CV3014 Semester 1 exam 2016-2017

1. (a) (i) jam density 200 veh/km , $v=0$

$$0 = C\ln\left(\frac{A}{200+B}\right)$$

$\because C \neq 0$

$$\therefore \ln\left(\frac{A}{200+B}\right) = 0$$

$$\frac{A}{200+B} = 1$$

$$A = 200+B \quad -①$$

when free flow speed is 80 km/h , $k=0$

$$80 = C\ln\left(\frac{A}{B}\right) \quad - ②$$

when $v=40$, $k=40$

$$40 = C\ln\left(\frac{A}{40+B}\right) \quad - ③$$

$\frac{②}{③}$

$$2 = \ln\left(\frac{A}{B}\right) / \ln\left(\frac{A}{40+B}\right)$$

$$2\ln\left(\frac{A}{40+B}\right) = \ln\left(\frac{A}{B}\right)$$

$$\left(\frac{A}{40+B}\right)^2 = \frac{A}{B}$$

$$200B + B^2 = (40+B)^2$$

$$200B + B^2 = 1600 + 80B + B^2$$

$$120B = 1600$$

$$B = 13.33$$

① $A = 200 + 13.33$

$$= 213.33$$

② $80 = C\ln\left(\frac{213.33}{13.33}\right)$

$$C = 28.85$$

$$\therefore V = 28.85\ln\left(\frac{213.33}{k+13.33}\right)$$

(ii) $Q = kV$

$$= k \times 28.85\ln\left(\frac{213.33}{k+13.33}\right) \quad - ①$$

$$\frac{dQ}{dk} = 28.85\ln\left(\frac{213.33}{k+13.33}\right) + 28.85k\left(\frac{k+13.33}{213.33}\right) \times 213.33(-1)\frac{1}{(k+13.33)^2}$$

$$0 = 28.85\ln\left(\frac{213.33}{k+13.33}\right) - \frac{28.85k}{k+13.33}$$

$$\frac{28.85k}{k+13.33} = 28.85\ln\left(\frac{213.33}{k+13.33}\right)$$

$$\frac{k}{k+13.33} = \ln\left(\frac{213.33}{k+13.33}\right)$$

$$\frac{213.33}{k+13.33} = e^{\frac{k}{k+13.33}}$$

$$k = 213.33e^{-\frac{k}{k+13.33}} - 13.33$$

solve the equation and get k

sub into ① to get Q

1. (b) Step 0: Preliminaries. Divide each origin-destination entry into N equal portions. (i.e. set $q_{rs}^{n} = q_{rs}/N$). Set $n=1$ and $x_a^0 = 0$, $\forall a$

Step 1: Update. Set $t_a^n = t_a(x_a^{n-1})$, $\forall a$

Step 2: Incremental loading. Perform all-or-nothing assignment based on $\{t_a^n\}$, but using only the trip rates q_{rs}^n for each O-D pair. This yields a flow patern $\{w_a^n\}$

Step 3: Flow summation. Set $x_a^n = x_a^{n-1} + w_a^n$, $\forall a$

Step 4: Stopping rule. If $n=N$, stop (the current set of link flows is the solution); otherwise, set $n=n+1$ and go to Step 1.

The results from incremental assignment method is only an approximation of the user equilibrium.

