

Chapter 7

Measurement along a Length of Road

7.1 Overview

This is normally used to obtain variations in speed over a stretch of road. Usually the stretch will be having a length more than 500 meters. We can also get speed, travel time and delay. Speed and travel time are the most commonly used indicators of performance for traffic facilities and networks. Delays are often used to measure the performance of traffic flow at intersections.

7.2 Travel time study

Travel time is the elapsed time it takes for a vehicle to traverse a given segment of a street. Travel time studies provide the necessary data to determine the average travel time. Combined with the length of the corridor under study, this data can be used to produce average travel speed. Travel time and delay are two of the principal measures of roadway system performance used by traffic engineers, planners and analysts. Since vehicle speed is directly related to travel time and delay, it is also an appropriate measure-of-performance to evaluate traffic systems.

A study conducted to determine the amount of time required to traverse a specific route or section of a street or highway. The data obtained provide travel time and travel speed information but not necessarily delay. This term is often used to include speed and delay study. Travel time may be defined as the total elapsed time of travel, including stop and delay, necessary for a vehicle to travel from one point to another point over a specified route under existing traffic condition.

7.3 Delay studies

Delay is defined as an extra time spent by drivers against their expectation. Delay can have many forms depending on different locations. A study made to provide information concerning

the amount, cause, location, duration and frequency of delay as well as travel time and similar value. The time lost by traffic due to traffic friction and traffic control device is called delay.

7.4 Types of Delay

1. Congestion delay- Congestion delay is the delay caused by the constricting or slowing down effect of overloaded intersections, inadequate carriageway widths, parked cars, crowded pavement and similar factor.
2. Fixed Delay- The delay to which a vehicle is subjected regardless of the amount of traffic volume and interference present.
3. Operational Delay-The delay caused by interference from other component of the traffic stream. Examples include time lost while waiting for a gap in a conflicting traffic stream, or resulting from congestion, parking maneuvers, pedestrians, and turning movement.
4. Stopped Delay- The time a vehicle is not moving.
5. Travel Time Delay- The difference between the actual time required to traverse a section of street or highway and the time corresponding to the average speed of traffic under uncongested condition. It includes acceleration and deceleration delay in addition to stopped delay.
6. Approach Delay -Travel time delay encountered to an approach to an intersection.

7.5 Purpose of travel time and Delay Studies

1. The purpose of a Travel Time and Delay Study is to evaluate the quality of traffic movement along a route and determine the locations, types, and extent of traffic delays by using a moving test vehicle.
2. This study method can be used to compare operational conditions before and after roadway or intersection improvements have been made. It can also be used as a tool to assist in prioritizing projects by comparing the magnitude of the operational deficiencies (such as delays and stops) for each project under consideration.
3. The Travel Time and Delay Study can also be used by planners to monitor level of service for local government comprehensive plans.

4. The methodology presented herein provides the engineer with quantitative information with which he can develop recommendations for improvements such as traffic signal re-timing, safety improvements, turn lane additions, and channelization enhancements

7.6 Method for obtaining travel time and delay study

1. **Floating Car Method:** Floating car data are positions of vehicles traversing city streets throughout the day. In this method the driver tries to float in the traffic stream passing as many vehicles as pass the test car. If the test vehicle overtakes as many vehicles as the test vehicle is passed by, the test vehicles should, with sufficient number of runs, approach the median speed of the traffic movement on the route. In such a test vehicle, one passenger acts as observer while another records duration of delays and the actual elapsed time of passing control points along the route from start to finish of the run.
2. **Average Speed Method:** In this method the driver is instructed to travel at a speed that is judge to the representative of the speed of all traffic at the time.
3. **Moving-vehicle method:** In this method, the observer moves in the traffic stream and makes a round trip on a test section. The observer starts at section, drives the car in a particular direction say eastward to another section, turns the vehicle around drives in the opposite direction say westward toward the previous section again. Let, the time in minutes it takes to travel east (from X-X to Y-Y) is t_a , the time in minutes it takes to travel west (from Y-Y to X-X) is t_w , the number of vehicles traveling east in the opposite lane while the test car is traveling west be m_a , the number of vehicles that overtake the test car while it is traveling west be m_o , and the number of vehicles that the test car passes while it is traveling west from be m_p . The volume (q_w) in the westbound direction

