Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 09, September-2021

Macro and Micro Traffic Characteristics and Analysis for Ankara-Polatli State Highway Section

Ibukun Falilulahi Alao
Department of Civil Engineering,
Gazi University,
Ankara, Turkey.

Assist. Prof. Dr. Hikmet Bayirtepe
Department of Civil Engineering,
Gazi University,
Ankara, Turkey.

***Abstract*— In this study, data recorded throughout 2013 and 2014 with the camera system 80, installed by the General Directorate of Highways (GDH), is used in modeling traffic flow on the Ankara-Polatli highway section, evaluate and analyze the traffic characteristics of the section, the changes of these characteristics, and their relationships to one another. The data obtained from GDH includes vehicle transit date and time, vehicle type, movement direction, speed, and lane. Moreover, the data is classified according to 5-minute and 15-minute intervals in different time zones such as quarters, seasons, months, days of the month, and days of the week for each direction and lane. Traffic characteristics are evaluated by determining the 5-minute and 15-minute traffic distributions and flow parameters (such as flow, speed, and density) based on quarters, seasons, months, days of the month, and days of the week.**

Keywords: Modelling of traffic flow, traffic characteristics, traffic distribution, flow parameters.

I. INTRODUCTION

With increasing population and increasing migration from rural to urban areas, travel demand continues to rise [9]. The rise in travel demand creates a host of traffic problems, and the reduction in traffic speed, as well as an increase in travel time due to traffic congestion, are at the top of these problems. Other problems originating from travel demand increase include an increase in traffic operation cost, fuel consumption, and environmental pollution [1]. To address the issue of increasing travel demand, there is a need to either expand road capacity by constructing additional lanes, or efficient use of the available capacity to accommodate the travel demand growth. While the construction of new lanes might not be an economical and long-term solution, efficient use of road capacity is a more viable solution [2]. The efficient use of existing road capacity requires the knowledge of how the traffic characteristics, such as the flow, speed, and density of vehicles, change with time [3].

In this study, the traffic flow on the Ankara-Polatlı highway section is modeled and the traffic characteristics of all lanes in the section are evaluated using the traffic data obtained from the camera system number 80. In other words, the flow, density, speed, and space and time headway of all vehicles passing the camera are evaluated. Furthermore, traffic data obtained for each lane contains the 5-minute and 15-minute interval flow, density, speed, and space and time headway of vehicles recorded based on quarters, seasons, months, days of the month, and days of the week. With the help of MS EXCEL and Macro programs, a working database was created from the gathered data, and necessary analysis and evaluations are done based on the database.

II. BASIC INFORMATION

In this section traffic flow macro and micro parameters, the relationship between these parameters, and various flow models are discussed. Moreover, the statistical methods that will be used in this study are also examined.

A. Traffic Flow: Macro Traffic Parameters (Heading 2)

Macro traffic parameters are flow, density, and speed. In traffic flow theory, these parameters constitute a crucial aspect of research [4]. Additionally, they are important requirements for traffic management, especially in larger traffic networks. The analysis of these parameters does not consider the influence of individual vehicles in a traffic stream. Instead, a statistical model describing vehicle movement is used to represent traffic [5]. These parameters are summarized below.

Volume and Flow Rate

Traffic volume is the number of vehicles that pass a point on a highway, or a given lane or highway direction, during a defined time interval. Volume is often measured in “vehicle per day” or “vehicle per hour”.

Flow rate (q) refers to flow that occurs for periods less than one hour. It is measured in “vehicles per hour” [6]. Flow is represented mathematically as:

$$q = n/t \quad (1)$$

where,
q = flow (measured in vehicle per hour)
n = number of vehicles passing a given point
t = time (measured in hour)

In practice, the flow rate is obtained by standing at the side of the road and counting the number of vehicles (n) passing over a point during a given period (t) [6].

Traffic volume can be expressed as daily volumes which are used to establish trends over time (i.e daily, monthly, quarterly, seasonally, and yearly). Daily volumes are used to establish trends over time, and for general planning purposes.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 09, September-2021

Density

This is the number of vehicles occupying a given road section or lane. Generally, it is measured in vehicles per mile or vehicles per lane per mile. As a traffic stream parameter, it has the most direct relationship with traffic demand. Because it shows the proximity of vehicles to one another in traffic, it is an important measure of traffic flow quality [6].

The density (k) of a given road section, x, can be computed by taking the photograph of the section at a given point in time, and then counting the number of vehicles, n_x, occupying the section [8]. Thus,

$$k = \frac{n_x}{x} \quad (2)$$

where,
k = density
nx = number of vehicles occupying one mile or one kilometer.
x = length of the road section in mile or kilometer.

Speed

Speed is simply the rate of movement of vehicles in distance per unit time. Individual speed of vehicles is measured in m/s or km/h.

$$U = \frac{x}{t} \quad (3)$$

where,
U = vehicle speed in m/s or km/h
x = length of the road section in meters or kilometers
t = time in second or hour

In traffic engineering, traffic engineers are more concerned with average speed on the highway, and this is expressed as either time-mean speed or space-mean speed.

Time Mean Speed

This is the average speed of vehicles passing a specified point on a highway or lane during a time interval [9]. Time mean speed is calculated by summing the individual speed of vehicles and finding the average of the speeds [8]. Thus, the time-mean speed is given as:

$$u_t = \frac{1}{n}\sum_{i=1}^{n} u_i \quad (4)$$

where,
u_t = time mean speed
u_i = speed of the ith vehicle
n = number of vehicles

Space Mean Speed

This is the average speed of vehicles occupying a given road section or lane during a time interval [9]. Unlike time mean speed, the computation of the space mean speed does not involve the direct measurement of individual vehicle speed. To calculate the space mean speed, the average time taken by vehicles to travel a road section is obtained, and this is used to divide the length of the road section [8]. Thus, the space mean speed is expressed as:

$$u_s = \frac{1}{\frac{1}{n}\sum_{i=1}^{n}\frac{1}{u_i}} \quad (5)$$

where,

$$Average\ speed\ (t_{avg}) = \frac{1}{n}\sum_{i=1}^{n}\frac{1}{u_i}$$

u_s = space mean speed

B. Relationship Between Time Mean Speed and Space Mean Speed.

The space mean speed is always lesser than the time-mean speed. Moreover, an increase in the absolute values of speed decreases the difference between the time-mean speed and space mean speed [9]. The mathematical relationship between the time-mean speed and space mean speed is:

$$u_t = u_s + \frac{\sigma^2}{u_s} \quad (6)$$

where,
u_t = time mean speed
u_s = space mean speed
σ^2 = standard deviation of the mean. It is expressed as:

$$\sigma^2 = \frac{\sum q_i u_i^2}{\sum q_i} - (u_t)^2 \quad (7)$$

C. Time-Space Diagram

The time-space diagram is a graph that shows the position of vehicles in a traffic stream at different times as the vehicles move on the highway [9]. As shown in Fig. 1, the graph gives the position of the vehicles along path d, as a function of the time t. A linear graph implies that the vehicles move at a constant speed while a curve indicates that vehicles travel at an accelerated speed. From the time-space diagram, the basic traffic flow macro parameters such as flow, speed, and density. The diagram can also be used to obtain micro parameters such as time and space headway between vehicles on the highway [10].

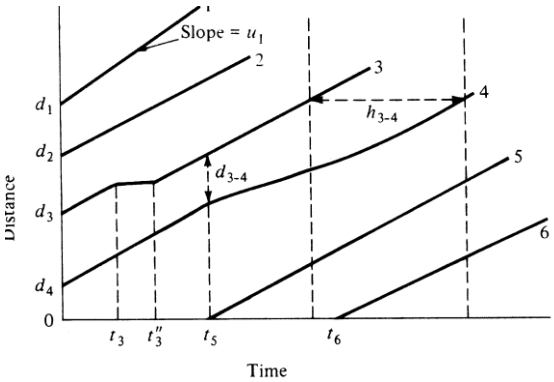


Fig.1: Time-Space Diagram

D. Traffic Flow: Micro Parameters

Through the density and flow values, the amount of traffic on a given road section or highway can be determined. Moreover, the separation between vehicles is of interest to the traffic engineer because this may influence safety and can affect how pedestrians and vehicles cross the traffic stream comfortably [8]. The separation between vehicles in traffic streams is expressed in both time and space.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 09, September-2021

Time Headway

This is the difference between the time the front bumper of a vehicle passes a point on the highway and the time the front bumper of the following vehicle passes the same point [9]. The time headway is measured in seconds, and it is represented as h. For a flow q measured over a time t, all the time headway obtained during this period can be given as:

$$\sum_{i=1}^{n} h_i = t \quad (8)$$

Thus, the relationship between flow and time headway is given as

$$q = \frac{n}{t} = \frac{n}{\sum_{i=1}^{n} h_i} = \frac{1}{h} \quad (9)$$

Space Headway

This is the difference between the front bumper of a vehicle and the front bumper of the following vehicle [9]. It is measured in feet and represented by d. Space headway can be measured from the photograph of a road section taken at a particular time. The distance from the front or rear bumper of the front vehicle to the front or rear bumper of the following vehicle is measured [8]-[9]. For a density k measured over a distance x, all the space headway obtained over this distance can be given as:

$$\sum_{i=1}^{n} d_i = x \quad (10)$$

Thus, the relationship between density and space headway is given as:

$$k = \frac{n}{x} = \frac{n}{\sum_{i=1}^{n} d_i} = \frac{1}{d} \quad (11)$$

E. Relationship Between Macro Traffic Parameters

Under stable traffic conditions, the density (K), flow (Q), and speed (U) have a direct relationship with one another (O'Flaherty, 1997). In Fig. 2, there is a 1-km road section consisting of vehicles traveling at equal speed. K, Q, and U are measured in vehicles./kilometer, vehicle/hour, and kilometer/hour respectively. At any instant in time, K vehicles are traveling at a speed U on the 1-km road section. If the flow is measured when the vehicles reach the end of the road, there will be Q vehicles passing per hour. A vehicle will take 1/U hours to travel from the beginning of the road section to the end at a speed of U km/h. The vehicle will be the Kth vehicle to pass the end of the road section; it will take K/Q hours. Thus,

$$\frac{1}{U} = \frac{K}{Q} \quad (12)$$

Or

$$Q = KU \quad (13)$$

Equation 2.20 expresses the fundamental relationship between density, flow, and speed.

