4 PYP 2019/2020

$V_{car} = -0.8t$

$V_{bus} = -0.8t - 1.5$

$t = 9 + q/500$

N = 4000 passengers/hr

a)

$P_{car} = \frac{e^{-0.8t}}{e^{-0.8t} + e^{-0.8t-1.5}}$

$= \frac{e^{-0.8t}}{e^{-0.8t}(1+e^{-1.5})}$

$= \frac{1}{1+e^{-1.5}} = 0.818$

$P_{bus} = \frac{e^{-0.8t-1.5}}{e^{-0.8t} + e^{-0.8t-1.5}}$

$= \frac{e^{-0.8t-1.5}}{e^{-0.8t-1.5}(e^{1.5}+1)}$

$= \frac{1}{e^{1.5}+1} = 0.182$

Travel demand for bus service

$= P_{bus} \times 4000$

$= 729.7 \approx 730$

Travel demand for car

$= 4000 - 730$

$= 3270$

$q = 3270 + 100 = 3370$

$t = 9 + 3370/500 = 15.74$ min

b) $t = 9 + q_c/300$

$q_c = 4000 \times P_c \Rightarrow P_c = \frac{q_c}{4000}$

For bus, travel time, t = 15

$V_{bus} = -0.8(15) - 1.5 = -13.5$

$V_{car} = -0.8t$

$P_c = \frac{e^{-0.8t}}{e^{-0.8t} + e^{-13.5}}$

$\frac{q_c}{4000} = \frac{e^{-0.8t}}{e^{-0.8t}(1 + e^{-13.5+0.8t})}$

$\frac{q_c}{4000} = \frac{1}{1+e^{-13.5+0.8t}}$

$\frac{4000}{q_c} = 1 + e^{-13.5+0.8(9+\frac{q_c}{300})}$

$\frac{4000}{q_c} = 1 + e^{-13.5+7.2+\frac{q_c}{375}}$

$\frac{4000}{q_c} = 1 + e^{-6.3+\frac{q_c}{375}}$

$\frac{4000}{q_c} = 1 + 0.00184\,(e^{\frac{q_c}{375}})$

$4000 = q_c + 0.00814\,q_c\,e^{\frac{q_c}{375}}$

$q_c = 4000 - 0.00814\,q_c\,e^{\frac{q_c}{375}}$

$x_1 + x_2 + x_3 = D_{AC}$

$x_2 = t_{AC}$

$x_4 = x_1 + x_2 + x_3 + 5$

$x_4 = \ln x_2 + 5$

~~$x_4 = x_4 - D_{AC} + 5$~~

~~D_{AC}~~

$x_4 = 25 - 0.25t_{AC} + 5$

4) $x_4 = 7$, $x_2 = 1$

a) A to C, B to C

At equilibrium,

$t_1 = t_2 = t_3$

$16 + 2x_1 = 12 + 2x_2 + 10 + x_3$

$16 + 2x_1 = 12 + 2x_2$

$16 + 2x_1 = 12 + 2(1)$

$2x_1 = -2$

$x_1 = -1$

let line 1 to be unused, $x_1 = 0$

$12 + 2x_2 = 10 + x_3$

$12 + 2(1) = 10 + x_3$

$x_3 = 4$

$t_2 = t_3$

$12 + 2x_2 = 10 + x_3$

$12 + 2(1) = 10 + x_3$

$x_3 = 4$

$D_{BC} + 4 + 1 = 7$

$D_{BC} = 2$

$D_{AC} = 5$

Demand from node A to node C

= Demand from node A to node B

$= x_2 + x_3 = 1 + 4 = 5$

As line 4 contains both demand of node A to C & node B to C,