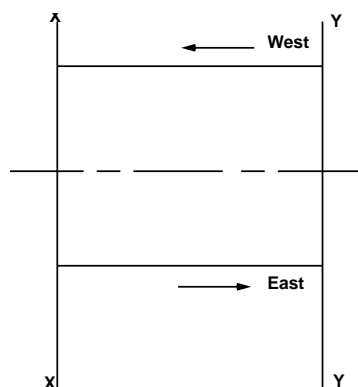


Figure 7:1: Illustration of moving observer method

can then be obtained from the expression and

$$qw = \frac{ma + mo - mp}{ta + tw}$$

the average travel time in the westbound direction is obtained from

$$tw(avg) = tw - \frac{mo - mp}{qw}$$

4. **Maximum-car method:** In this procedure, the driver is asked to drive as fast as is safely practical in the traffic stream without ever exceeding the design speed of the facility.
5. **Elevated Observer method:** In urban areas, it is sometime possible to station observers in high buildings or other elevated points from which a considerable length of route may be observed. These investigator select vehicle at random and record; time, location and causes-of-delay. The drawback is that it is sometime difficult to secure suitable points for observation throughout the length of the route to be studied.
6. **License Plate Method:** when the amount of turning off and on the route is not great and only over all speed value are to be secured, the license-plate method of speed study may be satisfactorily employed. Investigator stationed at control point along the route enters, on a time control basis, the license-plate numbers of passing vehicles. These are compared from point to point along the route, and the difference in time values, through use of synchronized watches, is computed. This method requires careful and time-consuming office work and does not show locations, causes, frequency, or duration of delay. Four basic methods of collecting and processing license plates normally considered are:
 - (a) **Manual:** collecting license plates via pen and paper or audio tape recorders and manually entering license plates and arrival times into a computer.
 - (b) **Portable Computer:** collecting license plates in the field using portable computers that automatically provide an arrival time stamp.
 - (c) **Video with Manual Transcription:** collecting license plates in the field using video cameras or camcorders and manually transcribing license plates using human observers.
 - (d) **Video with Character Recognition:** collecting license plates in the field using video, and then automatically transcribing license plates and arrival times into a computer using computerized license plate character recognition.

7. **Photographic Method:** This method is primarily a research tool, it is useful in studies of interrelationship of several factors such as spacing, speeds, lane usage, acceleration rates, merging and crossing maneuvers, and delays at intersections. This method is applicable to a short test section only.
8. **Interview Method:** this method may be useful where a large amount of material is needed in a minimum of time and at little expense for field observation. Usually the employees of a farm or establishment are asked to record their travel time to and from work on a particular day.
9. **Highway Capacity Manual 2000 or (Cycle- based method):** This method is applicable to all under saturated signalized intersections. For over-saturated conditions, queue buildup normally makes the method impractical. The method described here is applicable to situations in which the average maximum queue per cycle is no more than about 20 to 25 veh/ln. When queues are long or the demand to capacity ratio is near 1.0, care must be taken to continue the vehicle-in-queue count past the end of the arrival count period, vehicles that arrived during the survey period until all of them have exited the intersection.as detailed below. This requirement is for consistency with the analytic delay equation used in the chapter text.method does not directly measure delay during deceleration and during a portion of acceleration, which are very difficult to measure without sophisticated tracking equipment. However, this method has been shown to yield a reasonable estimate of control delay.