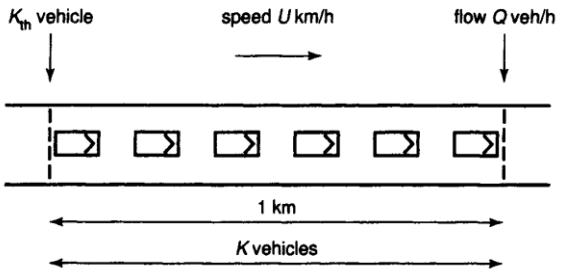


Fig. 2. Flow, speed, and density relationship

Flow-Density Relationship and Flow-Density Diagram

The flow-density diagram (Fig. 3) is also called the fundamental diagram of traffic flow. It shows the relationship between density and traffic flow. The flow-density curve follows some postulated theories, these are:

1. When density is zero, because of having no vehicles on the highway, the flow is zero.
2. An increase in density results in an increase in flow.
3. When density reaches a maximum, called jam density (kj), the flow becomes zero vehicles will tend to follow each other end to end.
4. It then follows that an increase in density from zero will initially cause the flow to increase from zero to a maximum value. The maximum value of flow is called the capacity. The subsequent increase in density will result in a reduction in flow. Eventually, the flow becomes zero when the jam density is reached [8].

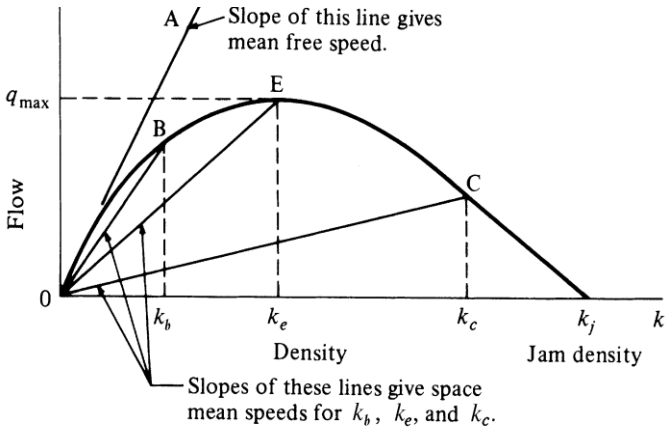


Fig. 3. Flow-density Relationship

The slopes of line OB, OC, and OE represent the space mean speed at densities k_b, k_e, and k_c respectively. The slope of line OA gives the speed as density approaches zero, and vehicles' interaction with one another is very insignificant. Thus, the slope of line OA gives the mean free speed (U_f). The mean free speed is the maximum attainable speed on the highway. Additionally, the slope of line OE gives the space mean speed for maximum flow (i.e., the capacity of the highway).

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 09, September-2021

Speed-Density Relationship and Speed-Density Diagram

Fig. 4 shows the most basic relationship between speed and density. When density is zero, there are two possibilities – either there are no vehicles on the road or vehicles follow one another at free-flow speed. At jam density, the speed of vehicles becomes zero.

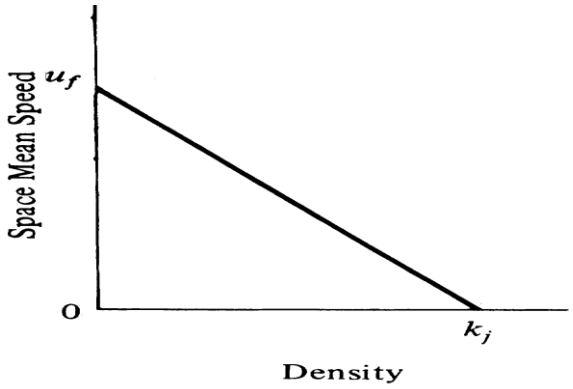


Fig. 4: Speed and Density Relationship

Speed – Flow Relationship and Speed – Flow Diagram

As shown in Fig. 5, the absolute maximum speed (U_f) occurs as the flow approaches zero. Speed decreases continuously with a continuous increase in flow. This continues to a point when the further increase in the number of vehicles will cause a reduction of flow on the highway. Congestion occurs at this point. Consequently, the speed and flow become zero [9].

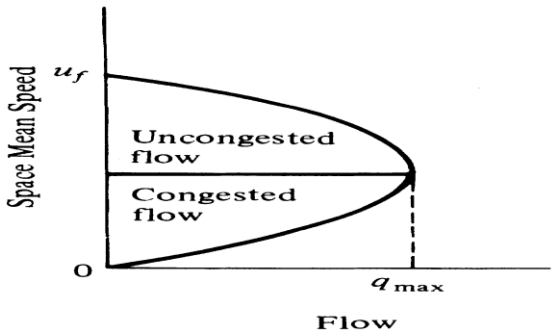


Fig. 5. Speed and Flow Relationship

D. Relationship Between Micro Traffic Parameters

The use of microscopic measures allows many data to be collected in a short period. Their application also allows the isolation of various vehicle types in a traffic stream [6].

Time Headway and Space Headway

The relationship between time and space headway is given as:

Average space headway = space mean speed * average time headway[9].

$$d_a = u_s h_a \quad (14)$$

III. CONCEPTUAL APPROACH TO DEVELOPMENT OF TRAFFİC FLOW CHARACTER AND MACRO FLOW MODELS.

To determine the traffic characteristics of the Ankara-Polatli highway section, the raw traffic data for the section throughout 2013 and 2014 was obtained and a series of processes were performed on the data. With the help of these processes, based on different periods, the flow-average speed-density relationship with time (i.e 5-minute and 15- minute time intervals) is established for all lanes in the Ankara-Polatli highway section.

A. Reading and Separation of Raw Data

The raw data obtained from the number 80 camera system in 2013 and 2014 include the date of measurement of vehicle counts, class of vehicle passing the camera, passing vehicle speed, headway, passed vehicle class, and passed vehicle speed. The data obtained is gathered to create the raw database. After the creation of the raw database, the traffic data is separated for each lane on the Ankara-Polatli highway section. The separation of data for each lane is based on the traffic obtained in five different periods namely: quarters, seasons, months, days of the month, and days of the year. Furthermore, for each period, the data is grouped based on the 5-minute and 15-minute time intervals in every hour of the day in each period.

B. Creation of Work Database

The working database is created using MS Excel and Macro Software. The working database contains traffic data on the traffic measurement date, periods, intervals (5-minute and 15-minute), the total number of vehicles obtained in each interval, days of observation for each interval, the hour of observation, and cumulative time headways, space headways, and speeds of vehicles on each lane found on the Ankara-Polatli highway section. All traffic data components are sectioned into different columns on MS Excel. Moreover, the traffic data is prepared for both 2013 and 2014.

C. Analysis

In the analysis section, the average time headway in each time interval, average space headway in each time interval, average speed in each time interval, and the average number of vehicles obtained in each time interval based on the number of observation days are calculated. The cumulative values of the time headway, space headway, and vehicle number obtained from the work database are used in the calculation of the average values. The flow and density are then calculated from the average time headway and average space headway, respectively.

D. Traffic Character

In this section, based on the 5-minute and 15-minute intervals, scatter-plot graphs showing the relationship between flow, density, speed are created for each period on each lane in each year. These graphs are examined to understand how the flow, density, and average speed parameters change across the periods.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 09, September-2021

E. Modelling

For the Ankara-Polatli highway section, the detailed explanation of the relationship between the change in flow, average speed, and density with time for each lane in each year is examined here.

The flow and density values, for the 5-minute and 15-minute time intervals in every hour of the day, are respectively calculated from the average time headway and average space headway. The flow is calculated as the inverse of the time headway while the density is calculated as the inverse of the space headway. Moreover, flow, average speed, and density are expressed in vehicle/hour, km/hour, and vehicle/km, respectively.

F. Conclusions and Recommendations

With the help of the analysis, traffic characteristics, and modelling studies, the change ın flow, density, and average speed parameters with time for all lanes on the Ankara-Polatli highway section is determined. Based on the changes seen in these parameters across all the periods, necessary conclusions and suggestions are presented.

IV. MACRO TRAFFIC MODELLING

For this study, the traffic data is obtained with the help of the number 80 camera system for the Ankara-Polatli highway section. The traffic data is compiled from 2013 to 2014, and a new database is created with the data. With the help of Microsoft Excel and Macro software, analysis is done using the new database created.

A. General Information

The Ankara-Polatli State highway is a 2*3 lane highway. It consists of two directions, and there are three lanes in each direction. The first direction is named as Ankara-Polatli direction while the second direction is named as Polatli-Ankara direction. Fig. 6 shows the different lanes and the directions they are located.

