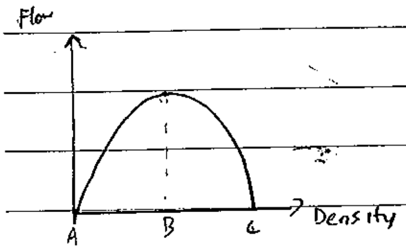
CV3014

Relationship between traffic flow and traffic density can be describe by parabolic equation / Convex flow density curve (Figure below)



When - density is zero, there will be zero flow

- at max density, there will be zero flow
- there'll be maximum flow for a certain density

- In Green shield's model, It is assume a linear relationship between V and K

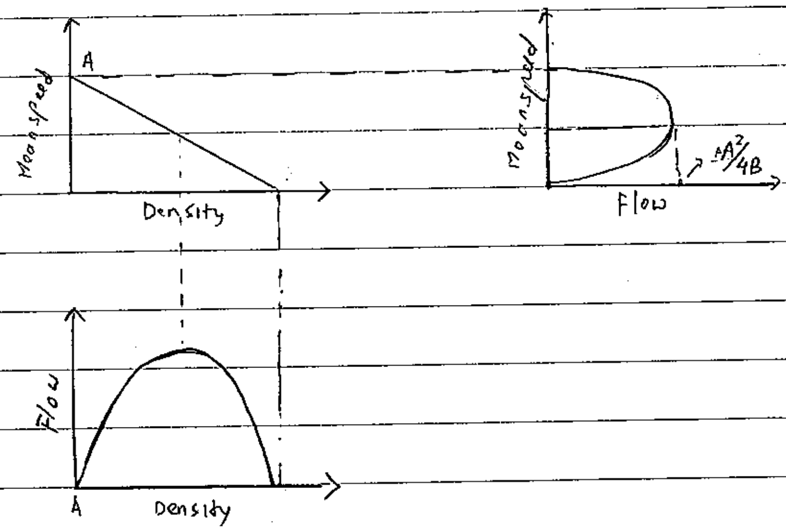
$$V = A - Bk$$

using Fundamental flow relationship

$$q = kv = Ak - Bk^2$$

$$q = \frac{A}{B} v - \frac{v^2}{B}$$

which can be plotted as below



b) - An initial value of c is assumed and

$$Q_{ij} = P_i \left[\frac{A_j / W_{ij}^{c}}{\sum_x (A_x / W_{ix}^{c})} \right]$$ is applied using

the know base-year productions, attractions and the impedances to compute interzonal volume Q_{ij}

- The computed Q_{ij} are then compared with the observed values
- An adjustment is made to c until the computed and observed values are close to each other

c) PHF is defined as the ratio of peak-hour volume to the maximum rate of flow computed on the basis of an interval t within the peak hour

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

Upper bound of PHF is no greater than 1
while for lower bound of PHF is depends on the t-interval used

In general PHF is between 0 and 1

$V_{rail} = -0.1(T_R + P_R)$

$V_{car} = -0.1(T_c + P_c)$

a) $P_R = 3$

$P_c = 10$

$N = 20.000$

$T_c = 30 + 2 10^{-6} Q_{car}$

$$\frac{e^{V_{car}}}{e^{V_{rail}} + e^{V_{car}}} \times N = Q_{car}$$

$$\frac{e^{-0.1(30 + 2 10^{-6} Q_{car} + 10)}}{e^{-0.1(45+3)} + e^{-0.1(30 + 2 10^{-6} Q_{car} + 10)}} \times 20000 = Q_{car}$$

$$\frac{e^{-4 - 2 10^{-7} Q_{car}^2}}{e^{-4.8} + e^{-4 - 2 10^{-7} Q^2_{car}}} \times 20.000 = Q_{car}$$

solving above equation will get $Q_{car} = 3443$

$Q_{rail} = 16557$

b) $$\frac{e^{V_{car}}}{e^{V_{rail}} + e^{V_{car}}} \times 20.000 = Q_{car}$$

$$\frac{e^{-0.1[30 + 2 10^{-6}(2500^2) + P_c]}}{e^{-4.8} + e^{-0.1[30 + 2 10^{-6}(2500^2) + P_c]}} \times 20.000 = 2500$$

