HIGHPLAN Computational Methodology

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Two-Lane Segment (w/o passing lane)

Inputs and Initial Computations

1. Input Roadway and Traffic Data

Roadway Variables

$AreaType := 2$ 1 = Urbanized, 2 = Transitioning/Urban, 3 = Rural developed, 4 = Rural undeveloped

$Class := 1$

$Median := 0$ 0 = No, 1 = Yes

$NumberofLanes := 2$

$LeftTurnLane := 1$ 0 = No, 1 = Yes

$AnalysisType := 0$ 0 = Segment, 1 = Facility

$\%NPZ := 60$

$Terrain := 2$ Level = 1, Rolling = 2

$PresencePassingLane := 1$ 0 = No, 1 = Yes

$PostedSpeed := 50$ mi/hr

$Spacing := 5$ mi

Traffic Variables

$AADT := 10000$

$PercentHeavyVehicles := 0.04$

$P_T := PercentHeavyVehicles$

$K := 0.096$

$BaseCapacity := 1700$

$D := 0.55$

$LocalAdjustmentFactor := 0.95$

$LAF := LocalAdjustmentFactor$

$PHF := 0.91$

2. Calculate DDHV (Design Directional Hour Volume)

$$DDHV := AADT \cdot K \cdot D$$

$$DDHV = 528$$

3. Determine adjustment for the presence of a median and/or left turn lanes

Left Turn Lane Adjustment (LTadj) = -0.2 for left turn lanes NOT present, LTadj = 0 otherwise.

Median Adjustment (MedAdj) = 0.05 for median present, MadAdj = 0 otherwise.

Left Turn Lane:

$$LTadj(LeftTurnLane) := \left| \begin{array}{l} out \leftarrow -0.2 \ \text{ if } \ LeftTurnLane = 0 \\ out \leftarrow 0 \ \text{ if } \ LeftTurnLane = 1 \\ out \end{array} \right.$$

$LTadj(LeftTurnLane) = 0$ $LTadj := LTadj(LeftTurnLane)$ $LTadj = 0$

Median:

$$MedAdj(Median) := \left| \begin{array}{l} out \leftarrow 0 \ \text{ if } \ Median = 0 \\ out \leftarrow 0.05 \ \text{ if } \ Median = 1 \\ out \end{array} \right.$$

$MedAdj(Median) = 0$ $MedAdj := MedAdj(Median)$ $MedAdj = 0$

Final Adjustment Value for Left Turn Lane and Median:

$AdjMedLTL := 1 + LTadj + MedAdj$

$AdjMedLTL = 1$

4. Determine Facility Adjustment Factor (FacAdj)

FacAdj = 1.0 for Analysis Type = Segment

FacAdj = 0.9 for Analysis Type = Facility

$$FacAdj(AnalysisType) := \left| \begin{array}{l} out \leftarrow 1.0 \ \text{ if } \ AnalysisType = 0 \\ out \leftarrow 0.9 \ \text{ if } \ AnalysisType = 1 \\ out \end{array} \right.$$

$FacAdj(AnalysisType) = 1$ $FacAdj := FacAdj(AnalysisType)$ $FacAdj = 1$

5. Calculate Adjusted Volume (AdjVol)

$$AdjVol := \frac{DDHV}{PHF \cdot LAF \cdot AdjMedLTL \cdot FacAdj}$$

$AdjVol = 610.8$ veh/h $V := AdjVol$ $V = 610.8$ veh/h

Calculations for Percent Time Spent Following (PTSF)

6. Determine E_T (Truck passenger car equivalency factor)

$$
\mathrm{PCEs}(\mathrm{Terrain}, V) := \left|
\begin{array}{l}
\text{if Terrain} = 1 \\
\quad \left|
\begin{array}{l}
E_T \leftarrow 1.1 \;\text{ if }\; 0 \le V \le 300 \\
E_T \leftarrow 1.1 \;\text{ if }\; 300 < V \le 600 \\
E_T \leftarrow 1.0 \;\text{ if }\; V > 600 \\
E_R \leftarrow 1.0 \\
\text{out} \leftarrow \begin{pmatrix} E_T \\ E_R \end{pmatrix} \\
\text{out}
\end{array}
\right. \\
\text{if Terrain} = 2 \\
\quad \left|
\begin{array}{l}
E_T \leftarrow 1.8 \;\text{ if }\; 0 \le V \le 300 \\
E_T \leftarrow 1.5 \;\text{ if }\; 300 < V \le 600 \\
E_T \leftarrow 1.0 \;\text{ if }\; V > 600 \\
E_R \leftarrow 1.0 \\
\text{out} \leftarrow \begin{pmatrix} E_T \\ E_R \end{pmatrix} \\
\text{out}
\end{array}
\right. \\
\text{out}
\end{array}
\right.
$$