In the context of this study, the traffic data for the Ankara-Polatli state highway section is obtained from the number 80 camera system. The Ankara-Polatli highway location is shown in Fig. 7.

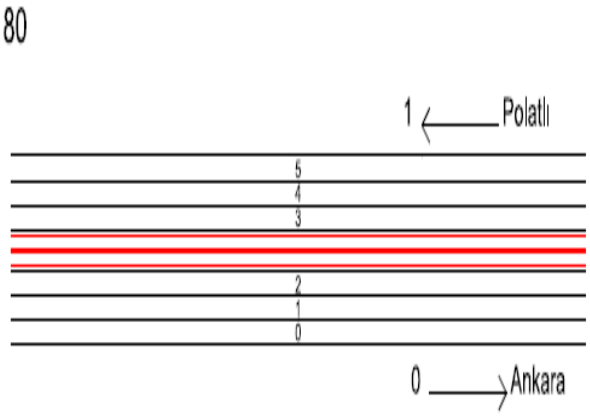


Fig. 6. Ankara-Polatli highway section and the lanes in each direction

Fig. 7. Ankara-Polatli state highway route location

B. Raw Data

Traffic measurement data is obtained for all lanes located in the Ankara-Polatli and Polatli-Ankara directions from 01.01.2013 to 31.12.2014. This data is referred to as raw data. The raw data is 72,677 kb in size, and it includes the date of measurement of vehicle counts, class of vehicle passing the camera, passing vehicle speed, headway, passed vehicle class, and passed vehicle speed. Fig. 8 shows a screenshot of part of the raw data for one of the lanes on the Ankara-Polatli highway section.

	A	B	C	D	E	F
1	0<== 0	123490				
2	Date	Passing Vehicle Class	Passing Vehicle Speed	eadway	Passed Vehicle Class	Passed Vehicle Speed
3	Thursday, January 3, 2013	7	87	-1	0	0
4	Thursday, January 3, 2013	9	71	31	7	87
5	Thursday, January 3, 2013	9	82	71	9	71
6	Thursday, January 3, 2013	7	77	9	9	82
7	Thursday, January 3, 2013	4	84	160	7	77
8	Thursday, January 3, 2013	9	82	71	4	84
9	Thursday, January 3, 2013	7	77	30	9	82
10	Thursday, January 3, 2013	7	64	75	7	77
11	Thursday, January 3, 2013	9	73	11	7	64
12	Thursday, January 3, 2013	7	73	4	9	73
13	Thursday, January 3, 2013	7	73	14	7	73
14	Thursday, January 3, 2013	7	84	214	7	73
15	Thursday, January 3, 2013	7	75	47	7	84
16	Thursday, January 3, 2013	2	57	126	7	75
17	Thursday, January 3, 2013	2	52	5	2	57
18	Thursday, January 3, 2013	9	77	5	2	52
19	Thursday, January 3, 2013	9	65	57	9	77
20	Thursday, January 3, 2013	9	74	68	9	65
21	Thursday, January 3, 2013	7	79	43	9	74
22	Thursday, January 3, 2013	9	74	11	7	79
23	Thursday, January 3, 2013	8	77	24	9	74
24	Thursday, January 3, 2013	9	87	25	8	77
25	Thursday, January 3, 2013	9	73	12	9	87
26	Thursday, January 3, 2013	9	77	22	9	73
27	Thursday, January 3, 2013	6	78	24	9	77
28	Thursday, January 3, 2013	9	40	31	6	78
29	Thursday, January 3, 2013	7	71	226	9	40
30	Thursday, January 3, 2013	7	74	367	7	71
31	Thursday, January 3, 2013	9	73	28	7	74
32	Thursday, January 3, 2013	9	77	99	9	73
33	Thursday, January 3, 2013	9	71	44	9	77
34	Thursday, January 3, 2013	9	79	46	9	71

follow01_03 Sheet1

Fig. 8. Screenshot of the raw data file

C. Creation of Work Database

In this thesis study, the work database is created from the raw database by using Microsoft Excel and Macro programs. For the two years(i.e 2013 and 2014) in which traffic data was obtained, the work database contains the details on the date of data measurement, periods, intervals (5-minute and 15-minute), the total number of vehicles obtained in each interval, days of observation for each interval, hour of observation, and cumulative time headways, space headways, and speeds of vehicles on each lane found on the Ankara-Polatli highway section. Each of these details is presented in 16 different columns for each lane in the work database file. Moreover, different number ranges are used to represent each of the five

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 09, September-2021

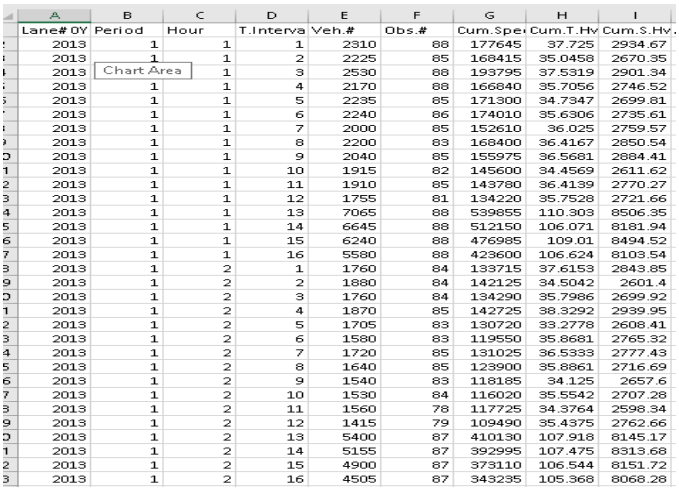
periods for which data was obtained. Table I shows the different periods and their respective number ranges.

TABLE I: NUMBER RANGES USED FOR THE FIVE PERIODS

Period	Number Range
Quarters	1 – 4
Seasons	5 – 8
Months	9 – 20
Days of the month	21 – 51
Days of the week	52 – 58

For each of the three lanes found in the Ankara-Polatli direction, the traffic data obtained in both 2013 and 2014 are grouped in the work database according to five periods (quarters, seasons, months, days of the month, and days of the week). Traffic data for each period contains all the details mentioned above. The traffic data grouping for each lane according to quarters consists of 1536 rows in the work database. Similarly, data grouping based on seasons consists of 1536 rows, 4608 rows on monthly basis, 11904 rows on days of the month basis, and 2688 rows on days of the week basis.

For the other three lanes located in the Polatli-Ankara direction, the traffic data obtained in both years are also grouped in the work database according to the same five periods. The traffic data also contains all the details highlighted previously. For these lanes, the number of rows corresponding to the traffic data for each period is the same as that specified for the lanes in the Ankara-Polatli direction. The work database is 64, 753 in size, and Fig. 9 shows a screenshot of part of the work database for lane numbered 0 found in the Ankara-Polatli direction.



	A	B	C	D	E	F	G	H	I
	Lane# 0Y	Period	Hour	T.Interva	Veh.#	Obs.#	Cum.Spe	Cum.T.Hv	Cum.S.Hv
	2013	1	1	1	2310	88	177645	37.725	2934.67
	2013	1	1	2	2225	85	168415	35.0458	2670.35
	2013	Chart Area	1	3	2530	88	193795	37.5319	2901.34
	2013	1	1	4	2170	88	166840	35.7056	2746.52
	2013	1	1	5	2235	85	171300	34.7347	2699.81
	2013	1	1	6	2240	86	174010	35.6306	2735.61
	2013	1	1	7	2000	85	152610	36.025	2759.57
	2013	1	1	8	2200	83	168400	36.4167	2850.54
	2013	1	1	9	2040	85	155975	36.5681	2884.41
	2013	1	1	10	1915	82	145600	34.4569	2611.62
	2013	1	1	11	1910	85	143780	36.4139	2770.27
	2013	1	1	12	1755	81	134220	35.7528	2721.66
	2013	1	1	13	7065	88	539855	110.303	8506.35
	2013	1	1	14	6645	88	512150	106.071	8181.94
	2013	1	1	15	6240	88	476985	109.01	8494.52
	2013	1	1	16	5580	88	423600	106.624	8103.54
	2013	1	2	1	1760	84	133715	37.6153	2843.85
	2013	1	2	2	1880	84	142125	34.5042	2601.4
	2013	1	2	3	1760	84	134290	35.7986	2699.92
	2013	1	2	4	1870	85	142725	38.3292	2939.95
	2013	1	2	5	1705	83	130720	33.2778	2608.41
	2013	1	2	6	1580	83	119550	35.8681	2765.32
	2013	1	2	7	1720	85	131025	36.5333	2777.43
	2013	1	2	8	1640	85	123900	35.8861	2716.69
	2013	1	2	9	1540	83	118185	34.125	2657.6
	2013	1	2	10	1530	84	116020	35.5542	2707.28
	2013	1	2	11	1560	78	117725	34.3764	2598.34
	2013	1	2	12	1415	79	109490	35.4375	2762.66
	2013	1	2	13	5400	87	410130	107.918	8145.17
	2013	1	2	14	5155	87	392995	107.475	8313.68
	2013	1	2	15	4900	87	373110	106.544	8151.72
	2013	1	2	16	4505	87	343235	105.368	8068.28

Fig. 9. Work database screenshot for lane number 0 in the Ankara-Polatli direction

In each of the periods examined, traffic data is allocated for each hour. Using the 5-minute time interval, traffic data is collected twelve times in an hour. By dividing each hour based on 15-minute time interval, traffic data is collected 4 times in an hour. Tables II and III show how data allocated is defined for each hour, and 5-minute and 15-minute intervals present in an hour.

