HIGHPLAN 2009

Computational Methodology Documentation

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Two-Lane Methodology

Inputs

Project Properties

Roadway Information:

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

Highway Data

Roadway Variables:

$NumberofLanes := 2$		$LeftTurnImpact := 0$	0 = No, 1 = Yes
$Terrain := 2$	Level = 1, Rolling = 2	$Median := 0$	0 = No, 1 = Yes
$PostedSpeed := 50$	mi/hr	$PresencePassingLane := 0$	0 = No, 1 = Yes
$SegLength := 4$	mi	$Spacing := 0$	mi
		$\%NPZ := 60$	

Traffic Variables:

$AADT := 14410$	$P_T := 4\%$	Percent trucks
$K := 0.096$	$BaseCapacity := 1700$	
$D := 0.60$	$LocalAdjustmentFactor := 1.0$	
$PHF := 0.91$		

LOS Computational Steps

1. Calculate DDHV (Design Directional Hour Volume)

$DDHV := AADT \cdot K \cdot D$ $\qquad DDHV = 830$

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

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

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

Left Turn Lane:

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

$LTadj(LeftTurnImpact) = 0 \qquad LTadj := LTadj(LeftTurnImpact) \qquad LTadj = 0$

Median:

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

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

Final Adjustment Value for Left Turn Lane and Median:

$AdjMedLTL := 1 + LTadj + MedAdj \qquad AdjMedLTL = 1$

3. Determine Facility Adjustment Factor (FacAdj)

FacAdj = 1.0 for Analysis Type = Segment
FacAdj = 0.9 for Analysis Type = Facility

$FacAdj := 1$

4. Calculate Adjusted Volume (AdjVol)

$LAF := LocalAdjustmentFactor$

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

$AdjVol = 912$ veh/h $\qquad V := AdjVol \qquad V = 912.1$ veh/h

Calculations for Percent Time Spent Following (PTSF)

5. Determine E_T (Truck passenger car equivalency factor)

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

From Exhibit 20-10
HCM 2000

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

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

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

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

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

Equation 20-4
HCM 2000

7. Determine grade adjustment factor (f_G)

$$
f_G(\mathrm{Terrain}, V) := \left|
\begin{array}{l}
\text{if Terrain} = 1 \\
\quad \left| \begin{array}{l} f_G \leftarrow 1.0 \\ out \leftarrow f_G \\ out \end{array} \right. \\
\text{if Terrain} = 2 \\
\quad \left| \begin{array}{l} f_G \leftarrow 0.77 \quad \text{if } 0 \le V \le 300 \\ f_G \leftarrow 0.94 \quad \text{if } 300 < V \le 600 \\ f_G \leftarrow 1.0 \quad \text{if } V > 600 \\ out \leftarrow f_G \\ out \end{array} \right. \\
out
\end{array}
\right.
$$

From Exhibit 20-8
HCM 2000

$f_G(\mathrm{Terrain}, V) = 1$ $\qquad$ $f_G := f_G(\mathrm{Terrain}, V)$ $\qquad$ $f_G = 1.00$

8. 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:

$$v_d := \frac{AdjVol}{f_G \cdot f_{HV}} \qquad v_d = 912.1 \quad \text{pc/hr}$$

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

9. 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:

$$v_o := \frac{v_d \cdot (1 - D)}{D} \qquad v_o = 608.1$$

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.

10. 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.

$v_{o\_rd} := \text{round}(v_o, -1)$ $\quad v_{o\_rd} = 610$ pc/hr

From Exhibit, for v_o = 600; $\quad a_1 := -0.0033 \quad b_1 := 0.870$

From Exhibit, for v_o = 800; $\quad a_2 := -0.0045 \quad b_2 := 0.833$

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

Interpolation:

$$a := a_1 + (a_2 - a_1)\cdot\left(\frac{v_{o\_rd} - 600}{800 - 600}\right) \qquad a = -0.0034$$

$$b := b_1 + (b_2 - b_1)\cdot\left(\frac{v_{o\_rd} - 600}{800 - 600}\right) \qquad b = 0.8681$$

11. Calculate base percent time spent following (BPTSF)

$$BPTSF_d := 100\cdot\left(1 - e^{a\cdot v_d{}^{b}}\right) \qquad BPTSF_d = 71.3$$

Equation 20-17 HCM 2000

12. 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 %NPZ.

