UTVRDJIVANJE KAPACITETA I NIVOA USLUGE AUTOPUTA HCM-2000

EXHIBIT 13-1. EXAMPLE OF BASIC FREEWAY SEGMENT

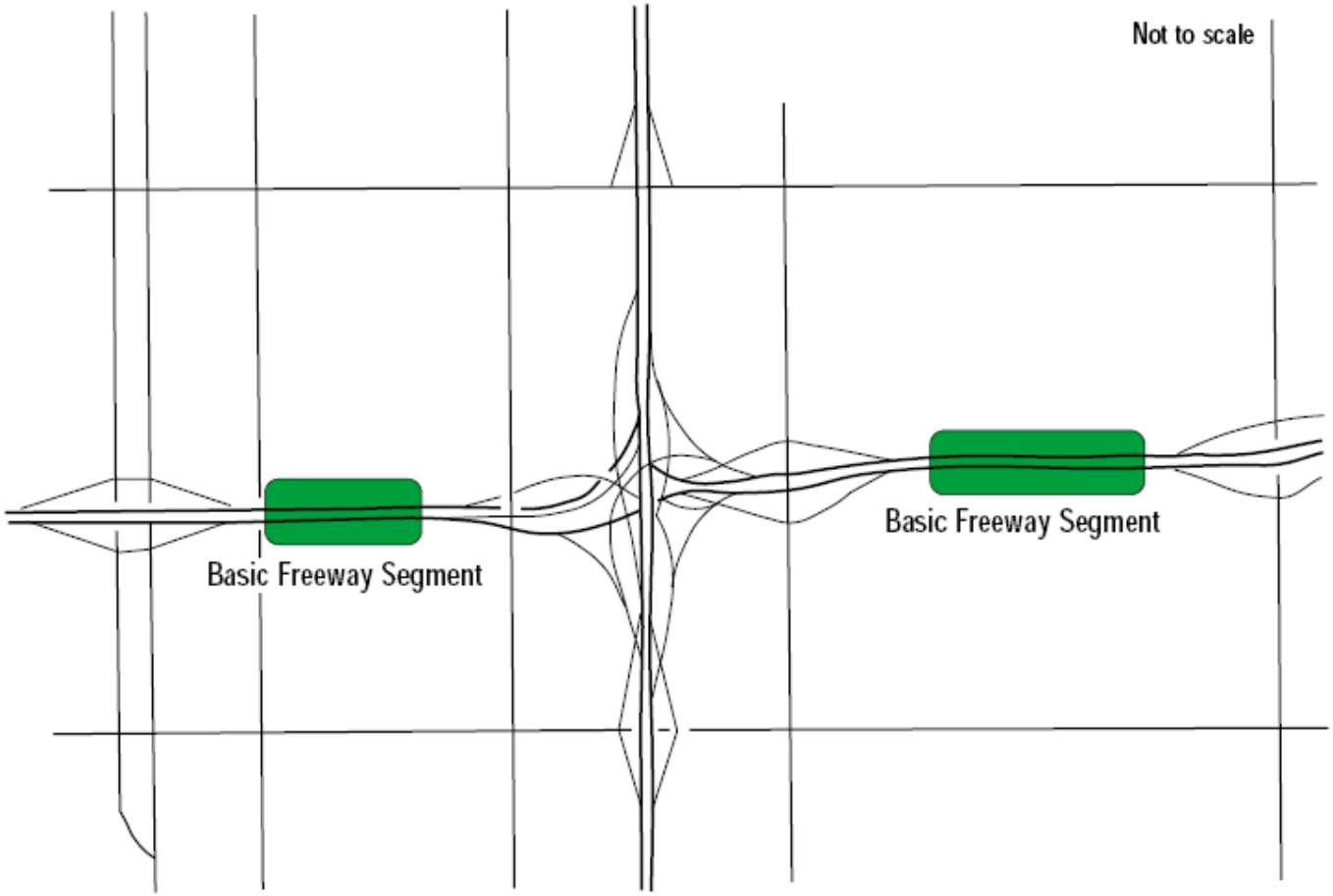
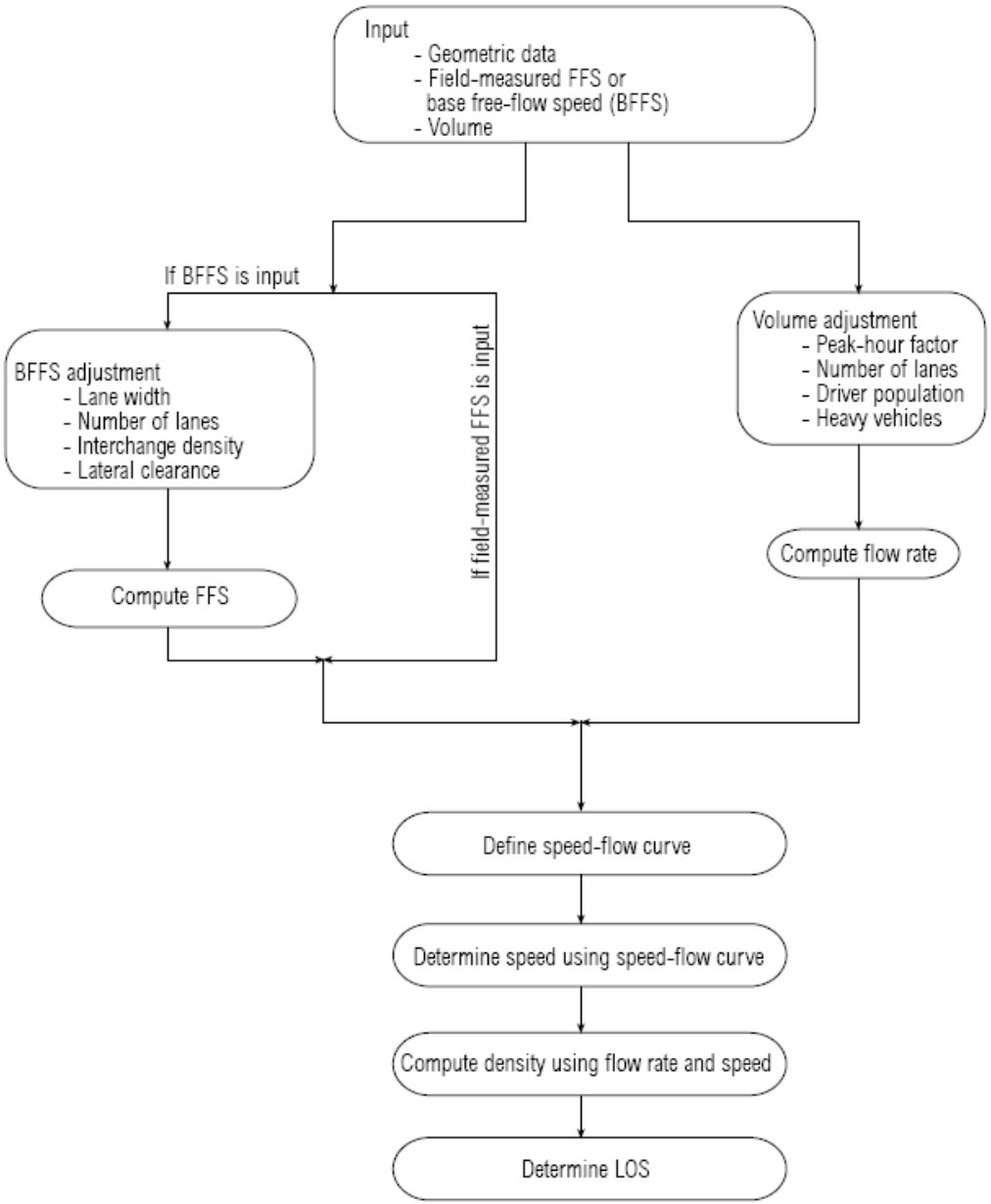