From Exhibit 20-10
HCM 2000

$$\mathrm{PCEs}(\mathrm{Terrain}, V) = \begin{pmatrix} 1.0 \\ 1.0 \end{pmatrix}$$

$$E_T := \mathrm{PCEs}(\mathrm{Terrain}, V)_1 \qquad E_T = 1.0$$

$$E_R := \mathrm{PCEs}(\mathrm{Terrain}, V)_2 \qquad E_R = 1.0$$

7. Calculate heavy vehicle factor (f_{HV})

$$f_{HV} := \frac{1}{1 + P_T \cdot (E_T - 1)}$$

Equation 20-4
HCM 2000

$$f_{HV} = 1$$

8. Determine grade adjustment factor (f_G)

$$f_G(\text{Terrain}, V) := \begin{vmatrix} \text{if } \text{Terrain} = 1 \\ \quad \begin{vmatrix} f_G \leftarrow 1.0 \\ \text{out} \leftarrow f_G \\ \text{out} \end{vmatrix} \\ \text{if } \text{Terrain} = 2 \\ \quad \begin{vmatrix} f_G \leftarrow 0.77 \ \text{ if } \ 0 \le V \le 300 \\ f_G \leftarrow 0.94 \ \text{ if } \ 300 < V \le 600 \\ f_G \leftarrow 1.0 \ \text{ if } \ V > 600 \\ \text{out} \leftarrow f_G \\ \text{out} \end{vmatrix} \\ \text{out} \end{vmatrix}$$

From Exhibit 20-8
HCM 2000

$f_G(\text{Terrain}, V) = 1$ $\qquad f_G := f_G(\text{Terrain}, V)$ $\qquad f_G = 1.0$

9. Calculate forward direction volume (v_d)

$$v_d := \frac{V}{PHF \cdot f_G \cdot f_{HV}}$$

Equation 20-12
HCM 2000

Since the PHF was already accounted for in Step 5, the following equation is used:

$$v_d := \frac{\text{AdjVol}}{f_G \cdot f_{HV}}$$

$v_d = 610.8$ pc/hr

Check this value against flow range used for Exhbits 20-10 and 20-8, and repeat steps 6 through 9 as necessary.

10. Calculate opposing direction volume (v_o).

$$v_o := \frac{V_o}{PHF \cdot f_G \cdot f_{HV}}$$

From Equation 20-13
HCM 2000

The "equivalent" is performed by the following equation:

$$v_o := \frac{v_d \cdot (1 - D)}{D}$$

$v_o = 499.7$

f_G and f_{HV} are not currently accounted for in the determination of v_o as they are in the HCM 2000 methodology. Additionally, the PHF is assumed to be the same in the off-peak direction.

11. Determine values of coefficients 'a' and 'b' for HCM Equation 20-17

Look up values from HCM Exhibit 20-21 (linear interpolation if necessary).

Input:

v_o is rounded to the nearest 10 veh/h.

$v_{o\_rd} := \mathrm{round}(v_o, -1)$ $\quad v_{o\_rd} = 500$ pc/hr

From Exhibit, for v_o = 400; $\quad a_1 := -0.0022 \quad b_1 := 0.923$

From Exhibit, for v_o = 600; $\quad a_2 := -0.0033 \quad b_2 := 0.870$

From Exhibit 20-21 HCM 2000 (per NCHRP 20-7 revisions)

Interpolation:

$$a := a_1 + (v_{o\_rd} - 400) \cdot \left(\frac{a_1 - a_2}{400 - 600} \right)$$

$a = -0.0028$

$$b := b_1 + (v_{o\_rd} - 400) \cdot \frac{b_1 - b_2}{400 - 600}$$

$b = 0.8965$

12. Calculate base percent time spent following (BPTSF)

$$BPTSF_d := 100 \cdot \left(1 - e^{a \cdot v_d{}^b} \right)$$

Equation 20-17 HCM 2000

$BPTSF_d = 57.9$

13. Determine adjustment for % no-passing zones in analysis direction (f_{np}) for HCM Equation

20-16

Look up value from HCM Exhibit 20-20 (linear interpolation if necessary, by both volume and percent no-passing zone).

