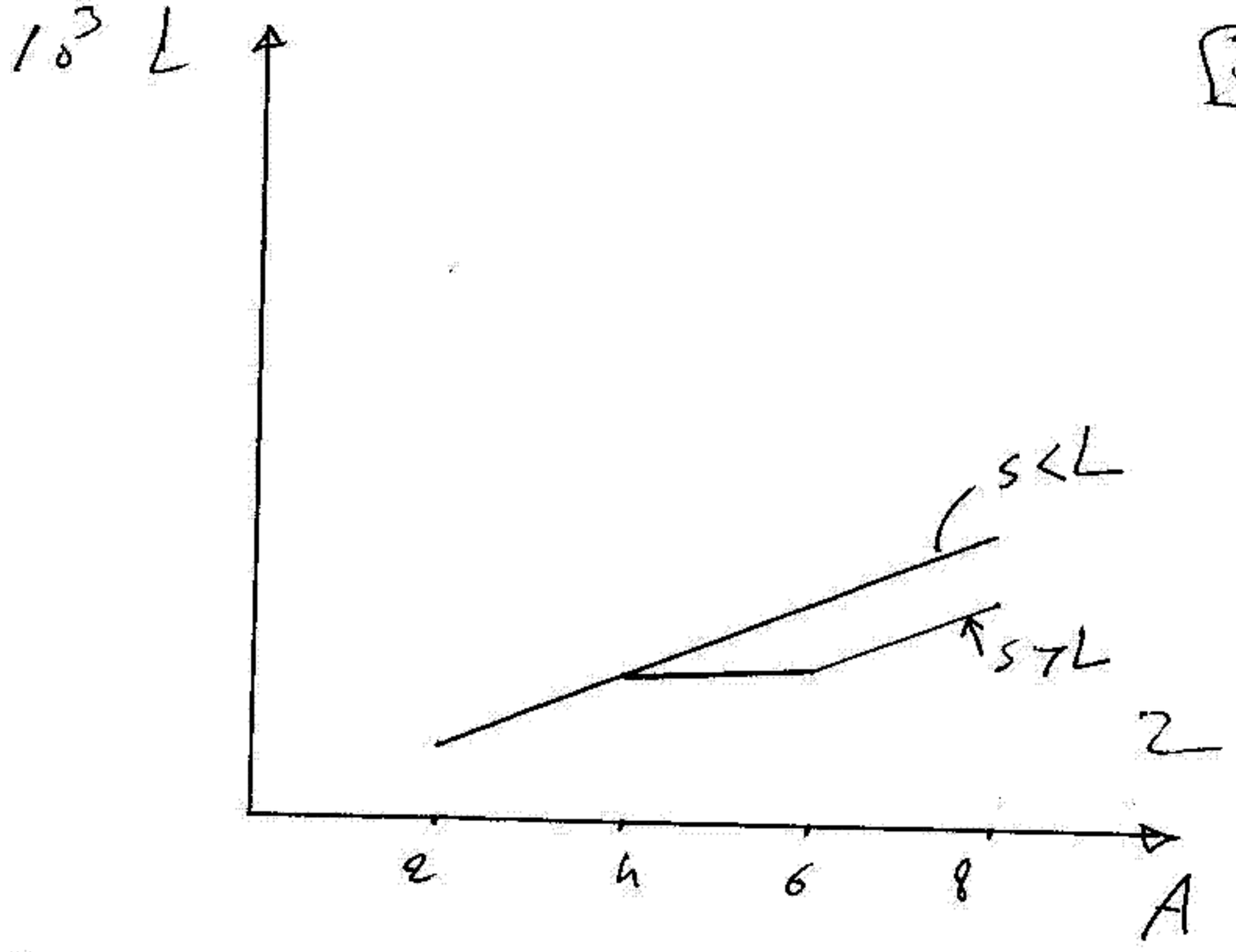
$$\boxed{L = 40.14A} \quad 3$$

for $S \geq L$

$$L = 2S - \frac{120 + 3.5S}{A}$$

$$\boxed{L = 338 - \frac{711.5}{A}} \quad 3$$

A	2	4	6	8	
(S<L) L	80.28	160.56	240.84	321.12	
(S≥L) L	—	160.125	219.4	249	



Q2. a) (27)