Demand from node B to C $= 7 - 5 = 2$

b) $D_{AC} = 25 - 0.2t_{AC}$

Travel demand from B to C = 5

$x_4 = 5 + D_{AC} = 5 + 25 - 0.2t_{AC}$

$= 30 - 0.2t_{AC}$

$t_{AC} = t_1 + t_4 = t_2 + t_4 = t_3 + t_4$

① express ~~x_4~~ & x_2 in terms of t_{AC}

② express x_1 & x_3 in terms of x_2

③ $x_1 + x_2 + x_3 = D_{AC}$

$16 + 2x_1 + 8 + x_4 = t_{AC}$

$16 + 2x_1 + 8 + 30 - 0.2t_{AC} = t_{AC}$

$54 + 2x_1 = 1.2t_{AC}$

$x_1 = 0.6t_{AC} - 27$

$12 + 2x_2 + 8 + 30 - 0.2t_{AC} = t_{AC}$

$50 + 2x_2 - 0.2t_{AC} = t_{AC}$

$x_2 = 0.6t_{AC} - 25$

$10 + x_3 + 8 + 30 - 0.2t_{AC} = t_{AC}$

$48 + x_3 = 1.2t_{AC}$

$x_3 = 1.2t_{AC} - 48$

$t_1 = t_2$

$16 + 2x_1 = 12 + 2x_2$

$8 + x_1 = 6 + x_2$

$x_1 = x_2 - 2$

$t_3 = t_2$

$10 + x_3 = 12 + 2x_2$

$x_3 = 2x_2 + 2$

~~$0.6t_{AC} - 27 = x_1$~~

~~$0.6t_{AC} - 27 = x_2 - 2$~~

~~$0.6t_{AC} = x_2 + 25$~~

~~$2x_2 + 2 = 1.2t_{AC} - 48$~~

~~$2x_2 + 50 = 1.2t_{AC}$~~

$x_1 + x_2 + x_3 = D_{AC}$

$x_2 - 2 + x_2 + 2x_2 + 2 = 25 - 0.2t_{AC}$

$4x_2 = 25 - 0.2t_{AC}$

$2.4t_{AC} - 100 = 25 - 0.2t_{AC}$

$2.6t_{AC} = 125$

$t_{AC} = 48.1$

$x_2 = 3.85$

$x_3 = 9.70$

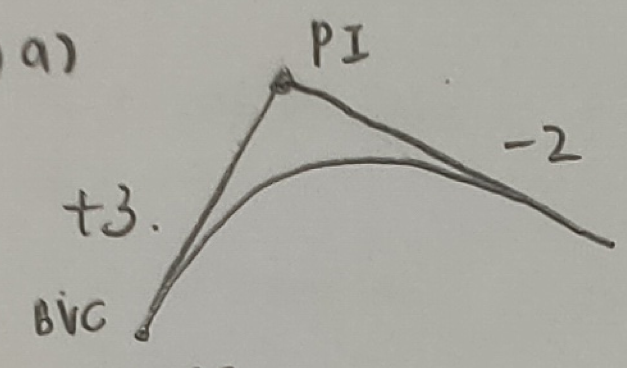
$x_1 = 1.85$

$D_{AC} = x_1 + x_2 + x_3 = 15.4$

$x_4 = 5 + D_{AC} = 20.4$

2019/20

1) a)



For highest pt,

$y' = 0$

$y = y_0 + g_1 x + \frac{1}{2} r x^2$

$y' = g_1 + rx = 0$

$x = \frac{-g_1}{g_2 - g_1} L$

$x = \frac{-3}{-2-+3}(400)$

$= 240\,m$

∴ highest pt located at 152+60 station //

b) $R = \frac{V^2}{127(f+e)}$

$= \frac{80^2}{127(0.14+0.08)}$

$= 229.06\,m$

2) a) $PHF = \frac{V}{q} = \frac{V}{N_t(60/t)}$

$= \frac{3950}{1200(60/15)}$

$= 0.823$ //

b) $v = 40 \ln\left(\frac{200}{k}\right)$

at $k = k_j$, $v = 0$

$0 = 40 \ln\left(\frac{200}{k_j}\right)$

$\frac{200}{k_j} = 1$

$k_j = 200$ veh / km

at capacity, $q' = 0$

$q = vk$

$q = 40 \ln\left(\frac{200}{k}\right) k$

$q' = 40 \ln\left(\frac{200}{k}\right) + 40k\left(\frac{k}{200}\right)\left(-\frac{200}{k^2}\right) = 0$

