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ASSESSMENT OF TRAFFIC CONGESTION AND ITS IMPACT ON ROAD CAPACITY IN URBAN AREAS UNDER MIXED TRAFFIC CONDITIONS USING MULTIPLE REGRESSION ANALYSIS - A CASE STUDY OFADDIS ABABA CITY

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Abstract

Traffic congestion is a complex phenomenon that is connected to several vehicle movements on the road. The major reasons behind this problem are the various continuous activities in the urban areas such as education, employment, recreation, business, political, social, and cultural. In addition to these activities, floating and migration, increase congestion on city roads. This will affect the traffic stream characteristics and reduce the road capacity and level of service. The present study aims to evaluate and analyze traffic congestion and its effect on road capacity and level of service at Mebrathail's mid-block location in Addis Ababa city. To achieve the objective, the Mebrathail mid-block was divided into four segments appropriately, and the traffic volume and speed studies were conducted at each segment for 10 hours a day at 15-minute consecutive intervals. The necessary traffic data including road geometry at each segment was recorded. The congestion levels at each segment were then measured by estimating the reduced speed between each segment. The volume-to-capacity ratio (v/c ratio) was then estimated and found to be exceeding 1 in most of the hours of the day, resulting in a poor level of service F. Various Multiple Regression Models were developed correlating the reduced speed with traffic volume, composition, and road geometry. The results from the analysis indicate that traffic congestion on urban roads has an impact on urban characteristics.

Keywords: ***Road Capacity, Level of Service, Reduction in Speed, Traffic congestion, V/C ratio***

I. INTRODUCTION

Traffic congestion is a critical problem in urban areas and probably become a challenge for designers and administrators to control vehicles on the roads. Road congestion cannot be simply solved by improving infrastructure facilities but also needs a technological system for

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transportation management. The traffic control system has direct influence on traffic problems and traffic jams that occur due to various incidents, maintenance works, and other activities on roads. The transportation system should satisfy the perceived social and economic needs of users. The transportation system evolves itself to accommodate users' demand change and problems occur if it becomes inadequate [1]. In addition, improper transportation systems are one of the main causes of traffic congestion in many countries. Traffic has grown proportionate to urbanization in almost all countries in recent years [2].

Traffic congestion is currently high in Addis Ababa city due to the increase in the number of vehicles and pedestrian users concerning economic and social development. Traffic congestion is also influenced by long queues and excessive delays during peak hours in the city and has become a major problem in different sections of the road especially at road mid-blocks. The increasing traffic volume creates a reduction in the speed of vehicles and affects the road capacity resulting poor level of service. This needs the attention of administrators and transport planners to evaluate and mitigate congestion levels by proper management techniques, geometric design, road markings, street lights, traffic signals, construction of flyovers, by-pass roads, outer ring roads, etc. Many cities in various regional states of Ethiopia have developed different ways to implement various measures for reducing the degree of congestion [7]. The traffic volume has been increasing rapidly from time to time in Addis Ababa city. And, as a result, transportation-related problems are getting worse day to day. The increase in traffic volume results in growing congestion levels with associated environmental pollution and a high risk of accidents and wastage of time during travel. This needs alternative intelligent transport management systems and the implementation of new technologies from the transportation planners in the city transportation to smoothen the traffic flow in Addis Ababa city.

II. LITERATURE REVIEW

Traffic congestion has been one of the major issues that most metropolises are facing. Due to this, many measures have been taken to mitigate congestion. It is believed that the identification of congestion characteristics is the first step for such efforts since it is an essential guide for selecting appropriate measures [3]. Traffic congestion can have significant adverse economic, social, and environmental impacts within densely populated urban areas. One of the major factors contributing to traffic congestion is traffic incidents. Traffic incident refers to any event that degrades safety

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and slows traffic, including disabled vehicles, accidents, debris on the roadway, and hazardous material spills; it temporarily reduces the roadway capacity [4]. Different researchers and reports identified many interrelated factors that cause traffic congestion in developed and developing countries where the road network and road users' behavior are different [1]. For instance, many reports show that road network was the main cause of traffic congestion in various developing countries. A research study [8] identified the major traffic congestion causes in Lagos Metropolitan. Accordingly, another study [5] results showed that the cause and their percentage share contribution to traffic congestion in the United States of America are: bottleneck (40%), traffic incidents (25%), work zone (10%), bad weather (15%), poor signal timing (5%), and special events (5%). It indicates that there is no consistent congestion measure used by transport engineers and planners to monitor system congestion [5]. In addition, a good set of congestion measures has the potential to improve not only the quality and consistency of public transportation policy but also public understanding about the congestion phenomenon, leading to political support for policy improvements and more rational behavior by individual travelers.