$$\frac{e^{-4.25 - 0.1 P_c}}{e^{-4.8} + e^{-4.25 - 0.1 P_c}} = \frac{1}{8}$$

$$8 e^{-4.25 - 0.1 P_c} = e^{-4.8} + e^{-4.25 - 0.1 P_c}$$

$$\ln(7 e^{-4.25 - 0.1 P_c}) = \ln(e^{-4.8})$$

$$\ln 7 - 4.25 - 0.1 P_c = -4.8$$

$$\ln 7 + 0.55 = 0.1 P_c$$

$$P_c = 10 \ln 7 + 5.5$$

3 a) link 1 → $t_1 = 10x_1$

$t_2 = 50 + x_2$

$t_3 = 50 + x_3$

$t_4 = 10x_4$

$x_1 = x_3$

$x_2 = x_4$

$x_3 + x_4 = 6$

$t_1 + t_3 = t_2 + t_4$

$10x_1 + \cancel{50} + x_3 = \cancel{50} + x_2 + 10x_4$

$11x_3 = 11x_4$

$x_3 = x_4$

$x_3 + x_4 = 6$

$2x_4 = 6$

$x_4 = 3$

$x_3 = 3$

$x_1 = 3$

$x_2 = 3$

Traffic flow = x_1 = 3000 Vehicles x_3 = 3000 Vehicles
x_2 = 3000 Vehicles x_4 : 3000 Vehicles

3b link 5 $= 10 + X_5$ $\quad X_1 = X_3 + X_5$

$X_4 = X_2 + X_5$

$t_1 + t_3 = t_1 + t_5 + t_4 = t_2 + t_4$

$10X_1 + 50 + X_3 = 10X_1 + 10 + X_5 + 10X_4 = 50 + X_2 + 10X_4$

$10X_1 + 50 + X_3 = 10X_1 + 10 + X_5 + 10X_4$

$10(X_3 + X_5) + 50 + X_3 = 10(X_3 + X_5) + 10 + X_5 + 10X_4$

$\cancel{10X_3} + \cancel{10X_5} + 50 + X_3 = \cancel{10X_3} + \cancel{10X_5} + 10 + X_5 + 10X_4$

$40 + X_3 = 11X_5 + 10X_4$

$X_3 + X_4 = 6$

$X_1 - X_5 + X_2 + X_5 = 6$

$X_1 + X_2 = 6$

Subtitute it

$40 + X_3 = 11X_5 + 10(6 - X_1)$

$40 + X_3 = 11X_5 + 60 - 10(X_3 + X_5)$

$-20 + X_3 = 11X_5 - 10X_3 - 10X_5$

$-20 + 11X_3 = X_5 \quad \ldots (1)$

$10X_1 + 50 + X_3 = 50 + X_2 + 10X_4$

$10X_3 + \cancel{10X_5} + \cancel{50} + X_3 = \cancel{50} + X_2 + 10X_2 + \cancel{10X_5}$

$11X_3 = 11X_2$

$X_3 = X_2$

Subtitute it to $\rightarrow X_1 + X_2 = 6$

$X_1 + X_3 = 6$

$X_1 = 6 - X_3 \rightarrow 6 - X_3 = X_3 + X_5$

$6 = 2X_3 + X_5 \quad (2)$

elimination (1) & (2)

$0 = 2X_3 + X_5 - 6$

$0 = 11X_3 - X_5 - 20$

we get $\rightarrow X_3 = 2$, $X_1 = 4$, $X_4 = 4$

$X_2 = 2$, $X_5 = 2$

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total System travel time = $(t_1 + t_2) =$

