Advanced Traffic Engineering

TE-504A/TE-504

Lecture-6

03-03-2020

Dr. Zia-ur-Rehman

DTEM

Travel Time and Delay Studies

A travel time study determines the amount of time required to travel from one point to another on a given route.

In conducting such a study, information may also be collected on the locations, durations, and causes of delays. When this is done, the study is known as a travel time and delay study.

Data obtained from travel time and delay studies give a good indication of the level of service on the study section. These data also aid the traffic engineer in identifying problem locations, which may require special attention in order to improve the overall flow of traffic on the route.

Applications of Travel Time and Delay Data

The data obtained from travel time and delay studies may be used in any one of the following traffic engineering tasks:

- **Determination of the efficiency of a route with respect to its ability to carry traffic**
- **Identification of locations with relatively high delays and the causes for those delays**
- **Performance of before-and-after studies to evaluate the effectiveness of traffic operation improvements**
- **Determination of relative efficiency of a route by developing sufficiency ratings or congestion indices**
- **Determination of travel times on specific links for use in trip assignment models**
- **Compilation of travel time data that may be used in trend studies to evaluate the changes in efficiency and level of service with time**
- **Performance of economic studies in the evaluation of traffic operation alternatives that reduce travel time**

Definition of Terms Related to Time and Delay Studies

Travel time is the time taken by a vehicle to traverse a given section of a highway.

Running time is the time a vehicle is actually in motion while traversing a given section of a highway.

Definition of Terms Related to Time and Delay Studies

Delay is the time lost by a vehicle due to causes beyond the control of the driver.

Operational delay is that part of the delay caused by the impedance of other traffic. This impedance can occur either as side friction, where the stream flow is interfered with by other traffic (for example, parking or unparking vehicles), or as internal friction, where the interference is within the traffic stream (for example, reduction in capacity of the highway).

Stopped time delay is that part of the delay during which the vehicle is at rest.

Fixed delay is that part of the delay caused by control devices such as traffic signals. This delay occurs regardless of the traffic volume or the impedance that may exist.

Travel-time delay is the difference between the actual travel time and the travel time that will be obtained by assuming that a vehicle traverses the study section at an average speed equal to that for an uncongested traffic flow on the section being studied.

Methods for Conducting Travel Time and Delay Studies

Several methods have been used to conduct travel time and delay studies. These methods can be grouped into two general categories:

(1) those using a test vehicle and

(2) those not requiring a test vehicle

The particular technique used for any specific study depends on the reason for conducting the study and the available personnel and equipment.

Methods Requiring a Test Vehicle

This category involves three possible techniques:

- **Floating-car,**
- **Average-speed,**
- **Moving vehicle techniques.**

Floating-Car Technique

In this method, the test car is driven by an observer along the test section so that the test car "floats" with the traffic.

The driver of the test vehicle attempts to pass as many vehicles as those that pass his test vehicle.

The time taken to traverse the study section is recorded.

This is repeated, and the average time is recorded as the travel time. the sample size for this type of study is usually less than 30, which makes the t distribution more appropriate

Floating-Car Technique

The equation is

$$N = \left(\frac{t_\alpha \times \sigma}{d}\right)^2$$

where

N = sample size (minimum number of test runs)
σ = standard deviation (mi/h)
d = limit of acceptable error in the speed estimate (mi/h)
t_α = value of the student's t distribution with $(1 - \alpha/2)$ confidence level and $(N - 1)$ degrees of freedom
α = significance level

Floating-Car Technique

The limit of acceptable error used depends on the purpose of the study. The following limits are commonly used:

- Before-and-after studies: $\pm$1.0 to 3.0 mi/h
- Traffic operation, economic evaluations, and trend analyses: $\pm$2.0 to 4.0 mi/h
- Highway needs and transportation planning studies: $\pm$ 3.0 to 5.0 mi/h

Average-Speed Technique

This technique involves driving the test car along the length of the test section at a speed that, in the opinion of the driver, is the average speed of the traffic stream.