$g_1 = +3$ $\quad g_2 = -2\%$ (14)

$A = |g_1 - g_2| = 5$

$g_{av} = \frac{|+3+(-2)|}{2} = 0.5$

⌐ PVI = 100

⌐ C° = 97 , $g_1° = -1$

1) ⌐ PVC = ⌐ PVI $- \frac{g_1 L}{200}$

⌐ PVC = $100 - \frac{3 \times L}{200}$ &

$X_{C°} = \frac{|g_1 - g_{C1}|}{A} \times L = \frac{|3-(-1)|}{5} \times L = 0.8L$

⌐ C° = ⌐ PVC + $Y_{C°} - g_{C°}$

$97 = (100 - 0.015L) + \frac{3 \times 0.8L}{100} - \frac{5 \times (0.8L)^2}{200L}$

$97 = 100 - 0.015L + 0.024L - 0.016L$

$L \approx 429$ m

f) For turning point $y_c^\circ = 0.0$ $\left(L = 429m\right)$ (4)

$$X_c^\circ = \frac{3}{5} \times L = 257.4m$$

$$y_c^\circ = \frac{5 \times (257.4)^2}{200 \times 429} = 3.86$$

$$Y_c^\circ = \frac{3 \times 257.4}{100} = 7.722$$

$$\nabla_{turning} = (100 - 0.015 \times 429) + 7.722 - 3.86$$

$$\boxed{\nabla_{turn} = 97.43m}$$

g) assume $S < L$ (3)

$$L = \frac{AS^2}{\cancel{180 \times 5} \times 400}$$

$$429 = \frac{S \times S^2}{400}$$

$$S = 185.25m < L$$ (0.1C)

$$S = 0.278\,V\left(2.5\right) + \frac{V^2}{255\left(0.3 - 0.005\right)}$$

$$V^2 + 52.28V - 13935 = 0.0$$

$$\boxed{V = 94.76\ kph}$$ 3

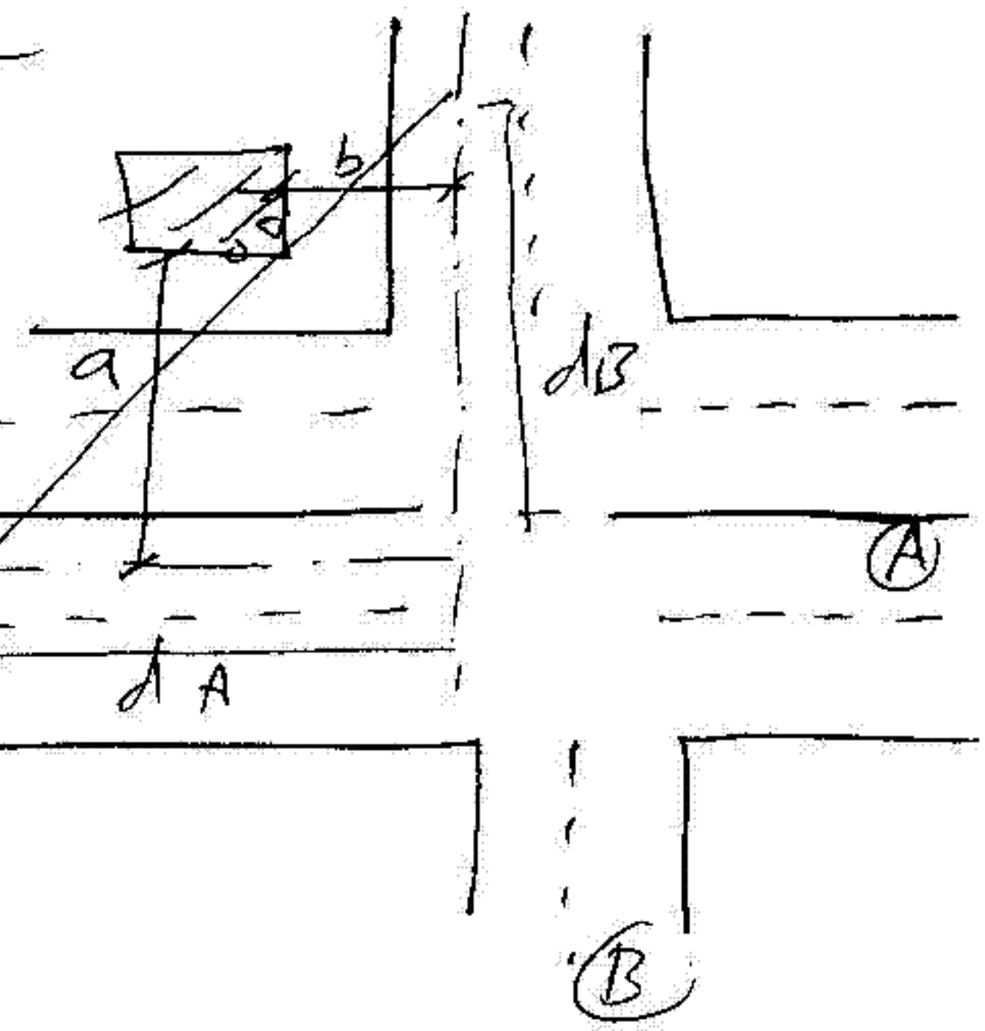
Q 2-b [5]