Accordingly, most literature agrees that the travel time approach for quantifying congestion gives a better opportunity for the public and policymakers to understand the level of congestion. According to a study [6], and other researchers, LOS is the best empirical indicator of congestion in transport systems. Moreover, the road user's perception as a measure for "acceptable" or "Unacceptable" congestion can be taken as an indicator or a demarcation for classifying a road section or an intersection as congested or not.

The current study identified a research gap in evaluating traffic congestion and its effect on road capacity and level of service by measuring the percentage of speed reduction at each segment in the selected mid-block in Addis Ababa. It, therefore, aims to assess the traffic congestion at the selected location and to observe the reduction of traffic speed at each segment in the selected mid-block in Addis Ababa city under variable roadway and traffic conditions.

III. MATERIALS AND METHODS

The research methodology selected the required materials and methods for selecting the study area, location, study design, methods of data collection, the variables for investigation, and the analysis.

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A. Study Area and Study Location

As depicted in Fig.1, Addis Ababa city is considered the study area in the present study, which is the capital city of Ethiopia and is located at a Latitude of 8°58'N and a Longitude of 38°47'E. The city is located at an altitude of 2324 m above mean sea level covering a total area of 527 sq. km. The city has a population of 3,384,569 as per the 2007 population census with a yearly growth rate of 3.8%. As depicted in Fig.2, the Mebrathail mid-block in Addis Ababa city was selected as a study location to evaluate the traffic congestion and its effect on road capacity and level of service.

Fig. 1. Addis Ababa study area aerial view (Courtesy: Google-earth)

Fig. 2. Mabrathail's zoomed mid-block

B. Study Design

The study was organized in two stages. The first stage involves the collection of traffic and roadway data by proper traffic surveys in the selected location of the study area. This includes the division of the selected location into four segments appropriately and collecting traffic volume and speed data with field studies at a time at each segment, for 10 hours at every 15-minute consecutive intervals. The measurement of road geometry at each segment was also part of the study.

The second stage involves the evaluation of traffic congestion levels and their impact on road capacity and level of service. This includes the estimation of road capacity at each segment by plotting respective capacity curves and the estimation of the level of service by measuring the degree of freedom (v/c ratio). The study design also includes the modeling of traffic congestion by considering the responsible factors. The study has considered that the congestion on the road is a

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function of traffic volume, its corresponding speed, and the existing road width. The other factors such as environmental and roadside effects are not considered because their influence in the selected location is found to be negligible.

C. Traffic Data Collection

The traffic data was collected by conducting traffic volume and speed studies at a time at Mebrathaile mid-block in Addis Ababa. Traffic volume data was collected by manual method for 10 hours at every 15-minute consecutive intervals and by counting the number of vehicles with a composition that crosses the reference line at each segment in the study location. Similarly, traffic speed data was also collected by manual method for 10 hours at every 15 minutes consecutive intervals. To collect traffic speed data, two reference lines were drawn at a distance of 30 meters at the study location. Then, the travel time taken for each vehicle to cross the two reference lines was measured. After knowing the distance and travel time, the traffic speed was calculated for different categories of vehicles. Later, the average speed was evaluated. Road geometry at each segment in the study location was also measured and recorded. The traffic data was collected on weekdays during the summer season. Table I and Fig. 3 indicate the traffic volume and speed data collected at the study location.

IV. ANALYSIS AND DISCUSSION

A. Evaluation of Reduced Speed

Traffic Speed on a road is the symbol of driving comfort that indicates the level of service of the road. The present research aims to observe the variation of traffic speed for a particular traffic volume and composition under variable traffic and roadway conditions. The reduction of traffic speed (km/hr) at each segment in the study location was then calculated by taking the difference of traffic speed at segment 1 with the traffic speeds at other consecutive segments. The congestion levels measured on the selected mid-block were the result of the traffic speed variation (speed reduction) along each segment, which was considered one of the major parameters to cause traffic congestion.