Input:

$PostedSpeed = 50$ $\%NPZ = 60$ $v_o = 499.7$

$FFS := PostedSpeed + 5$

$FFS = 55$

Interpolation:

$v_p := v_d + v_o$ $v_p = 1110$

$$f_{np} := 41.3 + (v_p - 800) \cdot \left(\frac{41.3 - 25.8}{800 - 1400} \right)$$

From Exhibit 20-20 HCM 2000 (per NCHRP 20-7 revisions)

$f_{np} = 33.3$

14. Calculate percent time spent following (PTSF)

$$PTSF_d := BPTSF_d + f_{np} \cdot \left(\frac{v_d}{v_p} \right)$$

Equation 20-16 HCM 2000 (per NCHRP 20-7 revisions)

$PTSF_d = 76.2$

Procedure if passing lanes are present

See separate example document.

Calculations for Average Travel Speed (ATS)

6. Determine E_T (Truck passenger car equivalency factor)

$$
\mathrm{PCEs}(\mathrm{Terrain}, V) := \left|\begin{array}{l}
\text{if Terrain} = 1 \\
\quad \left|\begin{array}{l}
E_T \leftarrow 1.7 \ \text{ if } \ 0 \le V \le 300 \\
E_T \leftarrow 1.2 \ \text{ if } \ 300 < V \le 600 \\
E_T \leftarrow 1.1 \ \text{ if } \ V > 600 \\
E_R \leftarrow 1.0 \\
\text{out} \leftarrow \begin{pmatrix} E_T \\ E_R \end{pmatrix} \\
\text{out}
\end{array}\right. \\
\text{if Terrain} = 2 \\
\quad \left|\begin{array}{l}
E_T \leftarrow 2.5 \ \text{ if } \ 0 \le V \le 300 \\
E_T \leftarrow 1.9 \ \text{ if } \ 300 < V \le 600 \\
E_T \leftarrow 1.5 \ \text{ if } \ V > 600 \\
E_R \leftarrow 1.1 \\
\text{out} \leftarrow \begin{pmatrix} E_T \\ E_R \end{pmatrix} \\
\text{out}
\end{array}\right. \\
\text{out}
\end{array}\right.
$$

From Exhibit 20-9
HCM 2000

$$\mathrm{PCEs}(\mathrm{Terrain}, V) = \begin{pmatrix} 1.5 \\ 1.1 \end{pmatrix}$$

$E_T := \mathrm{PCEs}(\mathrm{Terrain}, V)_1$ $\qquad E_T = 1.5$

$E_R := \mathrm{PCEs}(\mathrm{Terrain}, V)_2$ $\qquad E_R = 1.1$

7. Calculate heavy vehicle factor (f_{HV})

$$f_{HV} := \frac{1}{1 + P_T \cdot (E_T - 1)}$$

Equation 20-4
HCM 2000

$f_{HV} = 0.98$

8. Determine grade adjustment factor (f_G)

$$f_G(\text{Terrain}, V) := \begin{array}{|l} \text{if Terrain} = 1 \\ \quad \begin{array}{|l} f_G \leftarrow 1.0 \\ \text{out} \leftarrow f_G \\ \text{out} \end{array} \\ \text{if Terrain} = 2 \\ \quad \begin{array}{|l} f_G \leftarrow 0.71 \ \text{ if } 0 \le V \le 300 \\ f_G \leftarrow 0.93 \ \text{ if } 300 < V \le 600 \\ f_G \leftarrow 0.99 \ \text{ if } V > 600 \\ \text{out} \leftarrow f_G \\ \text{out} \end{array} \\ \text{out} \end{array}$$

From Exhibit 20-7
HCM 2000

$f_G(\text{Terrain}, V) = 0.99$ $\quad$ $f_G := f_G(\text{Terrain}, V)$ $\quad$ $f_G = 0.99$

9. Calculate forward direction volume (v_d)

$$v_d := \frac{V}{PHF \cdot f_G \cdot f_{HV}}$$

Equation 20-12
HCM 2000

Since the PHF was already accounted for in Step 5, the following equation is used:

$$v_d := \frac{AdjVol}{f_G \cdot f_{HV}}$$

$v_d = 629.3$ pc/h

Check this value against flow range used for Exhbits 20-10 and 20-8, and repeat steps 6 through 9 as necessary.

10. Calculate opposing direction volume (v_o)

$$v_o := \frac{V_o}{PHF \cdot f_G \cdot f_{HV}}$$

Equation 20-13
HCM 2000

The "equivalent" is performed by the following equation:

$$v_o := \frac{v_d \cdot (1 - D)}{D}$$

$v_o = 514.9$ pc/h

f_G and f_{HV} are not currently accounted for in the determination of v_o as they are in the HCM 2000 methodology. Additionally, the PHF is assumed to be the same in the off-peak direction.

11. Determine adjustment for % no-passing zones in analysis direction (f_{np}) for HCM Equation 20-15

Look up value from HCM Exhibit 20-19 (linear interpolation if necessary, by both volume and percent no-passing zone).