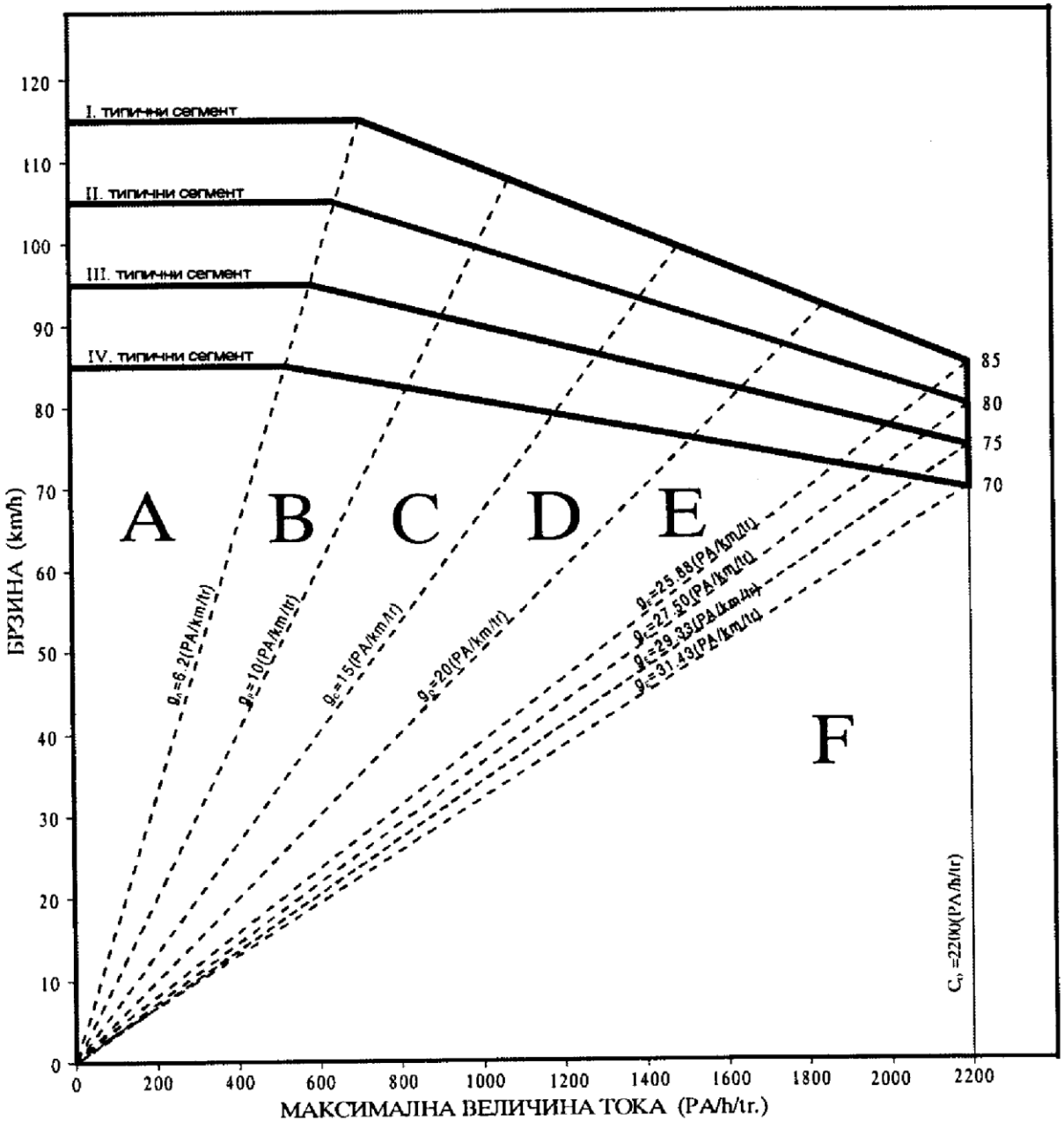
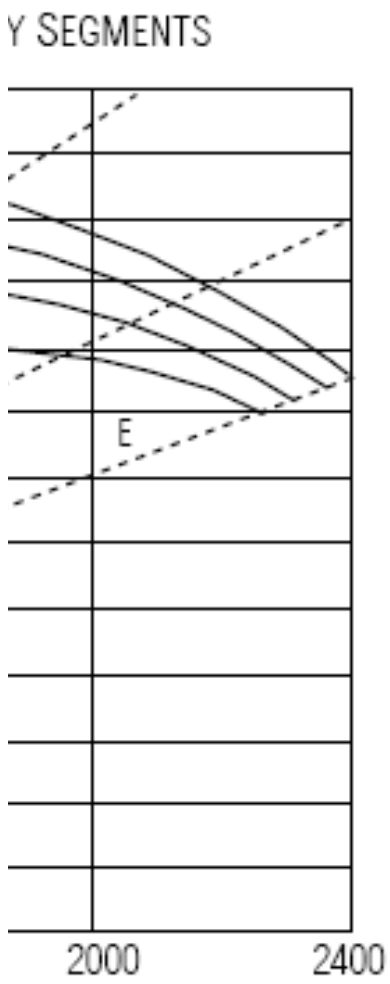


