

Chapter 4

Moving Observer Method

4.1 Overview

For a complete description of traffic stream modeling, one would require flow, speed, and density. Obtaining these parameters simultaneously is a difficult task if we use separate techniques. Since we have a fundamental equation of traffic flow, which gives the flow as the product of density and space mean speed, if we knew any two parameters, the third can be computed. Moving car or moving observer method of traffic stream measurement has been developed to provide simultaneous measurement of traffic stream variables. It has the advantage of obtaining the complete state with just three observers, and a vehicle. Determination of any of the two parameters of the traffic flow will provide the third one by the equation $q = u.k$. Thus, moving observer method is the most commonly used method to get the relationship between the fundamental stream characteristics. In this method, the observer moves in the traffic stream unlike all other previous methods.

4.2 Theory

Consider a stream of vehicles moving in the north bound direction. Two different cases of motion can be considered. The first case considers the traffic stream to be moving and the observer to be stationary. If n_o is the number of vehicles overtaking the observer during a period, t , then flow q is $\frac{n_o}{t}$, or

$$n_o = q \times t \quad (4.1)$$

The second case assumes that the stream is stationary and the observer moves with speed v_o . If n_p is the number of vehicles overtaken by observer over a length l , then by definition, density k is $\frac{n_p}{l}$, or

$$n_p = k \times l \quad (4.2)$$

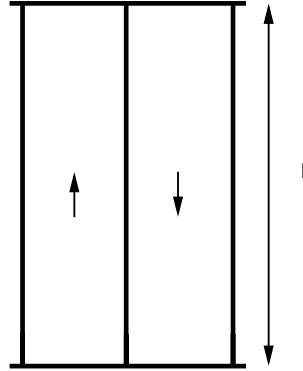


Figure 4:1: Illustration of moving observer method

or

$$n_p = k \cdot v_o \cdot t \quad (4.3)$$

where v_o is the speed of the observer and t is the time taken for the observer to cover the road stretch. Now consider the case when the observer is moving within the stream. In that case m_o vehicles will overtake the observer and m_p vehicles will be overtaken by the observer in the test vehicle. Let the difference m is given by $m_o - m_p$, then from equation 4.1 and equation 4.3,

$$m = m_o - m_p = q t - k v_o t \quad (4.4)$$

This equation is the basic equation of moving observer method, which relates q , k to the counts m , t and v_o that can be obtained from the test. However, we have two unknowns, q and k , but only one equation. For generating another equation, the test vehicle is run twice once with the traffic stream and another one against traffic stream, i.e.

$$\begin{aligned} m_w &= q t_w - k v_w t_w \\ &= q t_w - k l \end{aligned} \quad (4.5)$$

$$\begin{aligned} m_a &= q t_a + k v_a t_a \\ &= q t_a + k l \end{aligned} \quad (4.6)$$

where, a, w denotes against and with traffic flow. It may be noted that the sign of equation 4.6 is negative, because test vehicle moving in the opposite direction can be considered as a case when the test vehicle is moving in the stream with negative velocity. Further, in this case, all the vehicles will be overtaking, since it is moving with negative speed. In other words, when the test vehicle moves in the opposite direction, the observer simply counts the number of vehicles in the opposite direction. Adding equation 4.5 and 4.6, we will get the first parameter of the

stream, namely the flow(q) as:

$$q = \frac{m_w + m_a}{t_w + t_a} \quad (4.7)$$

Now calculating space mean speed from equation 4.5,

$$\begin{aligned} \frac{m_w}{t_w} &= q - kv_w \\ &= q - \frac{q}{v}v_w \\ &= q - \frac{q}{v} \left[\frac{l}{t_w} \right] \\ &= q \left(1 - \frac{l}{v} \times \frac{1}{t_w} \right) \\ &= q \left(1 - \frac{t_{avg}}{t_w} \right) \end{aligned}$$

If v_s is the mean stream speed, then average travel time is given by $t_{avg} = \frac{l}{v_s}$. Therefore,

$$\begin{aligned} \frac{m_w}{q} &= t_w \left(1 - \frac{t_{avg}}{t_w} \right) = t_w - t_{avg} \\ t_{avg} &= t_w - \frac{m_w}{q} = \frac{l}{v_s}, \end{aligned}$$

Rewriting the above equation, we get the second parameter of the traffic flow, namely the mean speed v_s and can be written as,

$$v_s = \frac{l}{t_w - \frac{m_w}{q}} \quad (4.8)$$

Thus two parameters of the stream can be determined. Knowing the two parameters the third parameter of traffic flow density (k) can be found out as

$$k = \frac{q}{v_s} \quad (4.9)$$

For increase accuracy and reliability, the test is performed a number of times and the average results are to be taken.