Input:

$\text{PostedSpeed} = 50 \qquad \%NPZ = 60 \qquad v_o = 608.1$

$FFS := \text{PostedSpeed} + 5 \qquad FFS = 55 \qquad D = 0.6$

Interpolation:

$f_{np1} := 25.4$ for Vp = 1400 and $f_{np2} := 16.0$ for Vp = 2000

$v_p := v_d + v_o \qquad v_p = 1520.176$

$$f_{np} := f_{np1} - (v_p - 1400)\cdot\left(\frac{f_{np1} - f_{np2}}{2000 - 1400}\right) \qquad f_{np} = 23.517$$

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

13. Calculate percent time spent following (PTSF)

$$PTSF_d := BPTSF_d + f_{np} \cdot \left(\frac{v_d}{v_p}\right) \qquad PTSF_d = 85.4$$

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

Calculations for Average Travel Speed (ATS)

14. Determine E_T (Truck passenger car equivalency factor)

From Exhibit 20-9 HCM 2000

$$
\begin{aligned}
PCEs(Terrain, V) := \; & \text{if } Terrain = 1 \\
& \quad E_T \leftarrow 1.7 \text{ if } 0 \le V \le 300 \\
& \quad E_T \leftarrow 1.2 \text{ if } 300 < V \le 600 \\
& \quad E_T \leftarrow 1.1 \text{ if } V > 600 \\
& \quad E_R \leftarrow 1.0 \\
& \quad out \leftarrow \begin{pmatrix} E_T \\ E_R \end{pmatrix} \\
& \quad out \\
& \text{if } Terrain = 2 \\
& \quad E_T \leftarrow 2.5 \text{ if } 0 \le V \le 300 \\
& \quad E_T \leftarrow 1.9 \text{ if } 300 < V \le 600 \\
& \quad E_T \leftarrow 1.5 \text{ if } V > 600 \\
& \quad E_R \leftarrow 1.1 \\
& \quad out \leftarrow \begin{pmatrix} E_T \\ E_R \end{pmatrix} \\
& \quad out \\
& out
\end{aligned}
$$

$$PCEs(Terrain, V) = \begin{pmatrix} 1.5 \\ 1.1 \end{pmatrix} \qquad E_T := PCEs(Terrain, V)_1 \qquad E_T = 1.5$$

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

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

$$f_{HV} := \frac{1}{1 + P_T \cdot (E_T - 1)} \qquad f_{HV} = 0.98$$

Equation 20-4 HCM 2000

16. Determine grade adjustment factor (f_G)

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

From Exhibit 20-7
HCM 2000

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

17. 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:

$$v_d := \frac{AdjVol}{f_G \cdot f_{HV}} \qquad v_d = 939.7 \quad \text{pc/h}$$

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

18. 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:

$$v_o := \frac{v_d \cdot (1 - D)}{D} \qquad v_o = 626.5 \quad \text{pc/h}$$

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.

19. 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:

$PostedSpeed = 50$ $\qquad$ $\%NPZ = 60$ $\qquad$ $v_o = 626.5$

$FFS := PostedSpeed + 5$ $\qquad$ $FFS = 55$

Interpolation:

This example only calls for interpolation by volume,

$$f_{np} := 1.6 - (v_o - 600)\cdot\left(\frac{1.6 - 1.1}{800 - 600}\right) \qquad f_{np} = 1.53$$

20. Calculate average travel speed (ATS)

Input:

$FFS_d := FFS$ $\qquad$ $FFS_d = 55$ $\qquad$ from inputs

$v_d = 939.7$ $\qquad$ from step 9

$v_o = 626.5$ $\qquad$ from step 10

$f_{np} = 1.53$ $\qquad$ from step 11

Calculation:

$$ATS_d := FFS_d - 0.00776\cdot(v_d + v_o) - f_{np} \qquad ATS_d = 41.3 \text{ mi/h}$$