ILLUSTRATION 13-2.

EXHIBIT 23-1. BASIC FREEWAY SEGMENT METHODOLOGY




I. типични сегмент
II. типични сегмент
III. типични сегмент
IV. типични сегмент
A
B
C
D
E
F
85
80
75
70
g_c=6.2(PA/km/tr)
g_c=10(PA/km/tr)
g_c=15(PA/km/tr)
g_c=20(PA/km/tr)
g_c=25.88(PA/km/tr)
g_c=27.50(PA/km/tr)
g_c=29.33(PA/km/tr)
g_c=31.43(PA/km/tr)
C_v=2210(PA/h/tr)
БРЗИНА (km/h)
0
10
20
30
40
50
60
70
80
90
100
110
120
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
МАКСИМАЛНА ВЕЛИЧИНА ТОКА (PA/h/tr.)


Y SEGMENTS
E
2000
2400

Utvrđivanje brzine u slobodnom toku

$$FFS = BFFS - f_{LW} - f_{LC} - f_N - f_{ID}$$

FFS	=	free-flow speed (km/h);
$BFFS$	=	base free-flow speed, 110 km/h (urban) or 120 km/h (rural);
f_{LW}	=	adjustment for lane width from Exhibit 23-4 (km/h);
f_{LC}	=	adjustment for right-shoulder lateral clearance from Exhibit 23-5 (km/h);
f_N	=	adjustment for number of lanes from Exhibit 23-6 (km/h); and
f_{ID}	=	adjustment for interchange density from Exhibit 23-7 (km/h).

Faktor širine saobraćajne trake

EXHIBIT 23-4. ADJUSTMENTS FOR LANE WIDTH

Lane Width (m)	Reduction in Free-Flow Speed, f_{LW} (km/h)
3.6	0.0
3.5	1.0
3.4	2.1
3.3	3.1
3.2	5.6
3.1	8.1
3.0	10.6

Faktor udaljenosti bočnih smetrnji

EXHIBIT 23-5. ADJUSTMENTS FOR RIGHT-SHOULDER LATERAL CLEARANCE

Right-Shoulder Lateral Clearance (m)	Reduction in Free-Flow Speed, f_{LC} (km/h)			
	Lanes in One Direction			
	2	3	4	≥ 5
≥ 1.8	0.0	0.0	0.0	0.0
1.5	1.0	0.7	0.3	0.2
1.2	1.9	1.3	0.7	0.4
0.9	2.9	1.9	1.0	0.6
0.6	3.9	2.6	1.3	0.8
0.3	4.8	3.2	1.6	1.1
0.0	5.8	3.9	1.9	1.3

Faktor broja saobraćajnih traka

EXHIBIT 23-6. ADJUSTMENTS FOR NUMBER OF LANES

Number of Lanes (One Direction)	Reduction in Free-Flow Speed, f_N (km/h)
≥ 5	0.0
4	2.4
3	4.8
2	7.3

Note: For all rural freeway segments, f_N is 0.0.

Faktor gustine petlji

EXHIBIT 23-7. ADJUSTMENTS FOR INTERCHANGE DENSITY

Interchanges per Kilometer	Reduction in Free-Flow Speed, f_{ID} (km/h)
≤ 0.3	0.0
0.4	1.1
0.5	2.1
0.6	3.9
0.7	5.0
0.8	6.0
0.9	8.1
1.0	9.2
1.1	10.2
1.2	12.1

Merodavni protok

$$v_p = \frac{V}{PHF * N * f_{HV} * f_p}$$

v_p = 15-min passenger-car equivalent flow rate (pc/h/ln),
V = hourly volume (veh/h),
PHF = peak-hour factor,
N = number of lanes,
f_{HV} = heavy-vehicle adjustment factor, and
f_p = driver population factor.

