2.4 Quantifying the Quality of Progression

The Highway Capacity Manual quantifies the quality of progression using the concept of the platoon ratio. The platoon ratio (R_p) is defined as the ratio of the arrival flow rate during green and the average arrival flow rate over the entire cycle.

Equation 1

$$R_p = \frac{v_g}{v}$$

where:

v_g = the arrival flow rate during green, veh/hr, and
v = average arrival flow rate over the entire cycle, veh/hr

Another concept that is commonly used to describe the quality of progression is the proportion of vehicles that arrive during the effective green period, P:

Equation 2

$$P = \frac{number\ of\ vehicles\ that\ arrive\ during\ g}{number\ of\ vehicles\ that\ arrive\ during\ C}$$

where:

g = effective green period, and
C = cycle.

When the vehicle counts described in Equation 2 are converted to flow rates, P can also be written as:

Equation 3

$$P = \frac{v_g}{v}\left(\frac{g}{C}\right)$$

Or, combining Equation 1 and Equation 3 leads to another form for the platoon ratio:

Equation 4

$$R_p = \frac{P}{g/C}$$

Let's consider three cases to see the relationship between the proportion of vehicles that arrive during green (P) and the delay experienced by these vehicles. It is assumed here that the flow rate is uniformly distributed during the effective green period and the effective red period, according the percentage listed below:

- Case 1: 10 percent of the vehicles arrive during green
- Case 2: 90 percent of the vehicles arrive during green
- Case 3: 50 percent of the vehicles arrive during green

Table 1 shows the effect of P on the delay experienced on one approach of a signalized intersection. The calculations summarized in the table assume that C = 90 sec, g/C = 0.5, the average arrival flow rate to be 800 veh/hr, and the saturation flow rate to be 1900 veh/hr. For case 1, only ten percent of the vehicles arrive during the effective green period, equivalent to a flow rate of 160 veh/hr. The queue service time (g_s), the time for the queue to clear after the beginning of green) is 37.2 sec, while the queue length at this point is 18 vehicles. The average uniform delay is equal to 37.0 sec/veh.

By contrast, in case 2, 90 percent of the vehicles arrive during the effective green period. The queue that formed during effective red, (2 vehicles) takes only 15.7 sec to clear. The average uniform delay is 3.0 sec/veh, a dramatic difference from case 1. It should be clear from the results of these three cases that the manner in which vehicles arrive at the intersection (particularly the proportion that arrive during effective green) directly affect the delay experienced by the vehicles.

The calculations for case 1 are summarized here:

$$g_s = \frac{v_r r}{s - v_g} = \frac{(1440)(45)}{1900 - 160} = 37.2\ sec$$

$$D_t = 0.5(r + g_s)(v_r r) = 0.5(45 + 37.2)(1440)(45) = 740.2\ veh - sec$$

$$d_a = \frac{D_t}{v/3600/C} = \frac{740.2}{800/(\frac{3600}{90})} = \ 37.0\ sec/veh$$

Table 1 Effect of P on average delay

Case	P	v_g	v_r	g_s	$v_r r$	D_t	d_a
1	0.1	160	1440	37.2	18	740.2	37.0
2	0.9	1440	160	15.7	2	60.7	3.0
3	0.5	800	800	32.7	10	388.6	19.4

The QAPs for each case are shown on the next page. The QAPs show that the more vehicles that arrive during red, the larger the area under the curve and the longer the resulting delay. When more vehicles arrive during green, the area is small and the delay is relatively short.

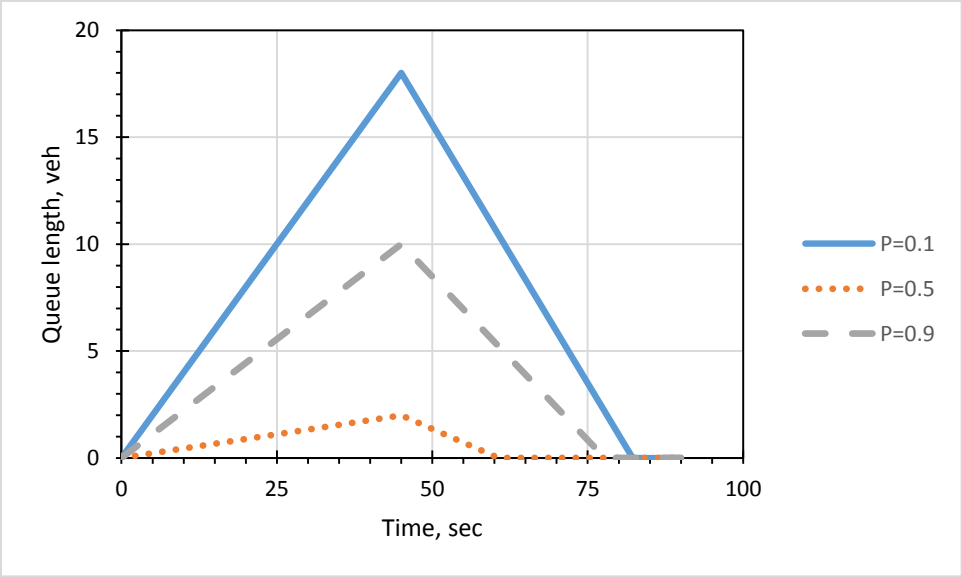

Figure 1. Queue accumulation polygons for three cases of P

Activity 2.2: Measuring Progression Quality – Field Observations

Purpose

The purpose of this activity is to determine the quality of progression on an approach to a signalized intersection by measuring the proportion of vehicles arriving during green.

Field Task

For each of 20 cycles during the afternoon peak period (approximately between 445 pm and 530 pm), record the following data on the data sheet provided for the approach to which you have been assigned:

- Green start time (clock time) to the nearest second
- Green end time (clock time) to the nearest second
- Number of vehicles arriving during the green display
- Number of vehicles arriving during the yellow and red displays

Analysis

1. Enter the above data into an Excel spreadsheet
2. Compute the following data for each cycle:
   - Green interval duration, in seconds
   - The cycle length, in seconds
   - Proportion of vehicles arriving during green and during red.
3. Compute the mean durations of the green interval and the cycle length, and the mean value of the green ratio (g/C).
4. Compute the platoon ratio (R_p) and the proportion of vehicles that arrive during green (P).

Critical Thinking Question

1. Based on the computed values of P and R_p, and comparison of these values with those shown in Table 1 and the three queue accumulation polygons (Figure 1), what is your assessment of the quality of progression on this intersection approach.

Deliverable

Excel workbook with your data, analysis, and answers to the Critical Thinking Question.

Data Collection Form

Intersection:
Approach:
Date:
Time:
Data collection
Team:

Cycle #	Clock time		Number of vehicles arriving during…	
	Green time start	Green time end	Green	Red
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				