$V_B = ??$ $V_A = 100 KPh.$

(13)

$a = 52 - 1.5 * \frac{13}{4} = 47.125m$

$b = 32 + \frac{7}{4} = 33.75m$ 3



$$\frac{d_B}{d_A} = \frac{a}{d_A - b}$$ (1)

For adjust speed

$d_A = 0.278 * 100 * 3 = 83.4m$

from (1)

$d_B = d_A \left(\frac{a}{d_A - b}\right) = 83.4 * \left(\frac{47.125}{83.4 - 33.75}\right)$ 4

$d_B = 79.16m = 0.278 V_B * 3$

$V_B \approx 95 KPh$

For case to stop

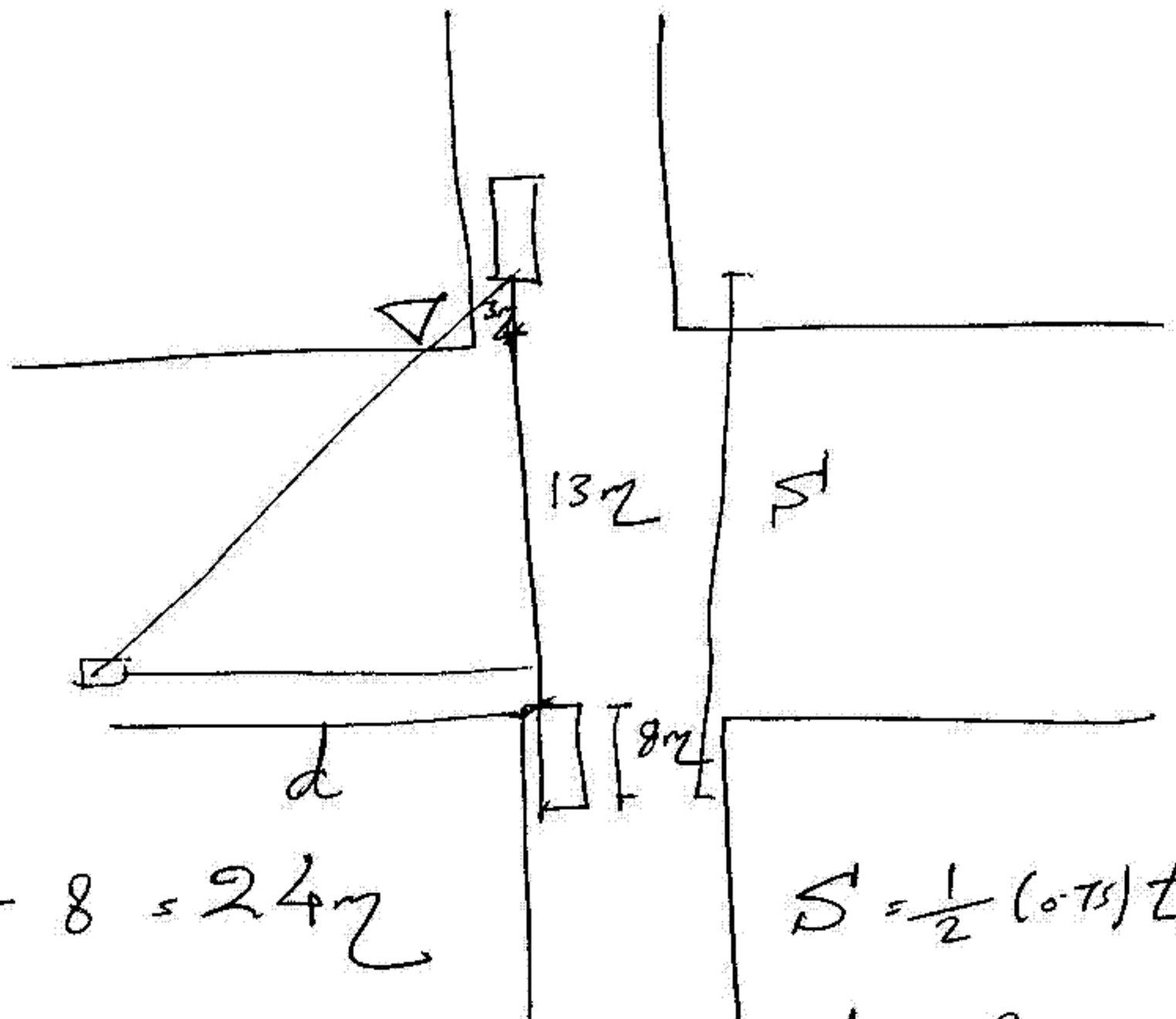
$d_A = 0.278 * 100 * 2.5 + \frac{(100)^2}{255(0.3)} = 200m$