2. (a) $V_{Bus} = -1.0 - 0.2(20) - 0.1(25) - 0.1(10)$
$= -8.5$

$V_{car} = -1.0 - 0.2(5) - 0.1(15) - 0.1(50)$
$= -8.5$

$P_{Bus} = \frac{e^{-8.5}}{e^{-8.5}+e^{-8.5}}$
$= 50\%$

$P_{car} = 50\%$

$Q_{car} = 5000 \times 50\%$
$= 2500$ veh/h

$Q_{Bus} = 5000 \times 50\% / 50$
$= 50$ veh/h

$Q_T = 2500 + 50$
$= 2550$ veh/h

(b) $P_{car} = \frac{1000}{5000}$
$= 20\%$

$P_{Bus} = 80\%$

$\frac{e^{-8.5}}{e^{-8.5}+e^{V_{car}}} = 80\%$

$e^{-8.5} = 0.8e^{-8.5} + 0.8e^{V_{car}}$

$e^{V_{car}} = \frac{0.2e^{-8.5}}{0.8}$
$= 5.087 \times 10^{-5}$

$V_{car} = -9.886$

$-1.0 - 0.2(5) - 0.1(15) - 0.1(c) = -9.886$

$c = 64$

64 dollars should be charge

(c) $t = 10 + \frac{x}{25}$

$= 10 + \frac{5000 P_c}{25}$

$= 10 + 200 P_c$

$V_{Bus} = -1.0 - 0.2(20) - 0.1(20) - 0.1(15)$

$= -8.5$

$V_{car} = -1.0 - 0.2(5) - 0.1(10 + 200P_c) - 0.1(50)$

$= -8 - 20P_c$

$= -28 + 20P_B$

$P_B = \frac{e^{-8.5}}{e^{-8.5} + e^{-28+20P_B}}$

$P_B [e^{-8.5} + e^{(-28+20P_B)}] = e^{-8.5}$

By try and error

get $P_B = 0.8768$

$Q_B = 5000 \times 0.8768$

$= 4384$

Revenue $= Q_B \times c$

$= 4384 \times \$15$

$= \$65760$

} not required

3. (a) $x_2 = 1$

$t_2 = 12 + 2 \times 1$

$= 14$

$t_2 = t_3$

$14 = 10 + x_3$

$x_3 = 4$

$x_4 = x_2 + x_3$

$= 5$

$t_4 = 8 + 5$

$= 13$

$t_1 = t_2 + t_4$

$= 14 + 13$

$= 27$

$x_1 = (27 - 24)/2$

$= 1.5$

$D = x_1 + x_4$

$= 1.5 + 5$

$= 6.5$

3 (b) $x_1 + x_4 = D$ — ①

$x_2 + x_3 = x_4$ — ②

$t_2 = t_3$

$12 + 2x_2 = 10 + x_3$

$x_3 = 2 + 2x_2$ — ③

② $x_2 + 2 + 2x_2 = x_4$

$x_4 = 2 + 3x_2$ — ④

$t_1 = t_4 + t_2$

$24 + 2x_1 = 8 + x_4 + 12 + 2x_2$

$24 + 2x_1 = 20 + 2 + 3x_2 + 2x_2$

$2 + 2x_1 = 5x_2$

$x_1 = 2.5x_2 - 1$ — ⑤

① $x_1 + x_4 = D$ sub ⑤, ④

$2.5x_2 - 1 + 2 + 3x_2 = D$

$5.5x_2 + 1 = D$

$x_2 = \frac{D-1}{5.5}$

$$\begin{cases} t_1 = 24 + 2x_1 \\ t_2 = 12 + 2x_2 \\ t_3 = 10 + x_3 \\ t_4 = 8 + x_4 \end{cases}$$

$$\begin{cases} t_1 = 22 + 5x_2 \\ t_2 = 12 + 2x_2 \\ t_3 = 12 + 2x_2 \\ t_4 = 10 + 3x_2 \end{cases}$$

$$\begin{cases} t_1 = 22 + 5\left(\frac{D-1}{5.5}\right) \\ t_2 = t_3 = 12 + 2\left(\frac{D-1}{5.5}\right) \\ t_4 = 10 + 3\left(\frac{D-1}{5.5}\right) \end{cases}$$

$$\begin{cases} t_1 = \frac{10}{11}D + \frac{232}{11} \\ t_2 = t_3 = \frac{4}{11}D + \frac{128}{11} \\ t_4 = \frac{6}{11}D + \frac{104}{11} \end{cases}$$