$40 \ln\left(\frac{200}{k}\right) = 40$

$\ln\left(\frac{200}{k}\right) = 1$

$\frac{200}{k} = e$

$k_o = \frac{200}{e}$

At $k = k_o = \frac{200}{e}$

$v_o = 40 \ln\left(\frac{200}{\frac{200}{e}}\right) = 40$

$q' = ~~vk~~ = 0$

$q' = v.k' + v'.k$

$= 40 \ln\left(\frac{200}{k}\right) + 40\left(\frac{k}{200}\right)\left(-\frac{200}{k^2}\right)k = 0$

$\ln \frac{200}{k} = 1$

$k = \frac{200}{e}$

$V = 40.$

$q_{max} = v_o k_o$

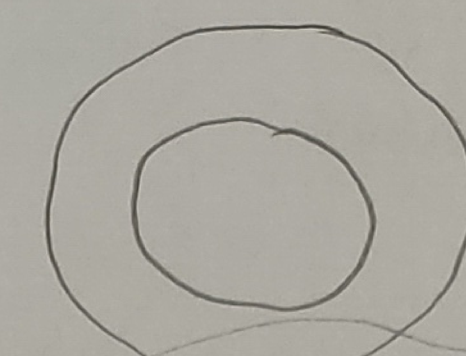
$= 40 \times \frac{200}{e}.$

b) $q_{max} = v_o k_o$

$= 40\left(\frac{200}{e}\right)$

$= 2943$ veh/h.

c)



10 km.

$v_1 = 60$ km/h

$v_2 = 70$ km/h

$v_3 = 100$ km/h.

t (time to complete track). # (no. of times the car finish the track in T)

$t_1 = 10/60 = 1/6$ $\#_1 = T/\frac{1}{6} = 6T$

$t_2 = 10/70 = 1/7$ $\#_2 = T/\frac{1}{7} = 7T$

$t_3 = 10/100 = 0.1$ $\#_3 = T/\frac{1}{10} = 10T$

$t_4 = 10/80 = 1/8$ $\#_4 = T/\frac{1}{8} = 8T$

$SMS = \frac{\Sigma L}{\Sigma \frac{t}{n}} = \frac{\Sigma L}{\Sigma t}$

$= \frac{(8T + 6T + 7T + 10T)(10)}{8T \times \frac{1}{8} + 6T \times \frac{1}{6} + 7T \times \frac{1}{7} + 10T \times 0.1}$

$= \frac{T(310)}{4T}$

$= 77.5$ km/h //

$PHF = \frac{V}{q} = \frac{V}{N_t(60/t)}$

$\frac{3950}{1200(60/15)}$

5) a) $A = \frac{W}{4}(h_l + h_r) + \frac{C}{2}(d_l + d_r)$

Station	Calculation	Area
101 + 60	$\frac{1}{2} \cdot \frac{12}{2}(1.1)$	= 3.3 m² cut
	$\frac{1}{2} \cdot \frac{14}{2}(1.0)$	= 3.5 m² fill
101 + 75	$\frac{14}{4}(0.0 + 2.0) + \frac{0.5}{2}(7 + 11)$	= 11.5 m³ fill
101 + 92	$\frac{1}{2} \cdot \frac{12}{2}(0.5)$	= 1.5 m² cut
	$\frac{1}{2} \cdot \frac{14}{2} \cdot (1.5)$	= 5.25 m² fill
102 + 10	$\frac{12}{4}(1.5 + 0.0) + \frac{1.1}{2}(9.0 + 6.0)$	= 12.75 m² cut

Station	Cut	Cut volume	Fill	Fill volume
101 + 60	3.3		3.5	
		$\frac{3.3}{3}(15)$ = 16.5 m³		$\frac{3.5 + 11.5}{2}(15)$ = 112.5 m³
101 + 75	0		11.5	
		$\frac{1.5}{3}(17)$ = 8.5 m³		$\frac{11.5 + 5.25}{2}(17)$ = 142.375 m³
101 + 92	1.5		5.25	
		$\frac{1.5 + 12.75}{2}(18)$ = 128.25 m³		$\frac{5.25}{3}(18)$ = 31.5 m³
102 + 10	12.75		0	
		153.25 m³		286.378 m³

b) Net amount of borrow = 286.375 − (1 − 0.08)(153.25)

= 145.385 m³ borrow.