Input:

$\text{PostedSpeed} = 50$ $\%\text{NPZ} = 60$ $v_o = 514.9$

$\text{FFS} := \text{PostedSpeed} + 5$

$\text{FFS} = 55$

Interpolation:

This example only calls for interpolation by volume,

$$f_{np} := 2.4 + (v_o - 400)\cdot\left(\frac{2.4 - 1.6}{400 - 600}\right)$$

$f_{np} = 1.94$

12. Calculate average travel speed (ATS)

Input:

$\text{FFS}_d := \text{FFS}$ $\text{FFS}_d = 55$ from inputs

$v_d = 629.3$ from step 9

$v_o = 514.9$ from step 10

$f_{np} = 1.94$ from step 11

Calculation:

$$\text{ATS}_d := \text{FFS}_d - 0.00776\cdot(v_d + v_o) - f_{np}$$ Equation 20-5 HCM 2000

$\text{ATS}_d = 44.2$ mi/h

Procedure if passing lanes are present

See separate example document.

Service Volumes

See separate example document.

Determine Level of Service

$$
\mathrm{Los}(\mathrm{Class}, \mathrm{PTSF}, \mathrm{ATS}, \mathrm{FFS}) := \left|
\begin{array}{l}
\text{if } \mathrm{Class} = 1 \\
\quad \left|
\begin{array}{l}
out_1 \leftarrow \text{"A"} \quad \text{if } \mathrm{PTSF} \le 35 \\
out_1 \leftarrow \text{"B"} \quad \text{if } 35 < \mathrm{PTSF} \le 50 \\
out_1 \leftarrow \text{"C"} \quad \text{if } 50 < \mathrm{PTSF} \le 65 \\
out_1 \leftarrow \text{"D"} \quad \text{if } 65 < \mathrm{PTSF} \le 80 \\
out_1 \leftarrow \text{"E"} \quad \text{if } \mathrm{PTSF} > 80 \\
out_2 \leftarrow \text{"A"} \quad \text{if } \mathrm{ATS} > 55 \\
out_2 \leftarrow \text{"B"} \quad \text{if } 50 < \mathrm{ATS} \le 55 \\
out_2 \leftarrow \text{"C"} \quad \text{if } 45 < \mathrm{ATS} \le 50 \\
out_2 \leftarrow \text{"D"} \quad \text{if } 40 < \mathrm{ATS} \le 45 \\
out_2 \leftarrow \text{"E"} \quad \text{if } \mathrm{ATS} \le 40 \\
out \leftarrow \begin{pmatrix} out_1 \\ out_2 \end{pmatrix}
\end{array}
\right. \\
\text{if } \mathrm{Class} = 2 \\
\quad \left|
\begin{array}{l}
out \leftarrow \text{"A"} \quad \text{if } \mathrm{PTSF} \le 40 \\
out \leftarrow \text{"B"} \quad \text{if } 40 < \mathrm{PTSF} \le 55 \\
out \leftarrow \text{"C"} \quad \text{if } 55 < \mathrm{PTSF} \le 70 \\
out \leftarrow \text{"D"} \quad \text{if } 70 < \mathrm{PTSF} \le 85 \\
out \leftarrow \text{"E"} \quad \text{if } \mathrm{PTSF} > 80 \\
out
\end{array}
\right. \\
\text{if } \mathrm{Class} = 3 \\
\quad \left|
\begin{array}{l}
out \leftarrow \text{"A"} \quad \text{if } \dfrac{\mathrm{ATS}}{\mathrm{FFS}} > 0.917 \\
out \leftarrow \text{"B"} \quad \text{if } 0.833 < \dfrac{\mathrm{ATS}}{\mathrm{FFS}} \le 0.917 \\
out \leftarrow \text{"C"} \quad \text{if } 0.750 < \dfrac{\mathrm{ATS}}{\mathrm{FFS}} \le 0.833
\end{array}
\right.
\end{array}
\right.
$$

From Exhibit 20-2
HCM 2000

From Exhibit 20-4
HCM 2000

$$\left|\begin{array}{l} \left|\begin{array}{l} out \leftarrow \text{"D"} \quad \text{if } 0.667 < \dfrac{ATS}{FFS} \le 0.750 \\ out \leftarrow \text{"E"} \quad \text{if } 0.583 < \dfrac{ATS}{FFS} \le 0.667 \\ out \leftarrow \text{"F"} \quad \text{if } \dfrac{ATS}{FFS} \le 0.583 \\ out \end{array}\right. \\ out \end{array}\right.$$

$$Los\left(Class, PTSF_d, ATS_d, FFS\right) = \begin{pmatrix} \text{"D"} \\ \text{"D"} \end{pmatrix}$$

If Class 1, the LOWER LOS GOVERNS