$d_B = 56.7m = 0.278 V_B * 2.5 + \frac{V_B^2}{255(0.3)}$

$$V_B^2 + 53.17V_B - 1337.6 = 0$$ (6)

$$V_B = 44.43 \text{ kph}$$ 3

- if controlled



$S = 3 + 13 + 8 = 24m$

$S = \frac{1}{2}(0.75)t_a^2$

$t_a = 8 sec$

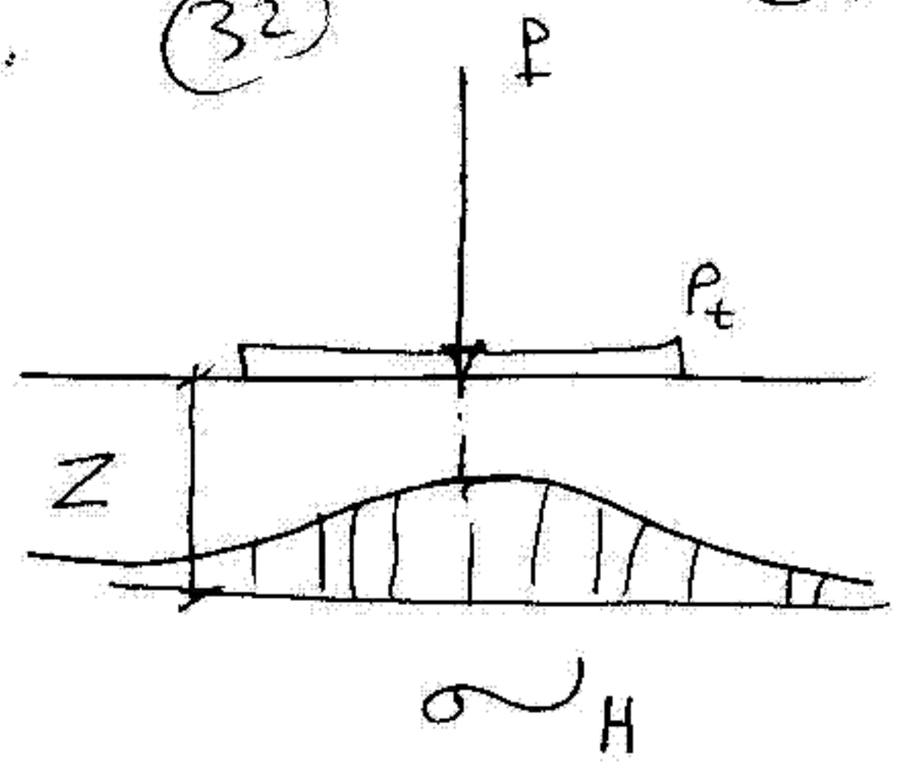
$d = 0.278(100)(2+8) = 278m$.