The time required to traverse the test section is noted. The test run is repeated for the minimum number of times, determined from Eq.1, and the average time is recorded as the travel time.

In each of these methods, it is first necessary to clearly identify the test section.

The way the travel time is usually obtained is that the observer starts a stopwatch at the beginning point of the test section and stops at the end.

Additional data also may be obtained by recording the times at which the test vehicle arrives at specific locations which have been identified before the start of the test runs.

A second stop-watch also may be used to determine the time that passes each time the vehicle is stopped. The sum of these times for any test run will give the stopped-time delay for that run.

Average-Speed Technique

Example of a set of data obtained for such a study

Street Name: 29 North *Date: July 7, 1994*
Weather: Clear *Non-peak* *Time: 2:00–3:00 p.m.*

Cross Streets	Distance (ft)	Travel Time (sec)	Segment Speed (mi/h)	Stop Time (sec)	Reason for Stoppage	Speed Limit (mi/h)	Ideal Travel Time (sec)	Segment Delay (sec)	Net Speed (mi/h)
Ivy Road	0	0.0	–	0.0		–	0.0	0.0	–
Massie Road	1584	42.6	25.4	20.1	Signal	40	27.0	15.6	17.2
Arlington Blvd.	1320	27.7	32.5	0.0		40	22.5	5.2	32.5
Wise Street	792	19.7	27.4	8.9	Signal	40	13.5	6.2	18.9
Barracks Road	1320	32.1	28.0	15.4	Signal	40	22.5	9.6	18.9
Angus Road	2244	49.8	30.7	9.2	Signal	40	38.3	11.5	25.9
Hydraulic Road	1584	24.4	44.3	0.0		45	24.0	0.4	44.3
Seminole Court	1584	42.6	25.4	19.5	Signal	45	24.0	18.6	17.4
Greenbrier Drive	1848	41.5	30.4	15.6	Signal	45	28.0	13.5	22.1
Premier Court	1320	37.4	24.1	11.8	Signal	45	20.0	17.4	18.3
Fashion Square I	1584	23.6	45.8	4.9	Signal	45	24.0	−0.4	37.9
Fashion Square II	1056	19.7	36.5	0.0		45	16.0	3.7	36.5
Rio Road	1056	20.2	35.6	14.1	Signal	45	16.0	4.2	21.0
Totals	17292	381.3	30.9	119.5			275.8	105.5	23.5

Average-Speed Technique

Alternatively, the driver alone can collect the data by using a laptop computer with internal clock and distance functions. The predetermined locations (control points) are first programmed into the computer. At the start of the run, the driver activates the clock and distance functions; then the driver presses the appropriate computer key for each specified location. The data are then recorded automatically. The causes of delay are then recorded by the driver on a tape recorder.

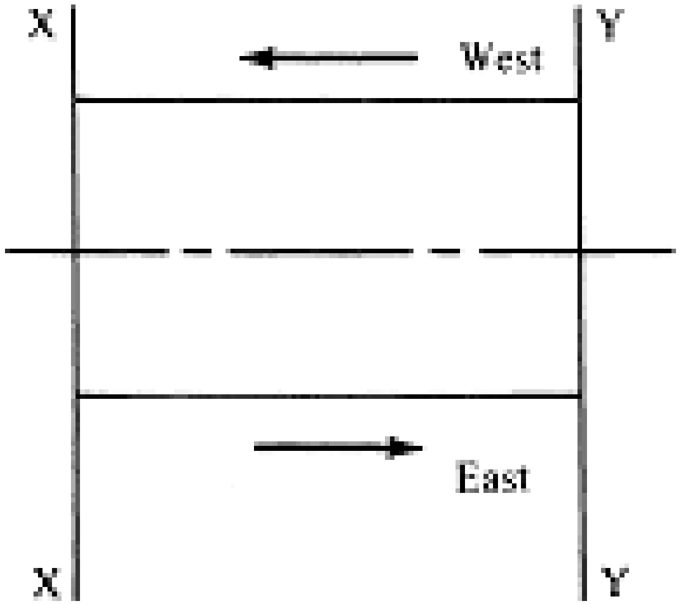
Moving-Vehicle Technique

In this technique, the observer makes a round trip on a test section like the one shown in Figure, where it is assumed that the road runs East to West.