TABLE II. TIME RANGE DEFINITION BY HOUR

HOUR	HOUR INTERVAL	HOUR	HOUR INTERVAL
1	0:00:00 – 01:00:00	13	12:00:00 – 13:00:00
2	01:00:00 – 02:00:00	14	13:00:00 – 14:00:00
3	02:00:00 – 03:00:00	15	14:00:00 – 15:00:00
4	03:00:00 – 04:00:00	16	15:00:00 – 16:00:00
5	04:00:00 – 05:00:00	17	16:00:00 – 17:00:00
6	05:00:00 – 06:00:00	18	17:00:00 – 18:00:00
7	06:00:00 – 07:00:00	19	18:00:00 – 19:00:00
8	07:00:00 – 08:00:00	20	19:00:00 – 20:00:00
9	08:00:00 – 09:00:00	21	20:00:00 – 21:00:00
10	09:00:00 – 10:00:00	22	21:00:00 – 22:00:00
11	10:00:00 – 11:00:00	23	22:00:00 – 23:00:00
12	11:00:00 – 12:00:00	24	23:00:00 – 24:00:00

TABLE III. TIME RANGE DEFINITION BY MINUTE

SEGMENT	MINUTE INTERVAL
1	00:00 – 00:05
2	00:05 – 00:10
3	00:10 – 00:15
4	00:15 – 00:20
5	00:20 – 00:25
6	00:25 – 00:30
7	00:30 – 00:35
8	00:35 – 00:40
9	00:40 – 00:45
10	00:45 – 00:50
11	00:50 – 00:55
12	00:55 – 01:00
13	00:00 – 00:15
14	00:15 – 00:30
15	00:30 – 00:45
16	00:45 – 01:00

D. Flow, Speed, and Densities According to Hours for Different Time Zones.

Ankara-Polatlı State Highway Section has three lanes in both directions and for each lane, hourly vehicle volume or flow, vehicle average speed, and vehicle density of section according to different time zones such as quarters of the year, seasons, months, days of the month vehicle density are analyzed under the following sub-headings based on data for 2013 and 2014.

Flow, Speed, and Density According to Quarters.

Flow, velocity, and density realizations and changes, calculated as a periodic average for 24 hours a day, to be evaluated together for four quarters of the year, are prepared schematically with the help of symbolic dates, which are defined as four quarters and are specified as four consecutive days. With this approach, the changes in flow, velocity, and density on a quarterly basis for 2013 and 2014 are presented in Fig. 10 for lane numbers 0 and 1, Fig. 11 for lane numbers 2 and 3, and Fig. 12 for lane numbers 4 and 5.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 09, September-2021

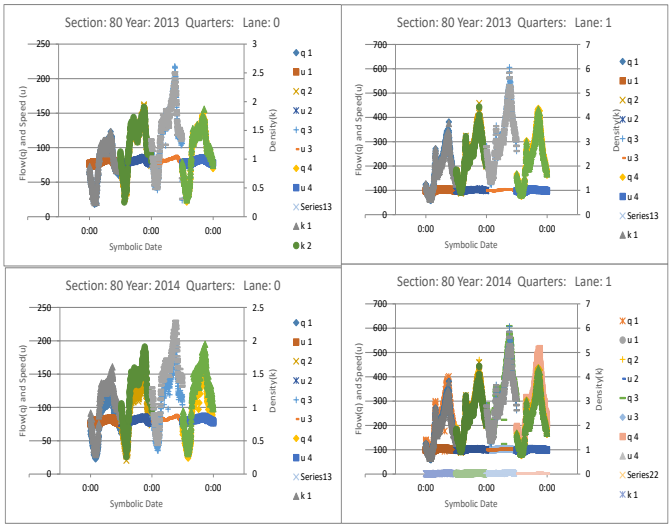


Fig. 10. Flows, speeds, and densities on lane numbers 0 and 1 for all quarters in 2013 and 2014.

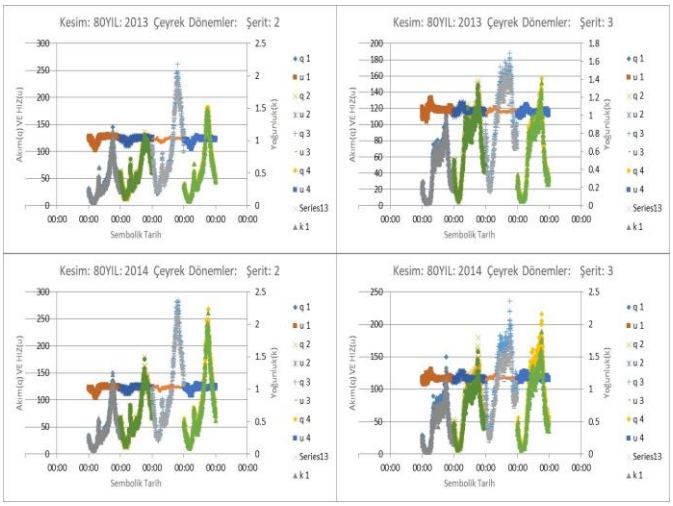


Fig. 11. Flows, speeds, and densities on lane numbers 2 and 3 for all quarters in 2013 and 2014.

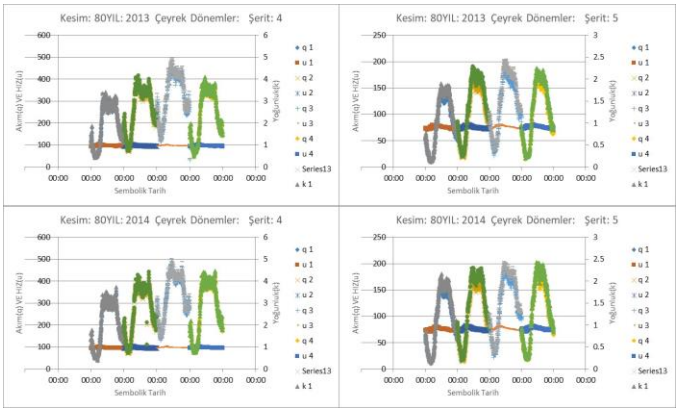


Fig. 12. Flows, speeds, and densities on lane numbers 4 and 5 for all quarters in 2013 and 2014.

As can be seen in the figures, hourly volume or flow and density for each lane in the analyzed quarters of 2013 and 2014 increased from the first quarter covering January-March to the third quarter covering July-September, while decreasing in the fourth quarter characterizing October-December. Average speed is relatively constant in each lane over all quarters. For lanes 0, 1, and 2 in the first direction, the average speed increases from lane 0 to lane 2 for all quarters each year. Also, the minimum and maximum flows, densities, and average velocities in each lane in the same direction occur mostly in the first and third quarters of each year.

If all lanes and quarters are considered together, the minimum flows, average speeds and densities range from 4 to 73 vehicles/hour, 73 to 104 kilometer/hour, and 0.03 to 0.80 vehicles/kilometer, respectively. Also, minimum flows and intensities in each lane generally occur between 3:00 and 4:00 during all quarters of both years. Minimum average speeds occur between 3:00 and 6:00. The lowest minimum flow and density are observed on lane 2 at 3:25 in the first quarter of 2013 as 4.97 vehicles/hour and 0.039 vehicles/kilometer, respectively. The lowest average speed was observed at 3:55 in the first quarter of 2013, at 73 kilometers/hour on lane number 0 (the right lane).

Similarly, maximum flow, average speed, and density range from 200 – 609 vehicles/hour, 88 – 132 kilometer/hour, and 2 – 6 vehicles/kilometer respectively. In addition, the maximum flows and densities on each lane occur mostly between 18:00 – 20:00. Maximum average speeds usually occur between 9:00 – 10:00, 12:00 – 15:00, and 18:00 – 19:00. The highest maximum current and density are seen at 18:15 on lane 1, and their values are obtained as 608.43 vehicles/hour and 5.85 vehicles/km respectively. However, the maximum flow occurs in the first quarter of 2013, while the maximum intensity is observed in the first quarter of 2014. The highest average speed observed is 131 kilometers/hour, and this is seen in the first quarter of 2013 at 19:20 on lane number 2.

On the other hand, for lane numbers 3, 4, and 5 in the second direction average speed decrease from lane number 3 to lane number 5 in all quarters each year. Also, the minimum and maximum flows and densities on each lane are mostly obtained in the first and third quarters of each year, respectively. However, the minimum and maximum speeds seen on each lane in this direction occur mainly in the first quarter of both years.

Based on the combined assessment of all lanes and quarters in the second direction, the minimum flow, average speed, and density range from 2 – 38 vehicles/hour, 70 – 108 kilometer/hour, and 0.02 – 0.40 vehicles/kilometer, respectively. Moreover, minimum flows and intensities in each lane occur mostly between 23:00 – 0:00 and 3:00 – 5:00 in all quarters of both years. Minimum average speeds are generally observed between 1:00 – 5:00. The lowest minimum flow and density are seen in lane number 3 at 3:45 in the first quarter of 2013; their values are 2.94 vehicles/hour and 0.025 vehicle/km, respectively. The minimum average speed observed is 70 kilometers/hour, and this occurs at 1:20 in the first quarter of 2013 on lane number 5.