Equation 20-5
HCM 2000

21. Calculate Percentage of Free-Flow Speed (%FFS)

$$\%FFS := \frac{ATS_d}{FFS_d}\cdot 100 \qquad \%FFS = 75.1$$

22. Calculate Free-Flow Delay

$$FFDelay := \left(\frac{SegLength}{ATS_d} - \frac{SegLength}{FFS_d}\right)\cdot 3600$$

$FFDelay = 86.7$ sec/veh

23. Calculate LOS Threshold Delay

$$LOSspeedthresh(AreaType) := \begin{array}{|l} \text{return } 37 \text{ if } AreaType = 1 \\ \text{return } 50 \text{ if } AreaType = 2 \vee AreaType = 3 \vee AreaType = 4 \end{array}$$

$LOSspeedthresh(AreaType) = 50$

$$LOSDelay := \left(\frac{SegLength}{ATS_d} - \frac{SegLength}{LOSspeedthresh(AreaType)}\right)\cdot 3600$$

$LOSDelay = 60.6$ sec/veh

24. Calculate v/c ratio

$$vcratioTwoWay := \frac{v_d + v_o}{BaseCapacity\cdot\left(\frac{3200}{1700}\right)}$$

$vcratioTwoWay = 0.49$

$$vcratioOneWay := \frac{v_d}{BaseCapacity}$$

$vcratioOneWay = 0.55$

$$vcratio := \max(vcratioTwoWay, vcratioOneWay)$$

$vcratio = 0.55$

25. Determine Class

$$ClassCalc(AreaType) := \begin{array}{|l} \text{return } 1 \text{ if } AreaType = 4 \\ \text{return } 3 \text{ if } AreaType = 1 \vee AreaType = 2 \vee AreaType = 3 \end{array}$$

$Class := ClassCalc(AreaType)$ $Class = 3$

26. Determine Level of Service

If Class = 1, the lower LOS governs

From Exhibit 20-2 HCM 2000

From Exhibit 20-4 HCM 2000

$$
\begin{aligned}
&\text{LosCalc}(\text{Class}, \text{PTSF}, \text{ATS}, \text{FFS}) := \\
&\quad \text{if Class} = 1 \\
&\qquad out_1 \leftarrow \text{"A"} \quad \text{if PTSF} \le 35 \\
&\qquad out_1 \leftarrow \text{"B"} \quad \text{if } 35 < \text{PTSF} \le 50 \\
&\qquad out_1 \leftarrow \text{"C"} \quad \text{if } 50 < \text{PTSF} \le 65 \\
&\qquad out_1 \leftarrow \text{"D"} \quad \text{if } 65 < \text{PTSF} \le 80 \\
&\qquad out_1 \leftarrow \text{"E"} \quad \text{if PTSF} > 80 \\
&\qquad out_2 \leftarrow \text{"A"} \quad \text{if ATS} > 55 \\
&\qquad out_2 \leftarrow \text{"B"} \quad \text{if } 50 < \text{ATS} \le 55 \\
&\qquad out_2 \leftarrow \text{"C"} \quad \text{if } 45 < \text{ATS} \le 50 \\
&\qquad out_2 \leftarrow \text{"D"} \quad \text{if } 40 < \text{ATS} \le 45 \\
&\qquad out_2 \leftarrow \text{"E"} \quad \text{if ATS} \le 40 \\
&\qquad out \leftarrow \begin{pmatrix} out_1 \\ out_2 \end{pmatrix} \\
&\quad \text{if Class} = 2 \\
&\qquad out \leftarrow \text{"A"} \quad \text{if PTSF} \le 40 \\
&\qquad out \leftarrow \text{"B"} \quad \text{if } 40 < \text{PTSF} \le 55 \\
&\qquad out \leftarrow \text{"C"} \quad \text{if } 55 < \text{PTSF} \le 70 \\
&\qquad out \leftarrow \text{"D"} \quad \text{if } 70 < \text{PTSF} \le 85 \\
&\qquad out \leftarrow \text{"E"} \quad \text{if PTSF} > 80 \\
&\qquad out \\
&\quad \text{if Class} = 3 \\
&\qquad out \leftarrow \text{"A"} \quad \text{if } \frac{\text{ATS}}{\text{FFS}} > 0.917 \\
&\qquad out \leftarrow \text{"B"} \quad \text{if } 0.833 < \frac{\text{ATS}}{\text{FFS}} \le 0.917 \\
&\qquad out \leftarrow \text{"C"} \quad \text{if } 0.750 < \frac{\text{ATS}}{\text{FFS}} \le 0.833 \\
&\qquad out \leftarrow \text{"D"} \quad \text{if } 0.667 < \frac{\text{ATS}}{\text{FFS}} \le 0.750 \\
&\qquad out \leftarrow \text{"E"} \quad \text{if } 0.583 < \frac{\text{ATS}}{\text{FFS}} \le 0.667 \\
&\qquad out \leftarrow \text{"F"} \quad \text{if } \frac{\text{ATS}}{\text{FFS}} \le 0.583 \\
&\qquad out \\
&\quad out
\end{aligned}
$$