☆ marks 6/.7

6) a) i)

$D_1 = \frac{SN_1}{a_1}$

$D_1 = \frac{2.5}{0.41}(25.4)$

$D_1 = 6.1(25.4)$

$D_1 = 154.87$ mm

$D_1^* = 160$ mm

$a_1 D_1^* = 0.41(160) = 65.6$

$D_2 = \frac{SN_2 - a_1 D_1^*}{a_2 m_2}$

$= \frac{3.0(25.4) - 65.6}{1.3(0.19)}$

$= 42.91$

$D_2^* = 50$ mm

relatively to adjacent roadway, property "subside"

$, time, layer (put up)

cost → 160mm of A/C on 50mm sandstone
→ expensive
→ can do something to sandstone layer

0.19 → 0.28 (for sandstone → reduce SN) → thinner A/C

★ ii). comment?

thickness of asphalt concrete ⇒ very thick, incur high cost (due to absence of base?)

1.3 → excellent drainage

2 layers ⇒ build very fast

50mm (no very thick) → 5 cm
⇒ too thin (troublesome)
↳ can be forget abt the thin layer

b) JRCP is a type of rigid pavement slab with stresses experienced to be in the form of tensile, flexural and compressive. The main sources of these stresses are wheel loads, changes in temperature and moisture content.

Curling stress can be induced from temperature differences & moisture differences. Curling stress from temperature differences is caused by the difference in temperature between the top & bottom of slab. During daytime, the top of the slab is at higher temp. and the slab has a tendency to hog. In contrast, during nighttime, the top slab is at a low temp and the slab has a tendency to dish. The weight of slab & load transfer devices / friction at joint impose restraint against curling, giving rise to curling stress. For example, on a hot day, restraint on curling result in tensile stress at the bottom and compressive stress on top. Curling stress from moisture differences is also caused by restraints at joints & weight of slab. It works in opposite direction with temp and mainly ignored in calc as conservation approach.

Wheel load stress is dependent upon position of application and can be at edge, corner or interior. The corner loading is the most critical for deflection and the magnitude of the stress depends on the stiffness of supporting layer and flexural stiffness of slab.

Temperature - friction stress is the friction between slab & layer below. It is compressive when slab expand & tensile stress when slab contracts.

Moisture - friction stresses works in opposite direction with temperature.

Frictional → long (>30)

Curling → short (10-15)

c) Merits of applying PCC rigid pavement in tropical countries compared with flexible pvt is that concrete pvt can readily span over poorly consolidated soils. This is because in the tropics, soil forming processes are very active & the surface rocks are deeply weathered, and wide areas covered with residual soil undergoing physical & chemical alteration. Hence tropics have harsh soil condition and rigid pvt can be more easily used / applied compared to flexible pvt.

Also, in the tropics, little variation in diurnal & annual temp, so provisions to acc for thermal strains in concrete slabs is not of paramount importance.

Also PCC rigid pavements do not suffer deterioration from weathering where its stiffness is not materially affected by temp changes. Hence, the pvt design methods evolved from experienced in temperate regions can be readily applied also in tropical climate, without having to make substantial modification to standard method as in the case of flexible pvt.

Also, a well designed & properly constructed concrete road has the potential of very high structural life and are better than flexible pavement to cope w/ overloading.

PCC rigid pvt also require lesser maintenance requirement and this is good as many tropical countries still in development stage where technical org for effective & sustained road maintenance are weak.