The method includes an adjustment for errors that may occurred when this type of sampling technique is used, as well as an acceleration-deceleration delay correction factor Table 7:1. The acceleration-deceleration factor is a function of the typical number of vehicles in queue during each cycle and the normal free-flow speed when vehicles are unimpeded by the signal. Before beginning the detailed survey, the observers need to make an estimate of the average free-flow speed during the study period. Free-flow speed is the speed at which vehicles would pass unimpeded through the intersection if the signal were green for an extended period.be obtained by driving through the intersection a few times when the signal is green and there is no queue and recording the speed at a location least affected by signal control. Typically, the recording location should be upstream about mid-block. Table 7:2 is a worksheet that can be used for recording observations and computation of average time-in-queue delay Steps for data reduction

- (a) Sum each column of vehicle-in-queue counts, then sum the column totals for the entire survey period.

| Free-Flow Speed | ≤ 7 Vehicles | 8-19 Vehicles | 20-30 Vehicles |
|----------------------|-------------------|---------------|----------------|
| $\leq 60\text{km/h}$ | 5 | 2 | 1 |
| 60-71 km/h | 7 | 4 | 2 |
| ≥ 71 km/h | 9 | 7 | 5 |

Table 7:1: Acceleration-Deceleration Delay Correction Factor, CF (seconds)

- (b) A vehicle recorded as part of a vehicle-in-queue count is in queue, on average, for the time interval between counts. The average time-in-queue per vehicle arriving during the survey period is estimated.

$$d_{vq} = \left(I_s \times \frac{\Sigma V_{iq}}{V_{tot}} \right) 0.9$$

where, I_s = interval between vehicle-in-queue counts (s), ΣV_{iq} = sum of vehicle-in-queue counts (veh), V_{tot} = total number of vehicles arriving during the survey period (veh), and 0.9 = empirical adjustment factor. The 0.9 adjustment factor accounts for the errors that may occur when this type of sampling technique is used to derive actual delay values, normally resulting in an overestimate of delay.

- (c) Compute the fraction of vehicles stopping and the average number of vehicles stopping per lane in each signal cycle, as indicated on the worksheet.
- (d) Using Table 7:1, look up a correction factor appropriate to the lane group free-flow speed and the average number of vehicles stopping per lane in each cycle. This factor adds an adjustment for deceleration and acceleration delay, which cannot be measured directly with manual techniques.
- (e) Multiply the correction factor by the fraction of vehicles stopping, and then add this product to the time-in-queue value of Step 2 to obtain the final estimate of control delay per vehicle.

Numerical Example

A test was conducted to determine the delay in an intersection. Table 7:3 presents a sample computation on direct observation of vehicle-in-queue counts at the intersection. The traffic signal at the intersection operates with a cycle time of 115 sec. The test was conducted on the 2 lane road over a 15-min period, which is almost thirteen cycles. Count interval was 15-s. The total number of vehicle is 530 and the total number of stopped vehicle is 223. Assume the free flow speed to be 65 km/h and the empirical adjustment factor 0.9

| INTERSECTION CONTROL DELAY WORKSHEET | | | | | | | | | | | |
|--------------------------------------|--------------|----------------|----|----|-----------------------------------|---|---------------------------------|---|---|---|----|
| General Information | | | | | Site Information | | | | | | |
| Analyst | _____ | | | | Intersection | _____ | | | | | |
| Agency or Company | _____ | | | | Area Type | <input checked="" type="checkbox"/> CBD | <input type="checkbox"/> Others | | | | |
| Date Performed | _____ | | | | Jurisdiction | _____ | | | | | |
| Analysis Time Period | _____ | | | | Analysis Year | _____ | | | | | |
| Input Initial Parameters | | | | | Input Field Data | | | | | | |
| Number of lanes, N | 2 | | | | Total vehicle arriving, V_{tot} | 530 | | | | | |
| Free-flow speed, FFS (km/h) | 65 | | | | Stopped vehicle count, V_{stop} | 223 | | | | | |
| Survey count interval, I_s (s) | 15 | | | | Cycle length, C (s) | _____ | | | | | |
| Input Field Data | | | | | Number of vehicles in Queue | | | | | | |
| Clock Time | Cycle Number | Count Interval | | | | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 4:34 | 1 | 3 | 8 | - | 15 | 12 | 2 | 0 | 2 | | |
| | 2 | 6 | 12 | 15 | 16 | 6 | 0 | 0 | 2 | | |
| 4:35 | 3 | 7 | - | 14 | 14 | 2 | 0 | 0 | | | |
| | 4 | 5 | 7 | 10 | 13 | 13 | 2 | 0 | 1 | | |
| 4:36 | 5 | 4 | 6 | 10 | 12 | 3 | 0 | 0 | 1 | | |
| | 6 | 5 | 7 | 9 | 13 | 4 | 0 | 0 | | | |
| 4:37 | 7 | 3 | 6 | 9 | 12 | 12 | 0 | 0 | 0 | | |
| | 8 | 4 | 7 | - | 16 | 9 | 0 | | | | |
| Total | | 37 | 64 | 88 | - | 61 | 4 | 0 | 6 | | |