$$\text{LOS} := \max\left(\text{LosCalc}\left(\text{Class}, \text{PTSF}_d, \text{ATS}_d, \text{FFS}_d\right)\right)$$

$$\text{LOS} = \text{"C"}$$

Service Volumes Check

From Exhibit 15-2 HCM 2000, for a Class II Arterial, the percent free flow speed (%FFS) threshold for LOS C is 0.75.

Using the procedure documented above, the following results are obtained for the displayed 830 veh/h peak direction service volume.

$$\text{InputAADT} := \text{Round}\left(\frac{830}{K \cdot D}, 10\right) = 14410$$

$ATS_d = 41.312$ miles/hour

$FFS_d = 55$ miles/hour

$$\frac{ATS_d}{FFS_d} = 0.751$$

Thus, the maximum service volume (AADT) for LOS C for the conditions in the example calculations file is ~14,410.

Passing Lane Improvement

If there is a passing lane in the analysis direction, the service volumes will be increased by the proportion of the length of the passing lane (assumed to be 1 mile) to the passing lane spacing, as illustrated below.

$\text{NoPassingSV} := 830$ veh/h

$\text{Spacing} := 2$ miles

$$\text{Improvement} := \frac{1}{\text{Spacing}} = 0.5$$

$$\text{PassingSV} := \text{NoPassingSV} \cdot (1 + \text{Improvement})$$

$$\text{PassingSV} := \text{PassingSV} - \text{mod}(\text{PassingSV}, 10)$$ * HIGHPLAN rounds down to multiples of 10

$\text{PassingSV} = 1240$ veh/h

Note that the improvement to the service volumes cannot exceed capacity. In other words, the service volume for any level of service is capped at the LOS E service volume for the no-passing lane condition.

Multilane Methodology

Inputs

Project Properties

Roadway Information:

$AreaType := 2$ 1 = Urbanized, 2 = Transitioning/Urban, 3 = Rural Developed, 4 = Rural Undeveloped

Highway Data

Roadway Variables:

$NumberofLanes := 4$

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

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

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

$PostedSpeed := 45$ mi/hr

$SegLength := 5$ mi

Traffic Variables:

$AADT := 33490$

$P_T := 2\%$ Percent trucks

$K := 0.095$

$BaseCapacity := 2000$

$D := 0.55$

$LocalAdjustmentFactor := 1.0$

$PHF := 0.925$

LOS Computational Steps

1. Calculate DDHV (Design Directional Hour Volume)

$DDHV := AADT \cdot K \cdot D$ $\qquad DDHV = 1750$

2. Determine E_T (Truck passenger car equivalency factor)

$$PCE(Terrain) := \left| \begin{array}{l} out \leftarrow 1.5 \ \text{ if } \ Terrain = 1 \\ out \leftarrow 2.5 \ \text{ if } \ Terrain = 2 \\ out \end{array} \right.$$

From Exhibit 21-8
HCM 2000

$PCE(Terrain) = 2.5$ $\qquad E_T := PCE(Terrain)$ $\qquad E_T = 2.5$

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

$$f_{HV} := \frac{1}{1 + P_T \cdot (E_T - 1)} \qquad f_{HV} = 0.971$$

Equation 21-4
HCM 2000

4. Calculate Base Analysis Volume (v_p)

$LAF := LocalAdjustmentFactor$

$$v_p := \frac{DDHV}{PHF \cdot \frac{NumberofLanes}{2} \cdot f_{HV} \cdot LAF} \qquad v_p = 974.2 \ \text{veh/h}$$

Equation 21-3
HCM 2000

5. 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 no median present, MedAdj = 0 otherwise. Note:
The presence of a median, but no left turn lanes is not a valid option per FDOT guidance.