Faktor teretnih i vikend vozila

$$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$$

E_T, E_R = passenger-car equivalents for trucks/buses and recreational vehicles (RVs) in the traffic stream, respectively;

P_T, P_R = proportion of trucks/buses and RVs in the traffic stream, respectively; and

f_{HV} = heavy-vehicle adjustment factor.

Za slučaj da je nagib manji od 3% na dužini manjoj od 500 m

EXHIBIT 23-8. PASSENGER-CAR EQUIVALENTS ON EXTENDED FREEWAY SEGMENTS

Factor	Type of Terrain		
	Level	Rolling	Mountainous
E_T (trucks and buses)	1.5	2.5	4.5
E_R (RVs)	1.2	2.0	4.0

Faktor teretnih i vikend vozača specijalni slučaj

EXHIBIT 23-9. PASSENGER-CAR EQUIVALENTS FOR TRUCKS AND BUSES ON UPGRADES

Upgrade (%)	Length (km)	E_T Percentage of Trucks and Buses								
		2	4	5	6	8	10	15	20	25
< 2	All	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
≥ 2–3	0.0–0.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	> 0.4–0.8	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	> 0.8–1.2	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	> 1.2–1.6	2.0	2.0	2.0	2.0	1.5	1.5	1.5	1.5	1.5
	> 1.6–2.4	2.5	2.5	2.5	2.5	2.0	2.0	2.0	2.0	2.0
	> 2.4	3.0	3.0	2.5	2.5	2.0	2.0	2.0	2.0	2.0
> 3–4	0.0–0.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	> 0.4–0.8	2.0	2.0	2.0	2.0	2.0	2.0	1.5	1.5	1.5
	> 0.8–1.2	2.5	2.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	> 1.2–1.6	3.0	3.0	2.5	2.5	2.5	2.5	2.0	2.0	2.0
	> 1.6–2.4	3.5	3.5	3.0	3.0	3.0	3.0	2.5	2.5	2.5
	> 2.4	4.0	3.5	3.0	3.0	3.0	3.0	2.5	2.5	2.5
> 4–5	0.0–0.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	> 0.4–0.8	3.0	2.5	2.5	2.5	2.0	2.0	2.0	2.0	2.0
	> 0.8–1.2	3.5	3.0	3.0	3.0	2.5	2.5	2.5	2.5	2.5
	> 1.2–1.6	4.0	3.5	3.5	3.5	3.0	3.0	3.0	3.0	3.0
	> 1.6	5.0	4.0	4.0	4.0	3.5	3.5	3.0	3.0	3.0
> 5–6	0.0–0.4	2.0	2.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	> 0.4–0.5	4.0	3.0	2.5	2.5	2.0	2.0	2.0	2.0	2.0
	> 0.5–0.8	4.5	4.0	3.5	3.0	2.5	2.5	2.5	2.5	2.5
	> 0.8–1.2	5.0	4.5	4.0	3.5	3.0	3.0	3.0	3.0	3.0
	> 1.2–1.6	5.5	5.0	4.5	4.0	3.0	3.0	3.0	3.0	3.0
	> 1.6	6.0	5.0	5.0	4.5	3.5	3.5	3.5	3.5	3.5
> 6	0.0–0.4	4.0	3.0	2.5	2.5	2.5	2.5	2.0	2.0	2.0
	> 0.4–0.5	4.5	4.0	3.5	3.5	3.5	3.0	2.5	2.5	2.5
	> 0.5–0.8	5.0	4.5	4.0	4.0	3.5	3.0	2.5	2.5	2.5
	> 0.8–1.2	5.5	5.0	4.5	4.5	4.0	3.5	3.0	3.0	3.0
	> 1.2–1.6	6.0	5.5	5.0	5.0	4.5	4.0	3.5	3.5	3.5
	> 1.6	7.0	6.0	5.5	5.5	5.0	4.5	4.0	4.0	4.0