Figure 7:2: Intersection delay worksheet

| General Information | | | | | Site Information | | | | | | |
|----------------------------------|--------------|----------------|----|----|-----------------------------------|---|---------------------------------|---|---|---|----|
| Analyst | _____ | | | | Intersection | _____ | | | | | |
| Agency or Company | _____ | | | | Area Type | <input checked="" type="checkbox"/> CBD | <input type="checkbox"/> Others | | | | |
| Date Performed | _____ | | | | Jurisdiction | _____ | | | | | |
| Analysis time period | _____ | | | | Analysis Year | 1999 | | | | | |
| Input Initial Parameters | | | | | Input Field Data | | | | | | |
| Number of lanes, N | 2 | | | | Total vehicle arriving, V_{tot} | 530 | | | | | |
| Free-flow speed, FFS (km/h) | 65 | | | | Stopped vehicle count, V_{stop} | 223 | | | | | |
| Survey count interval, I_s (s) | 15 | | | | Cycle length, C (s) | _____ | | | | | |
| Input Field Data | | | | | Number of vehicles in Queue | | | | | | |
| Clock Time | Cycle Number | Count Interval | | | | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 4:34 | 1 | 3 | 8 | - | 15 | 12 | 2 | 0 | 2 | | |
| | 2 | 6 | 12 | 15 | 16 | 6 | 0 | 0 | 2 | | |
| 4:35 | 3 | 7 | - | 14 | 14 | 2 | 0 | 0 | | | |
| | 4 | 5 | 7 | 10 | 13 | 13 | 2 | 0 | 1 | | |
| 4:36 | 5 | 4 | 6 | 10 | 12 | 3 | 0 | 0 | 1 | | |
| | 6 | 5 | 7 | 9 | 13 | 4 | 0 | 0 | | | |
| 4:37 | 7 | 3 | 6 | 9 | 12 | 12 | 0 | 0 | 0 | | |
| | 8 | 4 | 7 | - | 16 | 9 | 0 | | | | |
| Total | | 37 | 64 | 88 | - | 61 | 4 | 0 | 6 | | |

Figure 7:3: Example of the intersection control delay worksheet

Solution:

1. Number of lane, $N=2$
2. Free-flow Speed, $FFS = 65 \text{ km/h}$
3. Survey count interval, $I_s = 15 \text{ sec}$
4. Total vehicle in queue, $\sum V_{iq} = 371$
5. Total vehicles arriving, $V_{tot} = 530$
6. Stopped vehicles count, $V_{stop} = 223$
7. No of Cycle Surveyed, $N_c=7.8$
8. Acc./Dec. correction factor, $CF=4$ (from Table 7.1)

9. No. Of Vehicles stopped per lane each cycle

$$V_{stop} N_c \times N = \frac{223}{7.8 \times 2} = 14$$

10. Fraction of vehicles stopping,

$$FVS = \frac{V_{stop}}{V_{tot}} = \frac{223}{530} = 0.42$$

11. Time-in-queue per vehicle ,

$$d_{vq} = (Is \times \frac{\Sigma V_{iq}}{V_{tot}}) 0.9 = 9.5sec$$

12. Acc./Dec. correction delay,

$$dad = FVS \times CF = 0.42 \times 4 = 1.7sec$$

13. Control delay/vehicle,

$$d = dvq + dad = 11.2sec$$

7.7 Summary

The information assembled as part of this travel time and delay study forms a baseline for future assessment. This study helps to determine the amount of time required to travel from one point to another on a given route. Often, information may also be collected on the locations, durations, and causes of delays. Good indication of the level of service and identifying problem locations

7.8 References

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