4.3 Proof

4.4 Assumptions

Numerical Example

The length of a road stretch used for conducting the moving observer test is 0.5 km and the speed with which the test vehicle moved is 20 km/hr. Given that the number of vehicles encountered in the stream while the test vehicle was moving against the traffic stream is 107, number of vehicles that had overtaken the test vehicle is 10, and the number of vehicles overtaken by the test vehicle is 74, find the flow, density and average speed of the stream.

Solution Time taken by the test vehicle to reach the other end of the stream while it is moving along with the traffic is $t_w = \frac{0.5}{20} = 0.025$ hr

Time taken by the observer to reach the other end of the stream while it is moving against the traffic is $t_a = t_w = 0.025$ hr

Flow is given by equation, $q = \frac{107+(10-74)}{0.025+0.025} = 860$ veh/hr

Stream speed v_s can be found out from equation $v_s = \frac{0.5}{0.025 - \frac{10-74}{860}} = 5$ km/hr

Density can be found out from equation as $k = \frac{860}{5} = 172$ veh/km

Numerical Example

The data from four moving observer test methods are shown in the table. Column 1 gives the sample number, column 2 gives the number of vehicles moving against the stream, column 3 gives the number of vehicles that had overtaken the test vehicle, and last column gives the number of vehicles overtaken by the test vehicle. Find the three fundamental stream parameters for each set of data. Also plot the fundamental diagrams of traffic flow.

Sample no.	1	2	3
1	107	10	74
2	113	25	41
3	30	15	5
4	79	18	9

Solution From the calculated values of flow, density and speed, the three fundamental diagrams can be plotted as shown in figure 4:2.

Sample no.	m_a	m_o	m_p	$m_w = (m_o - m_p)$	t_a	t_w	$q = \frac{m_a + m_w}{t_a + t_w}$	$u = \frac{l}{t_w - \frac{m_w}{q}}$	$k = \frac{q}{v}$
1	107	10	74	-64	0.025	0.025	860	5.03	171
2	113	25	41	-16	0.025	0.025	1940	15.04	129
3	30	15	5	10	0.025	0.025	800	40	20
4	79	18	9	9	0.025	0.025	1760	25.14	70

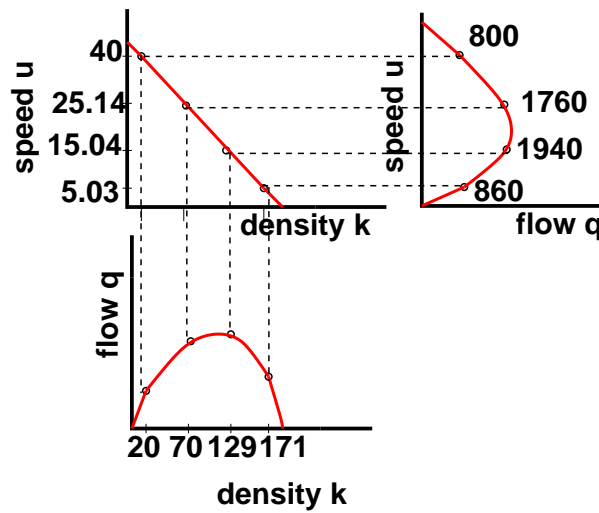


Figure 4:2: Fundamental diagrams of traffic flow

4.5 Summary

Traffic engineering studies differ from other studies in the fact that they require extensive data from the field which cannot be exactly created in any laboratory. Speed data are collected from measurements at a point or over a short section or over an area. Traffic flow data are collected at a point. Moving observer method is one in which both speed and traffic flow data are obtained by a single experiment.

4.6 References

1. L. R Kadiyali. *Traffic Engineering and Transportation Planning*. Khanna Publishers, New Delhi, 1987.