EXHIBIT 23-10. PASSENGER-CAR EQUIVALENTS FOR RVs ON UPGRADES

Upgrade (%)	Length (km)	E_R Percentage of RVs								
		2	4	5	6	8	10	15	20	25
≤ 2	All	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
> 2–3	0.0–0.8	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
	> 0.8	3.0	1.5	1.5	1.5	1.5	1.5	1.2	1.2	1.2
> 3–4	0.0–0.4	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
	> 0.4–0.8	2.5	2.5	2.0	2.0	2.0	2.0	1.5	1.5	1.5
	> 0.8	3.0	2.5	2.5	2.5	2.0	2.0	2.0	1.5	1.5
> 4–5	0.0–0.4	2.5	2.0	2.0	2.0	1.5	1.5	1.5	1.5	1.5
	> 0.4–0.8	4.0	3.0	3.0	3.0	2.5	2.5	2.0	2.0	2.0
	> 0.8	4.5	3.5	3.0	3.0	3.0	2.5	2.5	2.0	2.0
> 5	0.0–0.4	4.0	3.0	2.5	2.5	2.5	2.0	2.0	2.0	1.5
	> 0.4–0.8	6.0	4.0	4.0	3.5	3.0	3.0	2.5	2.5	2.0
	> 0.8	6.0	4.5	4.0	4.5	3.5	3.0	3.0	2.5	2.0