(c) Link 1 is the last link to be used

$\therefore t_1 = 24$

$t_2 + t_4 = 24$

$12 + 2x_2 + 8 + x_4 = 24$

$x_4 = 4 - 2x_2$ — ①

$t_2 = t_3$

$12 + 2x_2 = 10 + x_3$

$2 + 2x_2 = x_3$ — ②

$x_4 = 1 + x_2 + x_3$

$4 - 2x_2 = 1 + x_2 + 2 + 2x_2$

$x_2 = 0.2$

$x_3 = 2 + 2 \times 0.2$

$= 2.4$

$x_4 = 1 + 0.2 + 2.4$

$= 3.6$

minimum $D = 3.6$

4. for sag curve

$g = 7\%$

$d_r = V \times t_r$

$= 80/3.6 \times 2.5$

$= 55.55\ m$

$d_b = \frac{v^2}{2 \times 9.81(0.3-0.07)}$

$= 109.43\ m$

$SSD = 55.55 + 109.43$

$= 164.98\ m$

for crest curve

$g = 8\%$

$d_b = \frac{v^2}{2 \times 9.81(0.3-0.08)}$

$= 114.41\ m$

$SSD = 169.96\ m$

for sag curve

$L_{min,} = \frac{As^2}{200[0.6 + S(\tan 1°)]}$

$= \frac{7 \times 164.98^2}{120 + 3.5 \times 164.98}$

$= 273.19\ m$

for crest curve

$L_{min_2} = \frac{As^2}{200(\sqrt{1.05} + \sqrt{0.15})^2}$

$= \frac{8 \times 169.96^2}{200(\sqrt{1.05} + \sqrt{0.15})^2}$

$= 579.55\ m$

$L_{min,}/2 + L_{min_2}/2 = \frac{273.19}{2} + \frac{579.55}{2}$

$= 426.37\ m < 250\ m$

∴ the pair of sag and crest curves not be fully developed.

(b) - reduce the design speed

- reduce the tangent grades with slope.

5 (a) $e + f = \frac{v^2}{gR}$

e : superelevation

f : sideway force coeff

R = maximum curve radius

V = design speed

When the design speed increased the minimum curve radius will increase. this means the curve radius may be not enough for safety purpose. To remedial measures, can increase the radius.

5 (b)

Station	Cut, m^3	Fill, m^3
100+10		
	$\frac{25+16}{2}(30) = 615$	$\frac{(5.2)(30)}{3} = 52$
100+40		
	$\frac{16(30)}{3} = 160$	$\frac{5.2+8.3}{2}(30) = 202.5$
100+70		
		$\frac{8.3+27}{2}(30) = 529.5$
101+00		
		$\frac{27+1.2}{2}(50) = 705$
101+50		
Total	775 m^3	1489 m^3

Deficit in fill $= 1489 - 775 \times 0.95$
$= 752.75\ m^3$

6(a) $f_g = \frac{(1+g)^n - 1}{g}$
$= \frac{(1.02)^{20} - 1}{0.02}$
$= 24.3$

ESAL in the first year $= 1.75 \times 1800 / 2 \times 0.3 \times 0.8$ (two way)
$= 375$ ESAL / day
$= 137970$ ESAL / year

ESAL after 20 year $= 137970 \times 24.3$
$= 3350000$

∴ proved

(b) (i) $SN_1 = 0.45 \times 76$
$= 34.2$
$SN_2 = 34.2 + 0.25 \times 1.2 \times 101$
$= 64.5$
$SN_3 = 64.5 + 0.2 \times 1.1 \times 126$
$= 92.22$

$D_1 = \frac{SN_1}{a_1}$
$= \frac{34.2}{0.45}$
$= 76mm$
Round to 80mm

$SN_1^* = a_1 D_1^*$
$= 0.45 \times 80$
$= 36$

$D_2 = \frac{SN_3 - SN_1^*}{a_2 m_2} = \frac{92.22 - 36}{0.2 \times 1.1} = 255.5mm$
Round to 260mm

∴ The thickness for two layer is 80mm and 260mm

(b) (ii) - average rating of pvt by panel, from 0 (poor condition) to 5 (excellent)
- rating correlated to measured physical conditions of pvt
- initial serviceability → condition of pavement immediately after construction
- terminal serviceability → lowest quality (after + years) tolerated before reconstruction /resurfacing warranted
- p_t for design : 2.0-2.5

(c) (i) Normal reaction for half slab per metre width of slab given by

$F_w = 0.2m \times 12m/2 \times 2400 \times 9.8 \times 5$

$= 141.12$ kN

Friction force

$F_r = 141.12 \times 1.4$

$= 197.56$ kN

$F_s = V_s f_s$

$197.56 = V_s \times 300MPa$

$V_s = 658.56\ mm^3$

(ii) - Small bars /mesh more effective than larger bars.
- elongation properties main criterion (instead of strength)

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