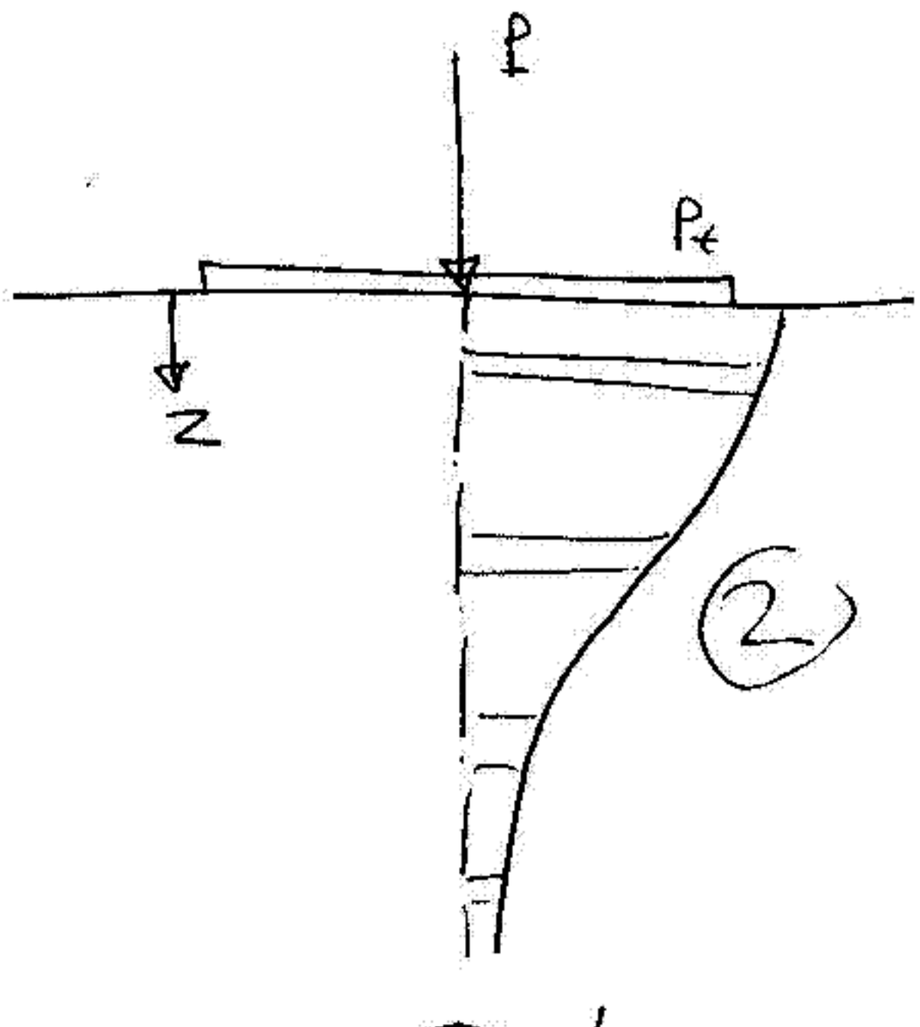
3

Q3. (32)

(7)

a)





b) $G_{agg} = \dfrac{100}{\frac{40}{2.74} + \frac{52}{2.77} + \frac{8}{2.86}} = 2.76$ (12)

$G_{asp} = 1.02$ assume $V_t = 1\ ft^3$

$\%V_a = 4\% = \dfrac{V_a}{V_t} \times 100$

$\therefore V_a = 0.04\ ft^3$ 3

$\therefore V_{asp} + V_{agg} = 0.96\ ft^3$ —— (1)

$\therefore \gamma_m = 151 = \dfrac{W_t}{V_t}$ $\therefore W_t = 151$ lbs

$W_{asp} + W_{agg} = 151$ lbs —— (2)