EXHIBIT A23-1. SAMPLE SOLUTION FOR COMPOSITE GRADE

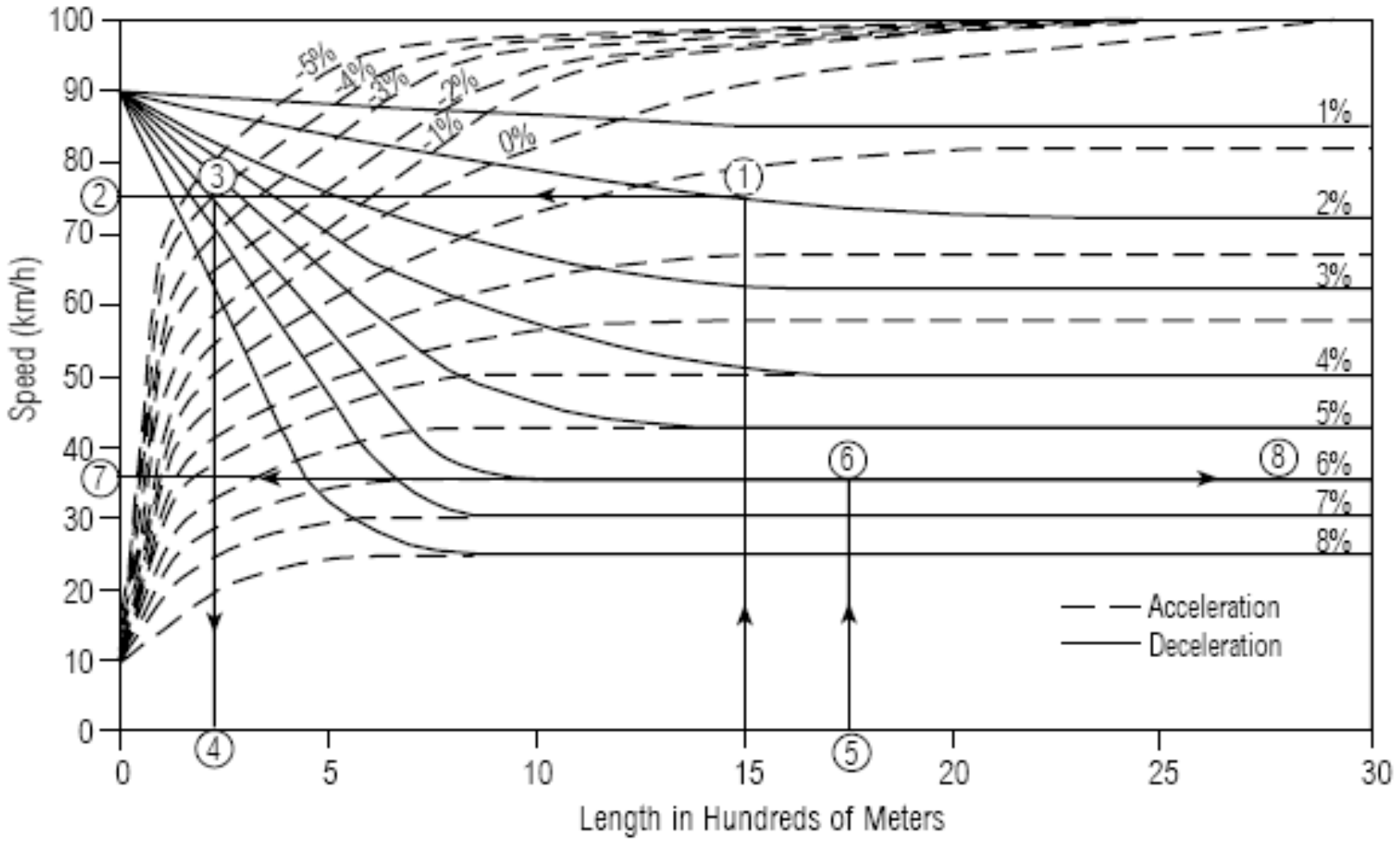


EXHIBIT 23-11. PASSENGER-CAR EQUIVALENTS FOR TRUCKS AND BUSES ON DOWNGRADES

Downgrade (%)	Length (km)	E_T Percentage of Trucks			
		5	10	15	20
< 4	All	1.5	1.5	1.5	1.5
4–5	≤ 6.4	1.5	1.5	1.5	1.5
4–5	> 6.4	2.0	2.0	2.0	1.5
> 5–6	≤ 6.4	1.5	1.5	1.5	1.5
> 5–6	> 6.4	5.5	4.0	4.0	3.0
> 6	≤ 6.4	1.5	1.5	1.5	1.5
> 6	> 6.4	7.5	6.0	5.5	4.5

UTVRĐIVANJE GUSTINE

$$D = \frac{v_p}{S}$$

D = density (pc/km/ln),
v_p = flow rate (pc/h/ln), and
S = average passenger-car speed (km/h).

Utvrđivanje prosečne brzine toka

For $90 \le FFS \le 120$ and for flow rate (v_p)

$(3100 - 15FFS) < v_p \le (1800 + 5FFS)$,

$$S = FFS - \left[\frac{1}{28}(23FFS - 1800)\left(\frac{v_p + 15FFS - 3100}{20FFS - 1300} \right)^{2.6} \right]$$

For $90 \leq FFS \leq 120$ and
$v_p \leq (3100 - 15FFS)$,
$S = FFS$

NIVO USLUGE
LOS (Level Of Service)