The observer starts collecting the relevant data at section X-X, drives the car Eastward to section Y-Y, then turns the vehicle around and drives Westward to section X-X again.

The following data are collected as the test vehicle makes the round trip:

- The time it takes to travel East from X-X to Y-Y (T_e), in minutes
- The time it takes to travel West from Y-Y to X-X (T_w), in minutes
- The number of vehicles traveling West in the opposite lane while the test car is traveling East (N_e)
- The number of vehicles that overtake the test car while it is traveling West from Y-Y to X-X, that is, traveling in the Westbound direction (O_w)
- The number of vehicles that the test car passes while it is traveling West from Y-Y to X-X, that is, traveling in the Westbound direction (P_w)



Moving-Vehicle Technique

The volume (V_w) in the westbound direction can then be obtained from the expression

$$V_W = \frac{(N_e + O_w - P_w)\,60}{T_e + T_w} \quad ......(1)$$

where $(N_e + O_w - P_w)$ is the number of vehicles traveling westward that cross the line X-X during the time $(T_e + T_w)$. Note that when the test vehicle starts at X-X, traveling eastward, all vehicles traveling westward should get to X-X before the test vehicle, except those that are passed by the test vehicle when it is traveling westward. Similarly, all vehicles that pass the test vehicle when it is traveling westward will get to X-X before the test vehicle. The test vehicle will also get to X-X before all vehicles it passes while traveling westward. These vehicles have, however, been counted as part of N_e or O_w and therefore, should be subtracted from the sum of N_e and O_w to determine the number of westbound vehicles that cross X-X during the time the test vehicle travels from X-X to Y-Y and back to X-X.

Moving-Vehicle Technique

Similarly, the average travel time in the westbound direction is obtained from

$$\frac{\overline{T_W}}{60} = \frac{T_W}{60} - \frac{O_{W-}P_W}{V_W}$$

$$\overline{T}_W = T_W - \frac{60(O_{W-}P_W)}{V_W} \quad \ldots(2)$$

If the test car is traveling at the average speed of all vehicles, it will most likely pass the same number of vehicles as the number of vehicles that overtake it. Since it is probable that the test car will not be traveling at the average speed, the second term of Eq.2 corrects for the difference between the number of vehicles that overtake the test car and the number of vehicles that are overtaken by the test car.

Moving-Vehicle Technique

Table 1 : Data from Travel Time Study

Run Direction/ Number	Travel Time (min)	No. of Vehicles Traveling in Opposite Direction	No. of Vehicles That Overtook Test Vehicle	No. of Vehicles Overtaken by Test Vehicle
Eastward				
1	2.75	80	1	1
2	2.55	75	2	1
3	2.85	83	0	3
4	3.00	78	0	1
5	3.05	81	1	1
6	2.70	79	3	2
7	2.82	82	1	1
8	3.08	78	0	2
Average	2.85	79.50	1.00	1.50
Westward				
1	2.95	78	2	0
2	3.15	83	1	1
3	3.20	89	1	1
4	2.83	86	1	0
5	3.30	80	2	1
6	3.00	79	1	2
7	3.22	82	2	1
8	2.91	81	0	1
Average	3.07	82.25	1.25	0.875

Moving-Vehicle Technique Problem

Volume and Travel Time Using Moving-Vehicle Technique

The data in Table 1 were obtained in a travel time study on a section of highway using the moving-vehicle technique. Determine the travel time and volume in each direction at this section of the highway. Mean time it takes to travel eastward (T_e)=2.85 min