$\therefore V_{\ell^o} = \dfrac{W_{\ell^o}}{G_{s\ell^o} \times \gamma_w}$ 3

$V_{agg} = \dfrac{W_{agg}}{2.76 \times 62.4} = 0.0058\, W_{agg}$ in (1)

$$V_{asp} = \frac{W_{asp}}{1.02 \times 62.4} = 0.0157\, W_{asp} \quad \text{in (1)}$$

3

$$0.0157\, W_{asp} + 0.0058\, W_{agg} = 0.96$$

$$W_{asp} + W_{agg} = 151$$

$$W_{asp} = 151 - W_{agg}$$

$$0.0157\,(151 - W_{agg}) + 0.0058\, W_{agg} = 0.96$$

$$0.0099\, W_{agg} = 1.4107$$

$$W_{agg} = 142.5 \text{ lbs}$$

$$W_{asp} = 8.50 \text{ lbs}$$

$$W_t = 151 \text{ lbs}$$

3

$$\%AC = \frac{8.5}{142.5} \times 100 = \boxed{5.96\%} \text{ of agg.}$$

$$\%AC = \frac{8.5}{151} \times 100 = 5.63\% \text{ of total wt.}$$

c) $\sigma_{c^\circ} = 10\ Psc^\circ$

(9)

(8)

$\therefore \sigma_{c^\circ} = \left(\frac{m}{100}\right) \times P_t$

$10 = \left(\frac{m}{100}\right) \times 100 \quad \therefore \boxed{m = 10}$

$$a = \sqrt{\frac{30000}{\pi \times 100}} = 9.77''$$

from Fig 6.4 $\quad m = 10, \ \frac{r}{a} = 50.0$

$$\underline{Z_{eq}} \cong 3.7$$
a

$$Z_{eq} = 3.7 \times 9.77 = 36.15''^3$$

$$Z_{eq} = 4 \times \sqrt[3]{\frac{EI}{2000}} + 8 \times \sqrt[3]{\frac{2000}{2000}} = 36.15$$

$$\boxed{E_I = 211464\ Psc^\circ}$$

d) $P = 100{,}000$ lbs

$P_t = 150$ psi

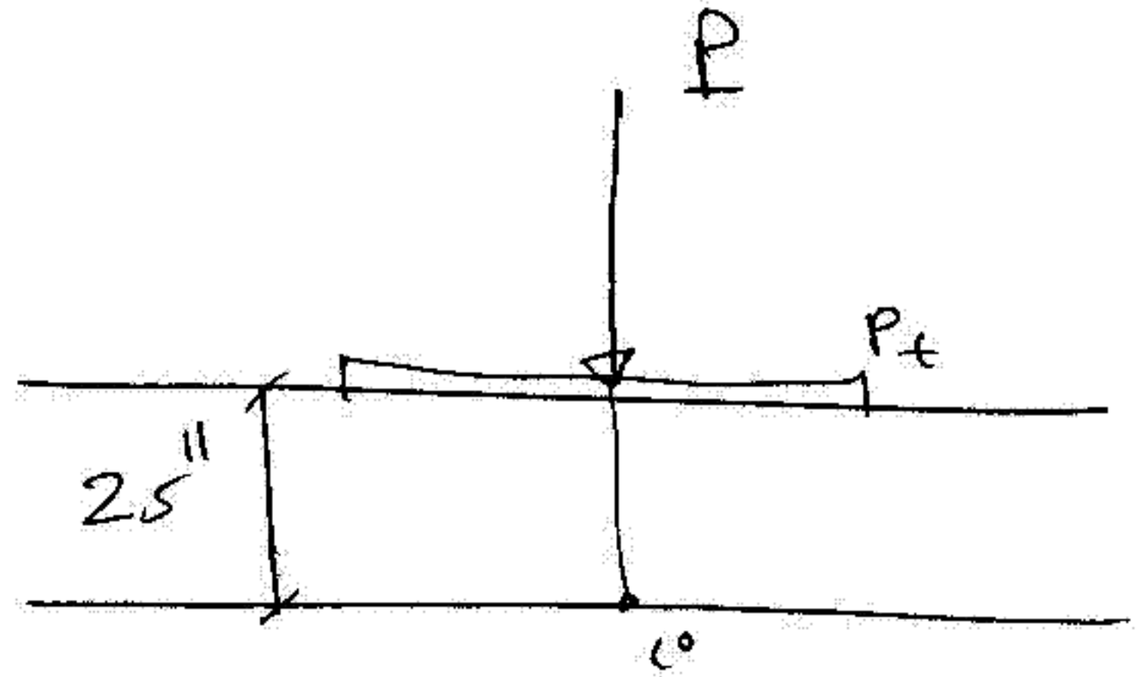
$\Delta = 0.1''$

$E_1 = 50{,}000$

$t = 25''$

(10)