$= 10(4) + 50 + (2)$

$= 92$ min for each unit

Total System travel time for old system: $t_1 + t_2$

$10(3) + 50 + 3$

83 min

$92 > 83 \Rightarrow$ not cost effective

c) $t_1 : \frac{x_1}{c_1}$

$x_1 = x_3 \quad x_3 + x_4 = 6$

$x_2 = x_4 \quad x_1 + x_2 = 6$

$t_1 + t_3 = t_2 + t_4$

$\frac{x_1}{c} + 50 + x_3 = 50 + x_2 + 10x_4$

$\frac{x_1}{c} + x_3 = 11 x_2$

$\frac{x_1}{c} + x_1 = 11(6 - x_1)$

$\frac{x_1}{c} + x_1 = 66 - 11x_1$

$\frac{x_1}{c} + 12x_1 = 66$

$x_1 = \frac{66}{(\frac{1}{c} + 12)}$

Saving : old system travel time − new system travel time

$= 83 - \left(\frac{x_1}{c} + 50 + x_3\right)$

$= 83 - \left(\frac{66}{1+12c} + 50 + \frac{66}{\frac{1}{c}+12}\right)$

$= 83 - \left(\frac{66}{1+12c} + 50 + \frac{66c}{1+12c}\right)$

$= 83 - \frac{66 + 50(1+12c) + 66c}{1+12c}$

$= 83 - \frac{116 + 666}{1+12c}$

$= \frac{83 + 996c - 116 - 666c}{1+12c}$

$= \frac{-33 + 330c}{1+12c}$

Profit = Saving - cost =

$$P = \frac{-33+330c}{1+12c} - \frac{30.000}{6000}(c-0.1)$$ → \$30.000 is for 6000 Vehicles Demand

$$P = \frac{-33+330c}{1+12c} - 5c + 0.5$$

$$\frac{dP}{dc} = \frac{dp}{dc} = 0 = \frac{330(1+12c) - (-33+330c)(12)}{(1+12c)^2} - 5$$

$$0 = 330 + 3960c + 396 - 3960c - 5(1+12c)^2$$

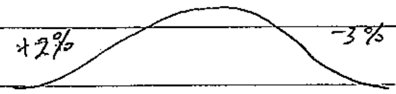
$$0 = 726 - 5(1+24c+144c^2)$$

$$0 = 726 - 5 - 120c - 720c^2$$

$$0 = 721 - 120c - 720c^2$$

$c = 0.9208$ units

4a)



$L = 350m$

$V_{design} = 80\ km/h \rightarrow 22.22\ m/s$

For SSD

Length of SSD required $= S = V_{design} \times t_r + \frac{V_{design}^2}{2g(f \pm G)}$ → two way highway, G → use critical value

$S = 22.22(2.5) + \frac{(22.22)^2}{2(9.81)(0.3-0.03)}$

$S = 55.55 + 93.2$

$S = 148.752$

L_{min} for $S \leq L \rightarrow \frac{AS^2}{200(\sqrt{h_1}+\sqrt{h_2})^2}$; $A = (g_2 - g_1) = 5\%$

For PSD

$= \frac{5(148.752)^2}{200(\sqrt{1.05}+\sqrt{0.15})^2}$

$= 277.45\ m$

$L_{min} < L_{provided}$ → okay

For PSD

$S = 540m$

L_{min} for $S \leq L \rightarrow \frac{AS^2}{200(\sqrt{h_1}+\sqrt{h_2})^2}$

$= \frac{5(540)^2}{200(\sqrt{1.05}+\sqrt{1.3})^2}$

$= 1555.48$

for $S \geq L = 2S - \frac{200(\sqrt{h_1}+\sqrt{h_2})^2}{A}$

$= 2(540) - \frac{200(\sqrt{1.05}+\sqrt{1.3})^2}{5}$

$= 892.53m$

$L_{min} > L_{provided}$ → not okay

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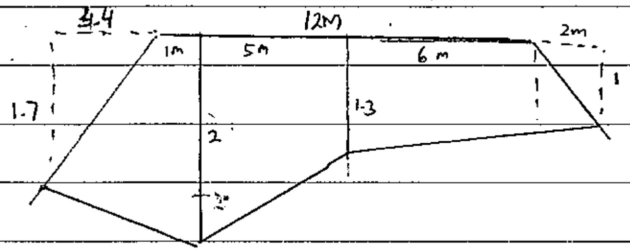
- Radius
  ↳ will determine whether the curve is allowable → avoid sharp changes
- Will affect stop passing distance