Likewise, the maximum flow, average speed, and densities vary between 187 – 492 vehicles/hour, 81 – 134 kilometer/hour, and 1.60 – 5.10 vehicles/kilometer, respectively. In addition, maximum flows and densities on each lane mostly occur between 10:00 - 13:00 respectively, while maximum average velocities generally occur between

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 09, September-2021

6:00 – 07:00 on each lane. The highest maximum flow and density occur on lane number 4 at 10:45 in the third quarter of 2014; their values are 491.33 vehicles/hour and 5.03 vehicles/kilometer, respectively. The maximum average speed seen is 133 kilometers/hour, and it is seen at 06:55 in the first quarter of 2013 on lane number 3 (the leftmost lane).

Flow, Speed, and Density According to Seasons

The holistic schematic representations prepared and explained above for the quarters are prepared similarly for the seasons and presented in Fig. 13 for lane numbers 0 and 1, Fig. 14. for lane numbers 2 and 3, and Fig. 15 for lane numbers 4 and 5.

Each year, the flow and density on each lane increase from the first to the second season and decrease from the second to the last season. Average speed is relatively constant on every lane in all seasons.

During all seasons studied each year, the average speed increases from the rightmost lane number 0 to the leftmost lane number 2. In addition, the minimum and maximum flows and densities on each lane occur in the winter and summer months of each year. Minimum and maximum average speeds are mostly seen in the winter months.

When all lanes and seasons in 2013 and 2014 are examined together, it is seen that the minimum flow, average speed, and densities vary between 4 – 71 vehicles/hour, 72 – 104 kilometer/hour, and 0.04 – 0.75 vehicles/kilometer, respectively. These range of values obtained for the parameters correspond to the ranges obtained in the quarterly examinations done for both years. Also, minimum flows, average speeds, and densities in each lane occur mostly between 3:00 – 6:00 in all seasons of both years. The lowest minimum flow and density are achieved on lane number 2 at 3:40 in the winter of 2013; their values are 4.92 vehicles/hour and 0.04 vehicle/kilometer, respectively. The lowest minimum average speed is 72 kilometers/hour and occurs on lane number 0 at 5:30 in the winter of 2013.

Similarly, it is seen that the maximum flow, average speed, and densities vary between 200 – 583 vehicles/hour, 88 – 130 kilometers/hour, and 1.80– 5.70 vehicles/kilometer, respectively. These range of values obtained for the parameters in the seasons also correspond to the ranges obtained in quarters of both 2013 and 2014. It is also seen that the maximum flows and densities on each lane mostly occur between 18:00 – 19:00, respectively. Maximum average speeds are usually found between 12:00 – 14:00 and 18:00 – 19:00. The highest maximum flow and density occur on lane number 1 at 18:15 in the summer of 2013; their values are 582.61 vehicles/hour and 5.61 vehicles/kilometer, respectively. The highest maximum average speed is 130 kilometers/hour and it is seen on lane number 2 at 13:45 in the winter of 2013.

According to the seasonal variation of traffic flow on all lanes in the second direction, the average speed decreases from lane number 3 to lane number 5 every year in all seasons. Also, the minimum and maximum flows, average velocities, and densities on each lane are mostly obtained in the winter and summer months of each year, respectively. Most of the minimum average speeds are observed during the winter months. The maximum average speeds are equally distributed in spring, winter, and summer.

When the traffic flow changes in all seasons and lanes in both years are examined together, it is seen that the minimum flow, average speed, and densities vary between 2 – 45 vehicles/hour, 70 – 106 kilometers/hour, and 0.02 – 0.50 vehicles/kilometer, respectively. This range of values is very close to the minimum value ranges obtained for the parameters in both the quarters of 2013 and 2014. Also, minimum flows and densities on each lane occur mostly between 23:00 – 0:00 and 3:00 – 5:00 in all seasons of both years. For the minimum average speeds, these occur between 1:00 – 3:00. The lowest minimum flow and density are seen on lane number 3 in the winter of 2014 at 3:50; their values are 2.44 vehicles/hour and 0.022 vehicles/kilometer, respectively. The lowest minimum average speed is 70 kilometers/hour, and it is observed on lane number 5 in the winter of 2014 at 1:45.

Likewise, it is observed that the maximum flows, average speeds, and densities vary between 192 – 493 vehicles/hour, 82 – 134 kilometers/hour, and 1.60 – 5.10 vehicles/kilometer, respectively. This range of values also almost corresponds to those obtained in both the 2013 and 2014 quarters. It is also seen that maximum flows and densities on each lane mostly occur between 10:00 – 12:00 and 18:00 – 19:00 respectively, while maximum average speeds occur mostly between 5:00 – 7:00 on each lane. The highest maximum flow and intensity occur on lane number 4 at 10:45 in the summer of 2014; their values are 492.06 vehicles/hour and 5.02 vehicles/kilometer, respectively. The highest average maximum speed is 133 kilometers/hour and it is seen on lane number 3 at 6:55 in the winter of 2013.

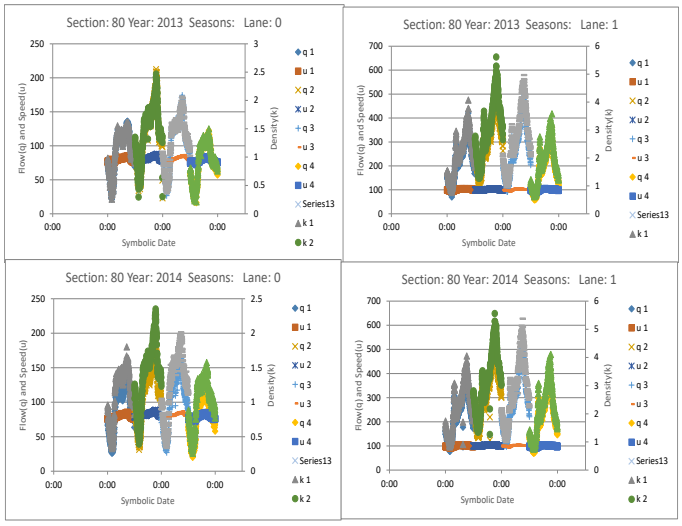


Fig. 13. Flows, speeds, and densities on lane numbers 0 and 1 for all seasons in 2013 and 2014.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 09, September-2021

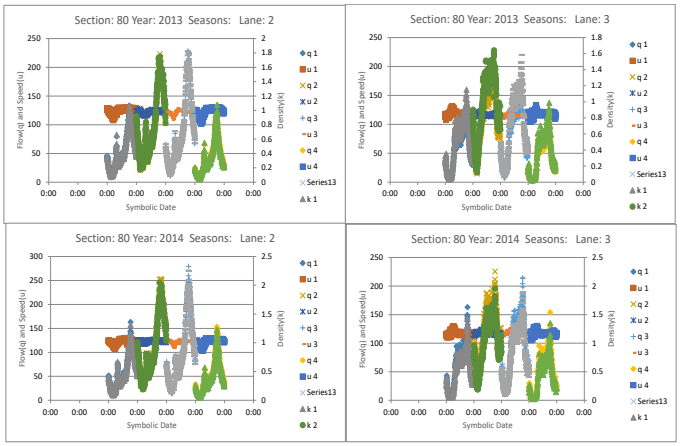


Fig. 14. Flows, speeds, and densities on lane numbers 2 and 3 for all seasons in 2013 and 2014.

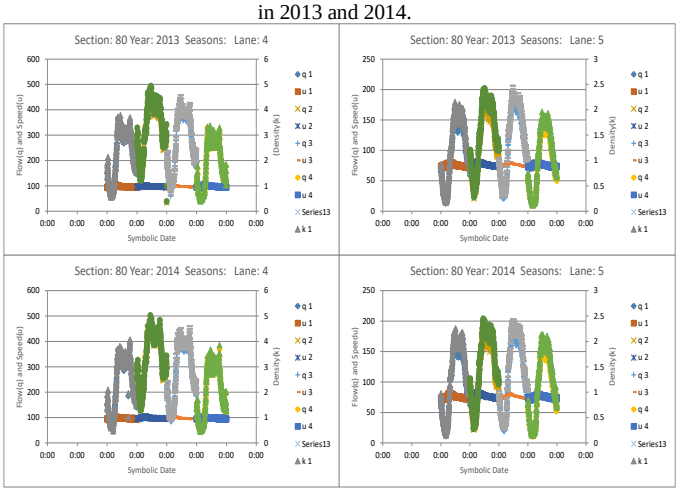


Fig. 15. Flows, speeds, and densities on lane numbers 4 and 5 for all seasons in 2013 and 2014

Flow, Speed, and Density According to Months

The flow, speed, and density obtained as well as their changes, which are calculated according to 24 hours of the day, are prepared as monthly averages. With the help of symbolic dates, the 24-hour change of flow, speed, and density over 12 months in a year are evaluated together and indicated as 12 consecutive days. Using this approach, monthly changes in flow, speed, and density for 2013 and 2014 are presented in Fig. 16 for lane numbers 0 and 1, Fig. 17 for lane numbers 2 and 3, and in Fig. 18 for lane numbers 4 and 5.

