


Cairo University
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Traffic Engineering

Intersection Delay and LOS Analysis

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Capacity

- *Saturation flow rate, S (veh/h)* = maximum hourly volume assuming green signal displayed constantly
- Portion of saturation flow used = portion of cycle which is effectively green
- *Capacity, c (veh/h)* = maximum hourly volume that can use the lane group

$$c = S \left(\frac{G_e}{C} \right)$$

Capacity (vph) ←

Effective green time (sec) ↗

Cycle length (sec) →

For a given approach or lane group

Saturation flow rate under prevailing conditions (vphg) ↓

Saturation Flow Rate Prediction

$$S = S_o \cdot N \cdot f_w \cdot f_{HV} \cdot f_g \cdot f_p \cdot f_{bb} \cdot f_a \cdot f_{LU} \cdot f_{LT} \cdot f_{RT}$$

where:

- S = saturation flow rate for subject lane group, expressed as a total for all lanes in lane group (veh/h);
 S_o = base saturation flow rate per lane = 1900 (pc/h/ln);
 N = number of lanes in lane group;
 f_w = adjustment factor for lane width;
 f_{HV} = adjustment factor for heavy vehicles in traffic stream;
 f_g = adjustment factor for approach grade;
 f_p = adjustment factor for existence of a parking lane and parking activity adjacent to lane group;
 f_{bb} = adjustment factor for blocking effect of local buses that stop within intersection area;
 f_a = adjustment factor for area type;
 f_{LU} = adjustment factor for lane utilization; **use default values**
 f_{LT} = adjustment factor for left turns in lane group ;
 f_{RT} = adjustment factor for right turns in lane group.

Intersection Delay and LOS analysis

Saturation Flow Rate Prediction

$$f_w = 1 + \frac{(W - 12)}{30}$$

W = lane width (ft)

$$f_{HV} = \frac{100}{100 + \%HV(E_T - 1)}$$

$\%HV$ = percent heavy vehicles for lane group volume

$$f_g = 1 - \frac{\%G}{200}$$

$\%G$ = percent grade on a lane group approach

$$f_p = \frac{N - 0.1 - \frac{18N_m}{3600}}{N}$$

N = number of lanes in lane group
 N_m = number of parking maneuvers/h

$$f_{bb} = \frac{N - \frac{14.4N_B}{3600}}{N}$$

N = number of lanes in lane group
 N_B = number of buses stopping/h

$$f_a = 0.900 \text{ in CBD}$$

$$f_a = 1.0 \text{ in all other areas}$$

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Saturation Flow Rate Prediction

f_{LU} :	Through or shared lane group:	$f_{LU}=0.95$	
	Exclusive left turn or right turn	$f_{LU}=1$	
f_{LT} :	Shared lane group:	$f_{LT}=1/(1+0.05 P_{LT})$	
	Exclusive left turn :	$f_{LT}=0.95$	P_{LT} = proportion of LTs in lane group
f_{RT} :	Exclusive right turn :	$f_{RT}=0.85$	
	Shared lane :	$f_{RT}=1-0.15P_{RT}$	P_{RT} = proportion of RTs in lane group

Intersection Delay and LOS analysis

Delay for each lane group

$$d_{li} = 0.5C \frac{\left(1 - \frac{g_i}{C}\right)^2}{1 - \left(\frac{g_i}{C}\right) [\min(X_i, 1.0)]}$$

Where:

d_{li} = delay per vehicle for lane group i (sec/veh),

C = cycle length (seconds),

g_i = effective green time for lane group i (seconds),

X_i = volume/capacity (v/c) ratio for lane group i

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Delay for each approach

Approach Delay is a weighted average of the stopped delays of all lane groups on that approach.

$$d_A = \frac{\sum_i d_i v_i}{\sum_i v_i}$$

Where:

d_A = average delay per vehicle for approach A in seconds,

d_i = average delay per vehicle for lane group i (on approach A) in seconds, and

v_i = analysis flow rate for lane group i in veh/h.

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Delay for Intersection

Intersection Delay is the weighted average of the stopped delays of all approaches .

$$d_I = \frac{\sum_A d_A v_A}{\sum_A v_A}$$

Where:

d_I = average delay per vehicle for intersection in seconds, and

d_A = average delay per vehicle for approach A in seconds, and

v_A = analysis flow rate for approach A in veh/h.

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LOS at intersections

LOS	Signalized Intersection
A	≤10 sec
B	10–20 sec
C	20–35 sec
D	35–55 sec
E	55–80 sec
F	≥80 sec

Example: find the delay for the intersection designed in previous lecture, and the LOS of each lane group, approach, and intersection.

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Example

Given: Look at dwg.
 No. of parking maneuvers per hour = 10
 No. of bus blockage/hour = 10
 PHF = 0.85

Solution:

$$f_{HV} = \frac{100}{100 + 4(2 - 1)} = 0.962$$

$$f_x = 1 - \left(\frac{-4}{200}\right) = 1.02$$

$$f_p = \left(\frac{2 - 0.1 - \left(\frac{18 \times 10}{3600}\right)}{2}\right) = 0.925$$

$$f_{bb} = \left[\frac{2 - \frac{14.4 \times 10}{3600}}{2}\right] = 0.98$$

$$P_{RT} = \left(\frac{115/0.85}{865/0.85}\right) = 0.133$$

$$f_{RT} = 1.0 - (0.15)0.133 = 0.980$$

The diagram shows a four-way intersection. The North-South Street (N/S STREET) has a width of 48' and a grade of -2%. It has two 12' lanes in each direction. The East-West Street (E/W STREET) has a width of 115' and a grade of 4%. It has two 12' lanes in each direction. The intersection is divided into four quadrants. The top-left quadrant shows a 68' wide area with a 12' lane and a 12' lane. The top-right quadrant shows a 150' wide area with a 12' lane and a 12' lane. The bottom-left quadrant shows a 750' wide area with a 12' lane and a 12' lane. The bottom-right quadrant shows a 40' wide area with a 250' wide area and a 45' wide area. The total number of vehicles per hour (NB TOTAL) is 335. The grade of the bottom-right quadrant is 2% and the %HV is 3%.

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Example

1. West Approach: Through-Right Lane group

$$S = S_o \cdot N \cdot f_w \cdot f_{HV} \cdot f_g \cdot f_p \cdot f_{bb} \cdot f_a \cdot f_{LU} \cdot f_{LT} \cdot f_{RT}$$

$$= 1900 \cdot 2 \cdot 1 \cdot 0.962 \cdot 1.02 \cdot 0.925 \cdot 0.98 \cdot 1 \cdot 0.95 \cdot 1 \cdot 0.98 =$$

grade = -2
%HV = 3%

2. West Approach: Left Lane group

$$S = S_o \cdot N \cdot f_w \cdot f_{HV} \cdot f_g \cdot f_p \cdot f_{bb} \cdot f_a \cdot f_{LU} \cdot f_{LT} \cdot f_{RT}$$

$$= 1900 \cdot 1 \cdot 1 \cdot 0.962 \cdot 1.020 \cdot 1 \cdot 1 \cdot 1 \cdot 1 \cdot 0.95 \cdot 1 =$$

grade = -4
%HV = 4%

Diagram details:
 - N/S STREET: 48' wide, 12' lane width, grade = -2, %HV = 3%.
 - E/W STREET: 250' wide, 40' and 45' lane widths, grade = -2, %HV = 3%.
 - West Approach: 68' wide, 12' lane width, grade = -4, %HV = 4%.
 - East Approach: 24' wide, 12' lane width, grade = -4, %HV = 4%.
 - Box: 335 NB TOTAL.

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