- Set back distance
  - will affect whether stop passing distance is satisfied

- SSD that available at the road
  ↳ whether it meet requirement or not
  - affect safety of driver

- Design speed that allowable in the road
  → - will affect sight distance required
  - safety upon entering the curve

5 a)



Vol fill: $\frac{1.7+2}{2}(4.4) + \frac{2+1.3}{2}(5) + \frac{1.3+1}{2}(8) - \frac{1}{2}(3.4)(1.7) - \frac{1}{2}(2)(1)$

$= 8.14 + 8.25 + 9.2 - 2.89 - 1$

$= 21.7 m^2$

5b)

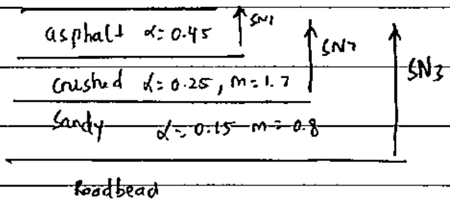
V_{cut}	V_{fill}
$\frac{18.1+9.75}{2}(150) = 2088.75$	—
$\frac{9.75+2.2}{2}(20) = 119.5$	—
$\frac{2.2+0.8}{2}(30) = 45$	$\frac{0+8.14}{3}(30) = 81.4$
$\frac{0.8+0}{3}(50) = 13.33$	$\frac{8.14+22.45}{2}(50) = 764.75$
$V_{cut} = 2266.58 m^3$	$V_{fill} = 846.15 m^3$

excess cut $= 2266.58(1-0.05) - 846.15$

$= 1307.101 m^3$

6 a) $30 = \frac{SN_1}{a_1} \times 25.4$

$SN_1 = 0.5315$



ii) $D_2 = \frac{SN_2(25.4) - a_1 D_1}{a_2 m_2}$

$110 = \frac{SN_2(25.4) - 0.45(30)}{0.25(1.2)}$

$SN_2 = 1.831$

$D_3 = \frac{SN_3(25.4) - a_1 D_1 - a_2 m_2 D_2}{a_3 m_3}$

$180 = \frac{SN_3(25.4) - 0.45(30) - 0.25(1.2)(110)}{0.15(0.8)}$

$SN_3 = 2.68$

for $D_1 = 40$

therefore $D_2 = \frac{1.831(25.4) - 0.45(40)}{0.25(1.2)}$

$D_2 = 95.025$

Use $D_2 = 100$ mm

$D_3 = \frac{2.68(25.4) - 0.45(40) - 0.25(1.2)(100)}{0.15(0.8)}$

$D_3 = 167.27$

Use $D_3 = 170$ mm

b) Curling stress

a) from temperature differential : - at daytime → top of slab at higher temp → tendency of slab to hog
- at nighttime → top of slab at lower tem → tendency of slab to dish
- weight of slab & load transfer at joint impose restraints against curling which develop curling stress

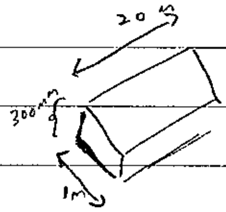
b) from moisture differences : - concrete swells when moisture contents increases
- bottom of slab usually damper i.e edges / corners curl upwards
- stress is develop from restraints at joints & weight of slab

2) wheel load stress
- dependent upon position of application, can be at edge, corner and interior
- magnitude dependent upon stiffness of supporting layer, flexural stiffness of slab
- stress is developed from force from load that acting through the wheel

3) Temperature - friction stress
- expansion / contraction of slab as temperature changes
- friction between slab & layer below
  - compressive stress during slab expansion
  - tensile stress during contraction

4) Moisture friction stress
- expand / contract when m/c changes
- frictional stress important for long slab
- curling stresses important for shorter slab

6c) $A_s = \frac{LFW}{2f_s}$; assume width = 1



$W = wd\rho g$

therefore

$A_s = \frac{20}{2} \frac{1.5}{297} \quad 1(300 10^{-3})(2400)(9.81)$

$A_s = 356.72\ m^2$ (per metre of width of slab)