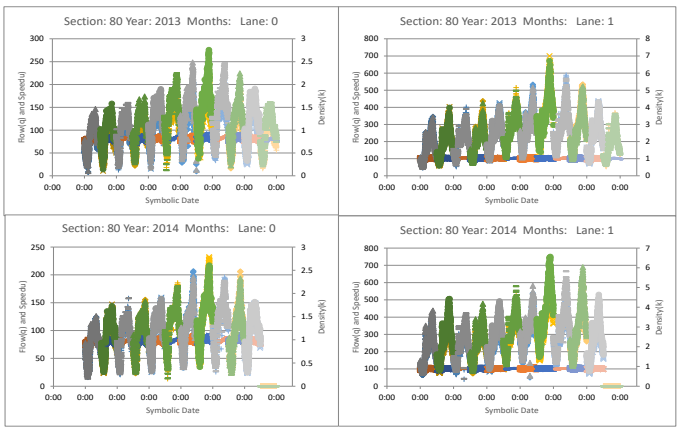


Fig. 16. Flows, speeds, and densities on lane numbers 0 and 1 for all months in 2013 and 2014.

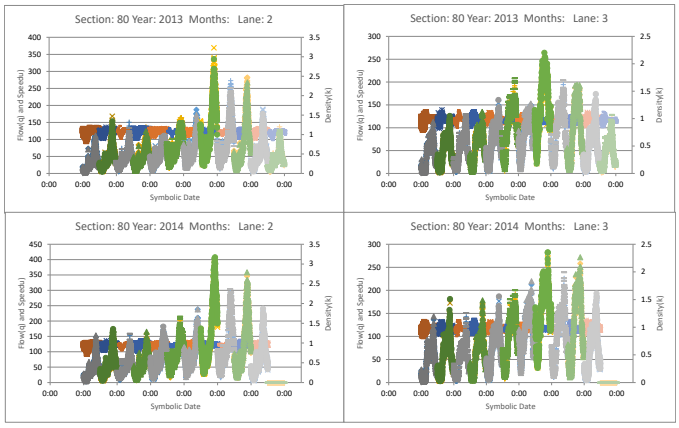


Fig. 17. Flows, speeds, and densities on lane numbers 2 and 3 for all months in 2013 and 2014.

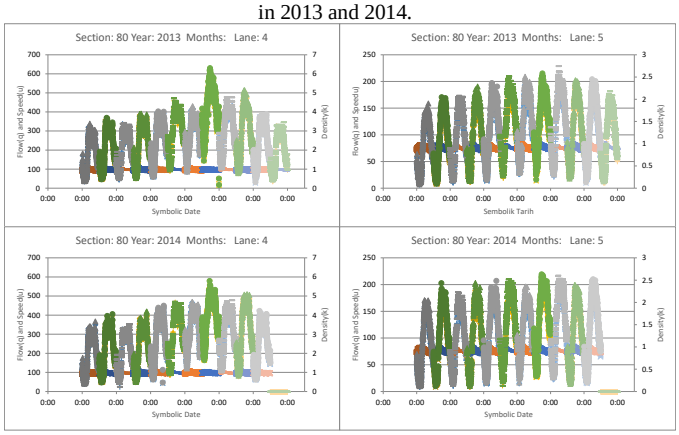


Fig. 18. Flows, speeds, and densities on lane numbers 4 and 5 for all months in 2013 and 2014.

The monthly variation of flow, speed, and density is analyzed for all 12 months of 2013. In 2014, however, the monthly change of these parameters is studied for only 11 months for which data are available. In addition, traffic data are collected for 30 days in September, April, June, and November. Data collection in February spans for 29 days, and traffic data for the remaining months are aggregated for 31 days.

For both years studied, flow and density on each lane increase from January to August and decrease from August to December. The average speed remains relatively unchanged.

For lane numbers 0, 1, and 2 in the first direction, the average speed increases from lane number 0 to lane number 2 during all months surveyed each year. In addition, the minimum and maximum flows and densities observed on each lane occur mostly in January and August, respectively. Most of the minimum and maximum speeds are observed in January and March, respectively.

Based on the combined evaluation of the change of flow, speed, and density on first-direction lanes for all months in each year, it is seen that the minimum flows, average speeds, and densities vary between 2 – 48 vehicles/hour, 70 – 95 kilometer/hour and 0.02– 0.60 vehicles/kilometer, respectively. Moreover, minimum flows, average speeds, and

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 09, September-2021

densities on each lane occur mostly between 3:00 – 6:00 during all months of both years. The lowest minimum flow and density occur on lane number 2 at 4:00 in January 2013; their values are 2.86 vehicles/hour and 0.02 vehicles/kilometer, respectively. The lowest minimum average speed is 70 kilometers/hour, and this is observed on lane number 0 at 05:10.

Similarly, maximum flow, average speed, and densities are seen to vary between 232–700 vehicles/hour, 91–140 kilometer/hour, and 2 – 7 vehicles/kilometer. In addition, most of the maximum flows and densities on each lane occur between 18:00 – 21:00. Maximum average speeds are seen between 03:00 – 04:00, 08:00 – 10:00, and 16:00 – 21:00. The highest maximum flow and density occur on lane number 1 at 18:35 in August 2013; their values are 699.57 vehicles/hour and 6.70 vehicles/kilometer, respectively. The highest maximum average speed is 140 kilometers/hour, and it is observed on lane number 2 at 3:20 in March 2013.

For lanes numbers 3, 4, and 5 located in the second direction, the average speed decreases from lane number 3 to lane number 5 in all months examined each year. Also, the minimum and maximum flows and densities obtained on each lane in each year mostly occur in January and August respectively. Most minimum speeds are seen in January, while maximum speeds are most common in February and March.

By evaluating the flow, density, and speed on all lanes together for all months of each year, it is seen that the minimum flows, average speeds, and densities vary between 1 – 24 vehicles/hour, 67 – 101 kilometer/hour, and 0.01 – 0.25 vehicles/kilometer, respectively. In addition, minimum flows, average speeds, and densities on each lane occur mostly between 23:00 – 0:00 and 3:00 – 6:00 in all months of both years. Minimum average speeds are observed between 1:00 – 5:00. The lowest minimum flow is obtained on lane number 3 at 3:05 in December 2013, while the lowest minimum density is observed on the same lane at 5:50 in January 2013. Their values are 1.65 vehicles/hour and 0.016 vehicles/kilometer, respectively. The lowest minimum average speed is 68 kilometers/hour, which occurs on lane number 5 at 4:25 in January 2013.

Similarly, it is seen that the maximum flow, average speed, and densities vary between 209 – 612 vehicles/hour, 86 – 140 kilometer/hour, and 2 – 7 vehicles/kilometer, respectively. Also, maximum flows and densities on each lane usually occur between 10:00 – 12:00, 14:00 –- 15:00, and 18:00 – 19:00, respectively; the maximum average speeds are generally seen between 5:00 – 7:00 on each lane. The highest maximum flow and density occur on lane number 4 at 11:15 in August 2013; their values are 611.35 vehicles/hour and 6.30 vehicles/kilometer, respectively. The highest average maximum speed is 139 kilometers/hour, and this is seen on lane number 3 at 6:50 in February 2013.

Flow, Speed, and Density According to Days of the Month

As in the case of quarters, seasons, and months, changes in flow, speed, and density are prepared based on days of the month. By using the previously mentioned symbolic dates, the 24-hour change of flow, speed, and density are evaluated together based on the days of the month and are indicated as 29 - 31 consecutive days. Using this approach, changes in flow, speed, and density, based on days of the month, for 2013 and 2014 are presented in Fig. 19 for lane numbers 0 and 1, in Fig. 20 for lane numbers 2 and 3, and in Fig. 21 for lane numbers 4 and 5.

In detail, traffic data for the first days of each month in 2013 are grouped; the same is done for all the first days of each month in 2014. This is repeated for all second days of each month in each year and so on. Thus, in 2013 and 2014, the change in flow, velocity, and density is established based on days of the month.

On all days of the month of each year investigated, the change of flow and density obtained on each lane follow an irregular pattern. The average speed, however, remains relatively unchanged. Starting from lane numbers 0, 1, and 2 in the first direction, the average speed observed for all days of the month in each year increases from lane number 0 to lane number 2. In addition, the minimum and maximum flows, densities, and average speeds obtained on each lane in each year generally occur in the first 20 days and last 10 – 11 days of each month, respectively.

For lane numbers 0, 1, and 2 in the first direction, joint evaluation of the change in flow, density, and speed for all days of the month of both years show that the minimum flows, average speeds, and densities vary between 2 – 35 vehicles/hour, 59 – 94 kilometer/hour and 0.03 – 0.50 vehicles/kilometer respectively. Also, the minimum flows and densities observed on each lane, on all days of each month in both years, usually occur between 23:00 – 0:00, 2:00 – 3:00, and 4:00 – 5:00. Minimum average speeds are observed between 4:00 – 7:00 and 13:00 – 14:00. The lowest minimum flow and density are obtained on lane number 0 at 23:55 on the 9th day of each month of 2013; their values are 2.61 vehicles/hour and 0.034 vehicle/kilometer, respectively. In 2014, the lowest minimum average speed of 60 kilometers/hour was recorded on lane number 2 at 13:20 on the 27th of every month.

Similarly, peak flow, average speed, and density range from 186 – 566 vehicles/hour, 93–163 km/hour, and 2.00 – 5.60 vehicles/km, respectively. Furthermore, maximum flows and densities on each lane occur mostly between 17:00 – 22:00 on all days of each month in both years; maximum average speeds are recorded on each lane primarily between 3:00 – 4:00, 10:00 – 11:00, and 13:00 – 14:00. At 18:20 on the 31st day of each month in 2014, both the highest peak flow and the highest peak intensity occur on lane number 1; their values are 565.89 vehicles/hour and 5.52 vehicles/kilometer, respectively. The highest maximum average speed of 163 kilometers/hour is observed on lane number 2 at 4:00 on the 31st day of each month in 2014.