Mean time it takes to travel westbound (T_w)=3.07 min

Average number of vehicles traveling westward when test vehicle is traveling eastward (N_e)=79.50

Average number of vehicles traveling eastward when test vehicle is traveling westward (N_w)=82.25

Average number of vehicles that overtake test vehicle while it is traveling west-ward (O_w)=1.25

Moving-Vehicle Technique Problem

Average number of vehicles that overtake test vehicle while it is traveling east-ward (P_e)=1.00

Average number of vehicles the test vehicle passes while traveling westward (P_w)=0.875

Average number of vehicles the test vehicle passes while traveling eastward (P_e)=1.5

Moving-Vehicle Technique
Solution

From Eq. 1, find the volume in the westbound direction

$$V_W = \frac{(N_e + O_w - P_w)\, 60}{T_e + T_w}$$

$$V_W = \frac{(79.50+1.25-0.875)\, 60}{2.85+3.07} = 809.5 \text{ (or 810 veh/h)}$$

Similarly, calculate the volume in the eastbound direction

$$V_W = \frac{(82.25+1.00-1.50)\, 60}{2.85+3.07} = 828.5 \text{ (or 829 veh/h)}$$

Moving-Vehicle Technique
Solution

Find the average travel time in the westbound direction.

$$\bar{T}_W = 3.07 - \frac{60(1.25 - 0.875)}{810} = 3.0 \text{ min}$$

Find the average travel time in the eastbound direction.

$$\bar{T}_e = 2.85 - \frac{60(1.00 - 1.50)}{829} = 2.9 \text{ min}$$

Methods Not Requiring a Test Vehicle

This category includes the license-plate method and the interview method.

License-Plate Observations: The license-plate method requires that observers be positioned at the beginning and end of the test section. Observers also can be positioned at other locations if elapsed times to those locations are required.

Each observer records the last three or four digits of the license plate of each car that passes, together with the time at which the car passes.

The reduction of the data is accomplished in the office by matching the times of arrival at the beginning and end of the test section for each license plate recorded.

The difference between these times is the traveling time of each vehicle.

The average of these is the average traveling time on the test section.

It has been suggested that a sample size of 50 matched license plates will give reasonably accurate results.

Methods Not Requiring a Test Vehicle

Interviews: **The interviewing method is carried out by obtaining information from people who drive on the study site regarding their travel times, their experience of delays, and so forth.**

This method facilitates the collection of a large amount of data in a relatively short time.

However, it requires the cooperation of the people contacted, since the result depends entirely on the information given by them.

ITS Advanced Technologies

ITS, which is also referred to as Telematics, generally can be described as the process through which data on the movement of people and goods can be collected, stored, analyzed, and related information disseminated.

The process has been used in many areas of transportation engineering including the management of traffic, public transportation, traveller information, electronic toll payment, and safety.

The onset of ITS has facilitated the development of advanced technologies to support the system.

The use of cell phones to collect travel times on roadways is one such technology. The cell phone network is divided into several sectors known as cells. The sizes of these cells range from a radius of a few hundred feet in a city to several hundred feet in rural areas. Each cell has a base station through which signals are received and transmitted from and /or to cell phones within it.

ITS Advanced Technologies

A switching centre controls each base station and saves the information on the locations and user identification of each cell phone as they change their service cells.

The signal to a given cell phone decreases with its distance from the base station. When the signal strength is less than a predetermined level, the network checks for a nearer base station and “hands off” to that cell.

A commonly used technology for locating the positions of the cell phones is the GPS satellite system. This system can locate the position of a cell phone with an accuracy of between 15 and 90 ft. By probing cell phones on highways, the technology is used to determine average speeds and travel times along highways.

Another method used to obtain the locations of cell phones is triangulation, which uses the computed distances of the cell phone from three nearby stations to obtain its position.