(10)



$$\Delta = 1.18 * \alpha'' * \frac{P_t}{E_2} * P_2$$

$$\alpha'' = \sqrt[3]{\frac{100{,}000}{\pi * 150}} = 14.57''$$

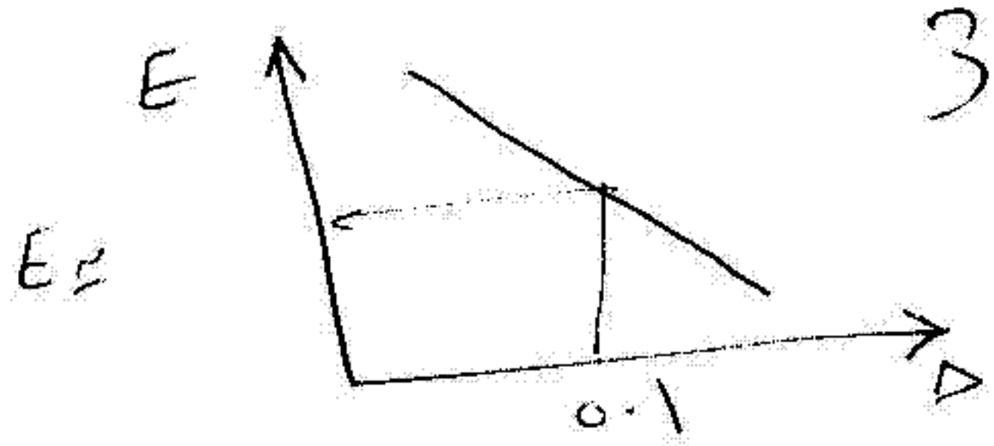
$$\frac{Z}{\alpha} = \frac{25}{14.57} = 1.72$$

E_1/E_2	$\frac{1}{100}$	$\frac{1}{200}$	$\frac{1}{500}$
E_2	5000	2500	1000
P_2	0.15	0.09	0.08
Δ	0.077	0.092	0.206

4

$E_2 \simeq (2200 \rightarrow 2300)$ psi

3



Q4. (18) (11)

a) $ESAL_{daily} = ADT * \sum_{c=1}^{4} (TF * LT)_c$

$= 5000 \left(0.04 * 3 + 0.03 * 7 + 0.29 * 5 + 0.07 * 2\right)$

$= 9600$

assume $DD = 0.7$

$LD = 1$ 2 lane or 4 lane.

$$Gr = \frac{(1.02)^{15} - 1}{0.02} = 17.29$$

$$ESAL_{design} = 9600 * 365 * 0.7 * 1 * 17.29$$

$$= 42.4 * 10^6.$$

b) $a_1 = 0.44$ $a_2 = 0.14$ $a_3 = 0.11$

$m_1 = 1$ $m_2 = 0.8$ $m_3 = 0.6$

$d_1 = t$ $d_2 = 2t$ $d_3 = 4t$

$SN_3 = 3.7$

$$3.7 = 0.44\,t + 0.14 * 0.8 * 2\,t + 0.11 * 0.6 * 4\,t$$

$t \simeq 3.99 = 4''$

$\therefore$ $d_1 = 4''$ $d_2 = 8''$ $d_3 = 16''$

c) $SN = 0.42 * 4 + 0.12 * 0.8 * 8 = 2.45$ (12)

$\Delta PSC^{\circ} = 4.5 - 1.5 = 3$

$R = 90\%$ $\quad S_0 = 0.4$

$M_{R_{subgrade}} = 5000$ psi 4

From fig.

$\Sigma ESAL = 0.05 \times 10^6$