Every year, the average speed on lane numbers 3, 4, and 5 in the second direction declines from lane number 3 to lane number 5 on all days of the month. Furthermore, as seen on lane numbers 0, 1, and 2, the minimum and maximum flows, densities, and average speeds recorded on each lane in each year occur mainly in the first 20 days and last 10–11 days of each month, respectively.

By evaluating all days of the month of both years and the flow, density, and speed on the lanes together, the minimum flow, average speed, and densities are found to vary between 2

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 09, September-2021

– 18 vehicles/hour, 64 – 99 kilometer/hour and 0.01 – 0.20 vehicles/kilometer, respectively. Also, minimum flows, average speeds, and densities on each lane occur mostly between 23:00 – 0:00 and 2:00 – 4:00 on every day of each month in both years. The lowest minimum flow and density are obtained on lane number 3 at 3:40 on the 15th day of each month of 2013; their values are 2.03 vehicles/hour and 0.017 vehicle/kilometer, respectively. The lowest minimum average speed is detected on lane number 5 at 3:55 on the 29th of each month in 2014.

Likewise, it is seen that the peak flows, average speeds and densities vary between 204 – 491 vehicles/hour, 90 – 170 kilometer/hour, and 2.00 – 5.10 vehicles/kilometer, respectively. It is also observed that most of the maximum flows and densities on each lane occur between 10:00 – 13:00 and 14:00 – 15:00. Average speeds, however, occur mostly between 3:00 – 7:00 on each lane. The highest flow and density both occur on lane number 4 at 10:15 am on the 31st day of each month in 2014; their values are 490.24 vehicles/hour and 5.00 vehicles/kilometer, respectively. The highest average maximum speed is 170 kilometers/hour, and this is recorded on lane number 3 at 04.20 on the 25th day of each month in 2014.

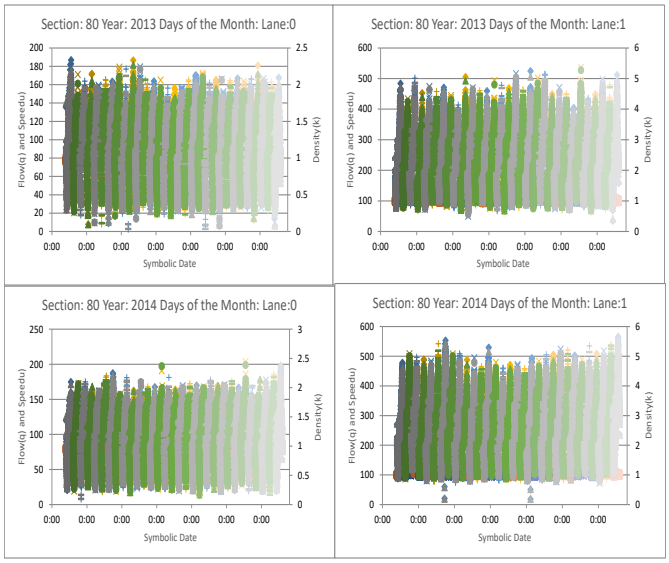


Fig. 19. Flows, speeds, and densities on lane numbers 0 and 1 for all days of the month 2013 and 2014

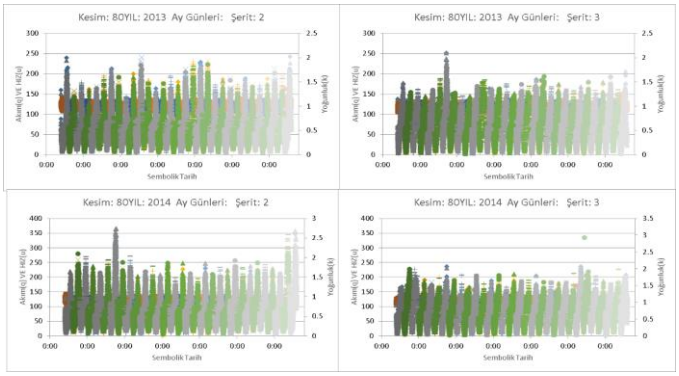


Fig. 20. Flows, speeds, and densities on lane numbers 2 and 3 for all days of the month in 2013 and 2014.

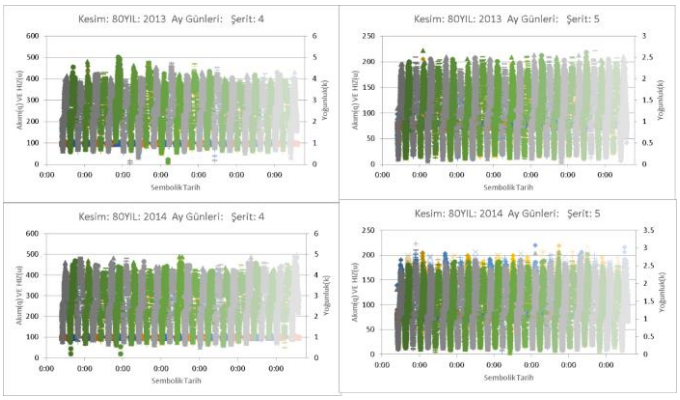


Fig. 21. Flows, speeds, and densities on lane numbers 4 and 5 for all days of the month in 2013 and 2014.

Flow, Speed, and Density According to Days of the Week

As in the other four periods, the changes in flow, velocity, and density are evaluated together based on days of the week, using symbolic dates, and were specified as 7 consecutive days. Fig. 22 – 24 show the variation of flow, speed, and density based on days of the week for lane numbers 0 and 1, lane numbers 2 and 3, and lane numbers 4 and 5, respectively.

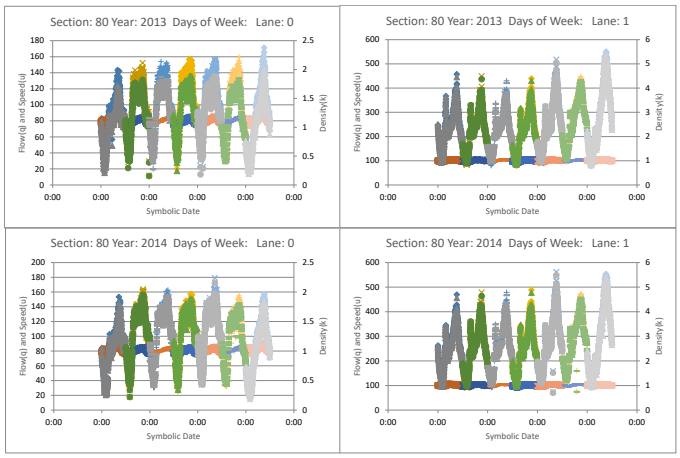


Fig. 22. Flows, speeds, and densities on lane numbers 0 and 1 for all days of the week in 2013 and 2014.

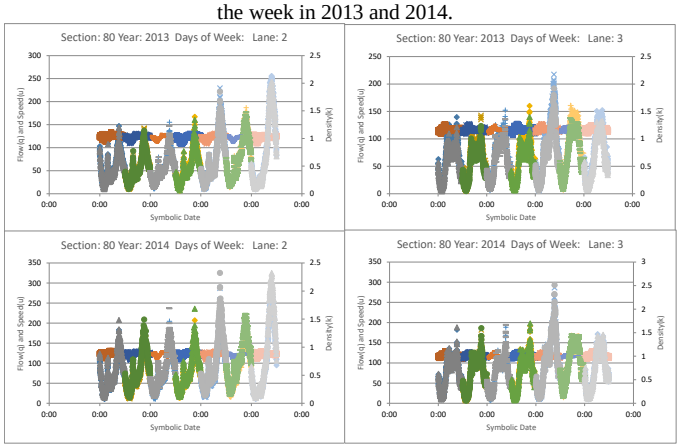


Fig. 23. Flows, speeds, and densities on lane numbers 2 and 3 for all days of the week in 2013 and 2014.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 09, September-2021

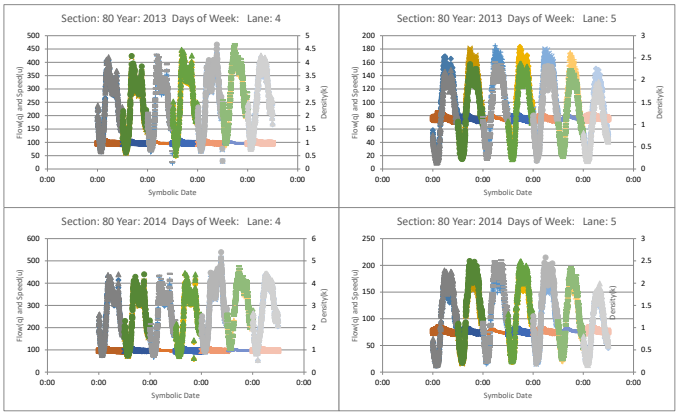


Fig. 24. Flows, speeds, and densities on lane numbers 4 and 5 for all days of the week in 2013 and 2014.

More specifically, traffic data is collected for all Mondays in each year. The same process is repeated for other days of the week. In this way, changes in flow, speed, and density are established based on days of the week in 2013 and 2014.

For each of the two years in which the data were collected, the flows and densities on lanes number 0, 1, and 2 increased from Monday to Sunday, while the average velocity remained relatively constant. In addition, the minimum and maximum flows and densities recorded on each lane in each year generally occur on weekdays and weekends, respectively; most of the minimum and maximum average speeds are seen on weekdays.