LOS	Density Range (pc/km/ln)
A	0–7
B	> 7–11
C	> 11–16
D	> 16–22
E	> 22–28
F	> 28

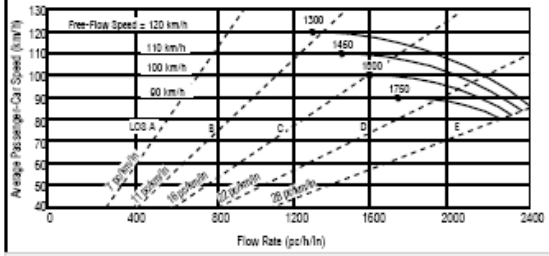
EXHIBIT 23-2. LOS CRITERIA FOR BASIC FREEWAY SEGMENTS

Criteria	LOS				
	A	B	C	D	E
FFS = 120 km/h					
Maximum density (pc/km/ln)	7	11	16	22	28
Minimum speed (km/h)	120.0	120.0	114.6	99.6	85.7
Maximum v/c	0.35	0.55	0.77	0.92	1.00
Maximum service flow rate (pc/h/ln)	840	1320	1840	2200	2400
FFS = 110 km/h					
Maximum density (pc/km/ln)	7	11	16	22	28
Minimum speed (km/h)	110.0	110.0	108.5	97.2	83.9
Maximum v/c	0.33	0.51	0.74	0.91	1.00
Maximum service flow rate (pc/h/ln)	770	1210	1740	2135	2350
FFS = 100 km/h					
Maximum density (pc/km/ln)	7	11	16	22	28
Minimum speed (km/h)	100.0	100.0	100.0	93.8	82.1
Maximum v/c	0.30	0.48	0.70	0.90	1.00
Maximum service flow rate (pc/h/ln)	700	1100	1600	2065	2300
FFS = 90 km/h					
Maximum density (pc/km/ln)	7	11	16	22	28
Minimum speed (km/h)	90.0	90.0	90.0	89.1	80.4
Maximum v/c	0.28	0.44	0.64	0.87	1.00
Maximum service flow rate (pc/h/ln)	630	990	1440	1955	2250

Note:
The exact mathematical relationship between density and v/c has not always been maintained at LOS boundaries because of the use of rounded values. Density is the primary determinant of LOS. The speed criterion is the speed at maximum density for a given LOS.

EXHIBIT 23-16. BASIC FREEWAY SEGMENTS WORKSHEET

BASIC FREEWAY SEGMENTS WORKSHEET



Application	Input	Output
Operational (LOS)	FFS, N, v_p	LOS, S, D
Design (N)	FFS, LOS, v_p	N, S, D
Design (v_p)	FFS, LOS, N	v_p, S, D
Planning (LOS)	FFS, N, AADT	LOS, S, D
Planning (N)	FFS, LOS, AADT	N, S, D
Planning (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst _____
Agency or Company _____
Date Performed _____
Analysis Time Period _____

Site Information

Highway/Direction of Travel _____
From/To _____
Jurisdiction _____
Analysis Year _____

❑ Operational (LOS) ❑ Design (N) ❑ Design (v_p) ❑ Planning (LOS) ❑ Planning (N) ❑ Planning (v_p)

Flow Inputs

Volume, V _____ veh/h
Annual avg. daily traffic, AADT _____ veh/day
Peak-hour proportion of AADT, K _____
Peak-hour direction proportion, D _____
DDHV = AADT * K * D _____ veh/h
Driver type ❑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF _____
% Trucks and buses, P_T _____
% RVs, P_R _____
General terrain
❑ Level ❑ Rolling ❑ Mountainous
Grade Length _____ km Up/Down _____ %

Calculate Flow Adjustments

f_p _____
E_T _____

E_R _____
$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$ _____

Speed Inputs

Lane width _____ m
Rt.-shoulder lateral clearance _____ m
Interchange density _____ i/km
Number of lanes, N _____
FFS (measured) _____ km/h
Base free-flow speed, BFFS _____ km/h

Calculate Speed Adjustments and FFS

f_{LW} _____ km/h
f_{LC} _____ km/h
f_{ID} _____ km/h
f_N _____ km/h
FFS = BFFS – f_{LW} – f_{LC} – f_{ID} – f_N _____ km/h

LOS and Performance Measures

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{PHF * N * f_{HV} * f_p}$ _____ pc/h/ln
S _____ km/h
D = v_p /S _____ pc/km/ln
LOS _____

Design (v_p) or Planning (v_p)

LOS _____
v_p _____ pc/h/ln
V = v_p * PHF * N * f_{HV} * f_p _____ veh/h
S _____ km/h
D = v_p /S _____ pc/km/ln

Design (N) or Planning (N) 1st Iteration

N _____ assumed
$v_p = \frac{V \text{ or } DDHV}{PHF * N * f_{HV} * f_p}$ _____ pc/h/ln
LOS _____

Design (N) or Planning (N) 2nd Iteration

N _____ assumed
$v_p = \frac{V \text{ or } DDHV}{PHF * N * f_{HV} * f_p}$ _____ pc/h/ln
S _____ km/h
D = v_p /S _____ pc/km/ln
LOS _____

Glossary

N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design-hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_R - Exhibits 23-8, 23-10
E_T - Exhibits 23-8, 23-9, 23-11
f_p - Page 23-12
LOS, S, FFS, v_p - Exhibits 23-2, 23-3
f_{LW} - Exhibit 23-4
f_{LC} - Exhibit 23-5
f_N - Exhibit 23-6
f_{ID} - Exhibit 23-7