$LTI := LeftTurnImpact$

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

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

$LTadj(LeftTurnImpact) = -0.2$

$LTadj := LTadj(LeftTurnImpact)$

$LTadj = -0.2$

$MedAdj(Median) = -0.05$

$MedAdj := MedAdj(Median)$

$MedAdj = -0.05$

Final Adjustment Value for Left Turn Lane and Median:

$AdjMedLTL := (1 + LTadj + MedAdj)$ $\qquad AdjMedLTL = 0.75$

6. Determine Facility Adjustment Factor (FacAdj)

FacAdj = 1.0 for Analysis Type = Segment
FacAdj = 0.9 for Analysis Type = Facility

$FacAdj := 1$

7. Calculate Adjusted Analysis Volume (AdjVol)

$$AdjVol := \frac{v_p}{AdjMedLTL \cdot FacAdj}$$

$AdjVol = 1299$ veh/h $\quad V := AdjVol \quad V = 1299$ veh/h

8. Determine Average Passenger Car Speed

$FFS := PostedSpeed + 5 \quad FFS = 50$

Exhibit 21-3
HCM 2000

$$Speed(FFS, AdjVol) := \left| \begin{array}{l} out \leftarrow FFS \text{ if } AdjVol \le 1400 \\ \text{if } AdjVol > 1400 \\ \quad \left| \begin{array}{ll} out \leftarrow FFS - \left(\frac{3}{10} \cdot FFS - 13\right) \cdot \left(\frac{AdjVol - 1400}{28 \cdot FFS - 880}\right)^{1.31} & \text{if } FFS > 55 \\ out \leftarrow FFS - \left(\frac{34}{205} \cdot FFS - \frac{219}{41}\right) \cdot \left(\frac{AdjVol - 1400}{\frac{171}{5} \cdot FFS - 1181}\right)^{1.31} & \text{if } 50 < FFS \le 55 \\ out \leftarrow FFS - \left(\frac{10}{43} \cdot FFS - \frac{350}{43}\right) \cdot \left(\frac{AdjVol - 1400}{33 \cdot FFS - 1050}\right)^{1.31} & \text{if } 45 < FFS \le 50 \\ out \leftarrow FFS - \left(\frac{1}{5} \cdot FFS - \frac{56}{9}\right) \cdot \left(\frac{AdjVol - 1400}{36 \cdot FFS - 1120}\right)^{1.31} & \text{if } FFS = 45 \end{array} \right. \end{array} \right.$$

$Speed(FFS, AdjVol) = 50.0 \quad S := Speed(FFS, AdjVol) \quad S = 50.000$ mi/h

9. Calculate Percentage of Free-Flow Speed (%FFS)

$$\%FFS := \frac{S}{FFS} \cdot 100$$

$\%FFS = 100$

10. Calculate Free-Flow Delay

$$FFDelay := \left(\frac{SegLength}{S} - \frac{SegLength}{FFS}\right) \cdot 3600$$

$FFDelay = 0.0$ sec/veh

11. Calculate LOS Threshold Delay

$$\text{LOSspeedthresh(AreaType)} := \left| \begin{array}{l} \text{return } 53 \text{ if AreaType} = 1 \\ \text{return } 60 \text{ if AreaType} = 2 \vee \text{AreaType} = 3 \vee \text{AreaType} = 4 \end{array} \right.$$

$$\text{LOSspeedthresh(AreaType)} = 60$$

$$\text{LOSDelay} := \left(\frac{\text{SegLength}}{\text{S}} - \frac{\text{SegLength}}{\text{LOSspeedthresh(AreaType)}} \right) \cdot 3600$$