Based on days of the week, combined evaluation of flows, speeds, and densities for both years show that the minimum flows, speeds, and densities on lane numbers 0, 1 and 2, change between 6 – 78 vehicles/hour, 73 – 109 kilometers/hour, and 0.06 – 0.90 vehicles/kilometer respectively. Also, in both years, minimum flows and densities on each lane occur mostly between 23:00 – 0:00 and 4:00 – 5:00 on weekdays. Most minimum average speeds are found between 4:00 – 6:00 and 13:00 – 14:00. The lowest minimum flow and density are observed on lane number 2 at 04:00 every Monday in 2013, as 6.50 vehicles/hour and 0.06 vehicles/kilometer, respectively. The lowest minimum average speed is 73 kilometers/hour, and it is seen on lane number 0 at 06:00 on Mondays of every week in 2013.

Similarly, peak flow, average speed, and density range from 171 – 562 vehicles/hour, 88 – 134 kilometers/hour, and 1.90 – 5.50 vehicles/kilometer, respectively. Moreover, the maximum flows and densities on each lane occur most frequently between 17:00 – 20:00. Maximum average speeds are generally observed between 9:00 – 11:00, 14:00 – 15:00, and 17:00 – 18:00. The highest peak flow and density occur on lane number 1 at 18:15 on Fridays of every week in 2014; their values are 561.89 vehicles/hour and 5.48 vehicles/kilometer, respectively. The highest maximum average speed is observed on lane number 2 as 134 kilometers/hour at 10:55 every Tuesday in 2013.

For the second-direction lanes, the flow and density observed on each lane in both years increase from Monday to Friday and decrease from Friday to Saturday; the average speed remains relatively constant on each lane on all days of the week. Average speed decreases from lane number 3 to lane number 5 on all days of the week in each year. In addition, the minimum and maximum flows and densities recorded on each lane in each year generally occur on weekdays and weekends, respectively. Minimum and maximum average speeds are mostly observed on weekdays.

According to the evaluation of the change of traffic flow (based on days of the week) on all lanes in the same direction, the minimum flows, average speeds, and densities change between 5 – 53 vehicles/hour, 70 – 110 kilometer/hour, and 0.04 – 0.60 vehicles/kilometer, respectively. Moreover, minimum flows and densities on each lane occur mostly between 23:00 – 0:00 and 3:00 – 5:00 on all days of the week in both years. Most minimum average speeds occur between 23:00 – 2:00 and 3:00 – 4:00. The lowest minimum flow and density are obtained on lane number 3 at 3:45 every Tuesday in 2013; their values are 5.23 vehicles/hour and 0.045 vehicle/kilometer, respectively. The lowest average speed is 70 kilometers/hour, and it is observed in lane number 5 at 03:30 every Tuesday in 2014.

Likewise, peak flows, average speeds, and densities range between 184 – 512 vehicles/hour, 84 –130 kilometers/hour, and 1.90 – 5.40 vehicles/kilometer, respectively. It is also seen that the maximum flows and densities on each lane mostly occur between 11:00 – 12:00 and 18:00 – 19:00. The maximum average speeds occur between 5:00 – 7:00. Both highest peak flow and density are observed on lane number 4 at 6:25 on Fridays of every week in 2014; their values are 511.42 vehicles/hour and 5.39 vehicles/kilometer, respectively. The highest average maximum speed is 130 kilometers/hour, and it is observed on lane number 3 at 06:45 every Wednesday in 2013.

V. CONCLUSİON AND RECOMMENDATİON

- The lanes in the Ankara-Polatli direction show similar changes of traffic characteristics to corresponding lanes in the Polatli-Ankara direction. In other words, the change of traffic flow, average speed, and density on lane number 0 are similar to the change of flow, average speed, and density on lane number 5; change of traffic parameters on lane number 1 is similar to those of lane number 4, and those of lane number 2 is similar to those of lane number 3. It can be said that the reason for this similarity is because the lanes in both directions are parallel to one another.
- For both years 2013 and 2014 in which data for this study was obtained, according to the five different periods used for evaluation, flow and density on each lane generally increase from year to year. The increase in population which leads to the increase in travel demand can be said to be the cause of the increase in flow and density.
- In both directions, the average speed observed across each period increases from the outermost lane to the innermost lane and vice versa. The reason for this can be because vehicles that can move much faster use the innermost lanes.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 09, September-2021

- Most of the minimum and maximum flow and densities on all lanes examined occur in January and August of both years. Since January and August are respectively found in the first and third quarters, as well as winter and summer, it can be said that the occurrence of the minimum and maximum flow and density values in January and August confirms the occurrence of the minimum and maximum values of the two parameters in the first and third quarter, and winter and summer, respectively.
- August is a month in summer, and summer months are characterised by a lot of movement since people travel on holidays in these months. Thus, it can be implied that the occurrence of most of the maximum flows in August is because of the increased travel demand in summer.
- According to the evaluation made based on days of the month, it was found that most of the minimum and maximum flow and densities occur on the first 20 days and last 10-11 days of the month. It can be said that the reason for this is because most trips are made in the last 10-11 days of the month. Since this is the end of the month, it is the time most people may want to visit their families or go on other recreation trips, and this results in the generation of maximum flow and densities within these days. Contrarily, the occurrence of minimum flow and densities in the first 20 days of the month might be because trips to or from Ankara, for recreation or visits to family, are undesirable within these days.
- Evaluations made based on days of the week show the occurrence of most minimum and maximum flow and densities on weekdays and weekends respectively. It can be said that the reason for the maximum flow and densities on weekends is because people generally choose to travel in or out of Ankara to visit families or go for recreation activities at weekends. Minimum flow and densities observed on weekdays might be because trips to or from Ankara, on recreational or family visits, are undesirable on weekdays; people are generally working within the city on weekdays.
- In this study, based on all periods for which data was evaluated, it is found that the minimum flow and densities occur during night hours, usually between 23:00 – 0:00 and 3:00 – 6:00, on all lanes in the Ankara-Polatli highway section. The movement of the lowest number of vehicles during night hours is expected since these are off-peak hours.
- As expected, the maximum flow and densities on all lanes evaluated occur at peak hours of the day usually between 10:00 – 12:00 and 18:00 – 20:00.
- For all the periods in which data was evaluated, the minimum speeds observed on most lanes mostly occur between 3:00 – 6:00, only on few lanes are the minimum speeds seen between 13:00 – 14:00. While the minimum speeds are not expected to mostly occur at night hours, their occurrence might imply that most lanes in the section are characterised by very high vehicular movement during these hours. It can be said that the reason for the very high volume of vehicles at night hours is because most road users want to avoid the increased travel time peculiar to peak hours of the day when there is maximum flow. They prefer to travel during night hours, and this results in minimum speeds on few lanes within these hours.
- From evaluations, the maximum speeds observed on most lanes occur during daytime usually between 9:00 – 11:00, 12:00 – 15:00, 17:00 – 18:00, and 18:00 – 19:00. On few lanes, however, the maximum speeds are seen between 5:00 – 7:00. The reason for the occurrence of the maximum speeds on most lanes during daytime is also because of the change in travel behavior. Since most road users want to avoid the increased travel time during peak hours of flow, thus travelling at night hours becomes more desirable. Peak hours, on most of the lanes, shift from day time to night time; minimum flows occur on these lanes during day time, and this implies that vehicles can travel at maximum speed.

REFERENCES

[1] Bull, A., & CEPAL, N. (2003). Traffic Congestion: The Problem and how to Deal with it. ECLAC.
[2] Organisation for Economic Cooperation and Development (OECD) (2002) “Road Travel Demand: Meeting the Challenge.” Available at:http://www.itf.oecd.org [Accessed 1 August 2009].
[3] Tiwari, G. (2000). Traffic flow and safety: Need for new models for heterogeneous traffic. Injury prevention and control, 72, 71-88.
[4] Darshan Chen (2013), “Characteristics of Parameters Identification of Macro Traffic Flow on Urban Expressway”, Applied Mechanics and Materials ISSN: 1662 – 7482. Vol 409 – 410. Pp 1209 – 1212. Available at [www.scientific.net/AMM 409 – 410.1209]. Accessed on: 3/1/2021.
[5] Kovacic K., Ivanjko E.; & Jelusic N., (2005), “Measurement of RoadTraffic Parameters Based on Multi-vehicle Tracking”, “Proceeding of the Croatian Vision Workshop, Year 3” Department of Intelligent Transportation System, Faculty of Transport and Traffic Sciences, University of Zagreb.
[6] Roess P., Prassas S. & McShane R., (2004), “Traffic Engineering”, Fourth Edition, Pearson, Pg 95 – 103.
[7] Federal Highway Administration (FHWA) (2018), “Traffic Data Computation Method Pocket Guide” FHWA-PL-18-027, Pg 52.
[8] O’Flaherty C.A (1997), “Transport Planning and Traffic Engineering”, United Kingdom, Elsevier Linacre House, Jordan Hill, Oxford. OX2 8DP.
[9] Garber N.J & Hoel L.A (2009), “Traffic and Highway Engineering”, Cengage Learning, Canada.
[10] Kadiyali L.R (1987) “Traffic Engineering and Transport Planning (1)” New Delhi: Khanna Publishers, 1- 19
[11] May A.D (1990) “Fundamentals of Traffic Flows”, Prentice-Hall, Inc. Englewood Cliff New Jersey 07632, Second Edition, 1990.
[12] Metz, D. (2012). Demographic determinants of daily travel demand. Transport Policy, 21, 20-25.