$\text{LOSDelay} = 60.0$ sec/veh

12. Calculate v/c ratio

$$\text{vcratio} := \frac{\text{V}}{\text{BaseCapacity}}$$

$\text{vcratio} = 0.65$

13. Calculate density

$$\text{Density} := \frac{\text{AdjVol}}{\text{S}}$$

Equation 21-5
HCM 2000

$\text{Density} = 26.0$ pc/mi/ln

Determine Level of Service

$$\text{LOSCalc}(\text{FFS}, \text{Density}) := \left|\begin{array}{l}
\text{if } \text{FFS} \geq 60 \\
\quad \left|\begin{array}{l}
\text{out} \leftarrow \text{"A"} \quad \text{if Density} \leq 11 \\
\text{out} \leftarrow \text{"B"} \quad \text{if } 11 < \text{Density} \leq 18 \\
\text{out} \leftarrow \text{"C"} \quad \text{if } 18 < \text{Density} \leq 26 \\
\text{out} \leftarrow \text{"D"} \quad \text{if } 26 < \text{Density} \leq 35 \\
\text{out} \leftarrow \text{"E"} \quad \text{if } 35 < \text{Density} \leq 40 \\
\text{out} \leftarrow \text{"F"} \quad \text{if Density} > 40
\end{array}\right. \\
\text{if } 55 \leq \text{FFS} < 60 \\
\quad \left|\begin{array}{l}
\text{out} \leftarrow \text{"A"} \quad \text{if Density} \leq 11 \\
\text{out} \leftarrow \text{"B"} \quad \text{if } 11 < \text{Density} \leq 18 \\
\text{out} \leftarrow \text{"C"} \quad \text{if } 18 < \text{Density} \leq 26 \\
\text{out} \leftarrow \text{"D"} \quad \text{if } 26 < \text{Density} \leq 35 \\
\text{out} \leftarrow \text{"E"} \quad \text{if } 35 < \text{Density} \leq 41 \\
\text{out} \leftarrow \text{"F"} \quad \text{if Density} > 41
\end{array}\right. \\
\text{if } 50 \leq \text{FFS} < 55 \\
\quad \left|\begin{array}{l}
\text{out} \leftarrow \text{"A"} \quad \text{if Density} \leq 11 \\
\text{out} \leftarrow \text{"B"} \quad \text{if } 11 < \text{Density} \leq 18 \\
\text{out} \leftarrow \text{"C"} \quad \text{if } 18 < \text{Density} \leq 26 \\
\text{out} \leftarrow \text{"D"} \quad \text{if } 26 < \text{Density} \leq 35 \\
\text{out} \leftarrow \text{"E"} \quad \text{if } 35 < \text{Density} \leq 43 \\
\text{out} \leftarrow \text{"F"} \quad \text{if Density} > 43
\end{array}\right. \\
\text{if } 45 \leq \text{FFS} < 50 \\
\quad \left|\begin{array}{l}
\text{out} \leftarrow \text{"A"} \quad \text{if Density} \leq 11 \\
\text{out} \leftarrow \text{"B"} \quad \text{if } 11 < \text{Density} \leq 18 \\
\text{out} \leftarrow \text{"C"} \quad \text{if } 18 < \text{Density} \leq 26 \\
\text{out} \leftarrow \text{"D"} \quad \text{if } 26 < \text{Density} \leq 35 \\
\text{out} \leftarrow \text{"E"} \quad \text{if } 35 < \text{Density} \leq 45 \\
\text{out} \leftarrow \text{"F"} \quad \text{if Density} > 45
\end{array}\right.
\end{array}\right.$$

From Exhibit 21-2
HCM 2000

$$\text{LOS} := \text{LOSCalc}(\text{FFS}, \text{Density})$$

$\text{LOS} = \text{"C"}$

Service Volumes Check

From Exhibit 15-2 HCM 2000, for a Class II Arterial, the density threshold for LOS C is 26 pc/mi/ln

Using the procedure documented above, the following results are obtained for the displayed 1750 veh/h peak direction service volume.

$$\text{InputAADT} := \text{Round}\left(\frac{1750}{K \cdot D}, 10\right) = 33490$$

$\text{AdjVol} = 1299$ veh/hour

$S = 50$ miles/hour

$\text{Density} = 25.98$ pc/mi/ln

Thus, the maximum service volume (AADT) for LOS C for the conditions in the example calculations file is ~33,490.