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Table I: Mebrathail Mid-Block – Traffic Volume and Speed Data

Time	Segment 1		Segment 2			Segment 3			Segment 4		
	Volume, Veh/hr	Speed, Km/hr	Volume, Veh/hr	Speed, Km/hr	Reduced Speed	Volume, Veh/hr	Speed, Km/hr	Reduced Speed	Volume, Veh/hr	Speed, Km/hr	Reduced Speed
8-8.15	1976	25.72	2040	18.12	7.6	1704	25.69	0.03	2168	18.62	7.1
8.15-8.30	1804	28.94	1116	20.25	8.69	2196	28.5	0.44	2368	21.3	7.64
8.30-8.45	2256	25.56	2096	18.03	7.53	2272	25.31	0.25	2416	18.46	7.1
8.45-9	1684	26.09	1832	21.08	5.01	1972	15.36	10.73	1928	18.68	7.41
9-9.15	2212	29.23	2008	23.4	5.83	2220	24.99	4.24	2100	27.13	2.1
9.15-9.30	2396	27.4	1636	17.86	9.54	1752	21.42	5.98	1976	26.3	1.1
9.30-9.45	2224	26.27	1748	17.09	9.18	1812	21.91	4.36	1960	25.74	0.53
9.45-10	1708	28.91	1496	20.39	8.52	1508	28	0.91	2000	20.85	8.06
10-10.15	2024	29.95	1652	20.34	9.61	1844	28.3	1.65	2028	20.61	9.34
10.15-10.30	1920	34.88	1932	21.15	13.73	1924	21.78	13.1	1980	33\.87	1.01
10.30-10.45	1944	27.9	1896	21.38	6.52	1896	19.68	8.22	1923	22.2	5.7
10.45-11	1888	34.31	1876	30.46	3.85	1876	22.12	12.19	1964	33.12	1.19
11-11.15	1748	32.55	1992	30.73	1.82	1992	21.93	10.62	2212	24.08	8.47
11.15-11.30	1864	28.34	1852	19.39	8.95	1840	25.24	3.1	2008	27.67	0.67
11.30-11.45	2108	26.65	1960	25.84	0.81	2100	26.21	0.44	1948	26.27	0.38
11.45-12	1844	28.06	1772	21.59	6.47	1776	21.71	6.35	2092	27.87	0.19
1-1.15	1800	28.91	1648	21.46	7.45	1760	24.69	4.22	1932	26.33	2.58
1.15-1.30	1860	39.15	1744	31.62	7.53	1820	38.34	0.81	1828	31.23	7.92
1.30-1.45	1840	37.77	1800	28.36	8.41	1840	32.96	4.81	1808	24.12	13.65
1.45-2	1716	30.36	1736	22.36	8	1776	28.06	2.3	1748	28.14	2.22
2-2.15	1672	26.33	1544	30.72	-4.39	1544	22.86	3.47	1648	31.17	-4.84
2.15-2.30	1636	26.24	1492	30.61	-4.37	1492	22.55	3.69	1552	28.35	-2.11
2.30-2.45	1576	28.94	1592	27.29	1.65	1592	20.1	8.84	1704	25.87	3.07
2.45-3	1592	31.37	1676	29.48	1.89	1704	21.51	9.86	1664	27.48	3.89
3-3.15	1680	29.91	1764	11	18.91	1764	29.4	0.51	1792	11	18.91
3.15-3.30	1620	32.38	2092	30.58	1.8	2032	22.06	10.32	1852	26.58	5.8
3.30-3.45	1636	26.42	1960	13.38	13.04	1960	25.81	0.61	1888	20.14	6.28
3.45-4	1756	34.93	2232	30.56	4.37	1912	22.85	12.08	1912	25.28	9.65
4-4.15	1744	33.58	1928	32.31	1.27	1928	23.74	9.84	1940	25.85	7.73
4.15-4.30	1752	29.19	2364	27.76	1.43	1920	21.95	7.24	1916	25.05	4.14
4.30-4.45	1896	28	2336	26.5	1.5	2044	21.23	6.77	1920	21.13	6.87
4.45-5	1892	29.03	2176	24.88	4.15	2176	20.77	8.26	2304	22.88	6.15
5-5.15	1928	27.49	2380	17.34	10.15	1964	21.71	5.78	2236	26.26	1.23
5.15-5.30	2212	32.41	2168	26.67	5.74	2168	30.53	1.88	2372	26.67	5.74
5.30-5.45	2016	27.73	2216	20.69	7.04	2320	26.74	0.99	2384	20.14	7.59
5.45-6	2012	28.27	2320	27.25	1.02	2346	24.65	3.62	2352	18.09	10.18
6-6.15	2144	31.77	2272	30.1	1.67	2400	22.1	9.67	2288	28.2	3.57
6.15-6.30	2288	29.95	2252	29.89	0.06	2252	26.9	3.05	2264	19.44	10.51
6.30-6.45	2188	28.13	2568	18.45	9.68	2384	27.61	0.52	2340	20.05	8.08
6.45-7	2164	23.05	2520	16.15	6.9	2309	16.67	6.38	2440	16.76	6.29

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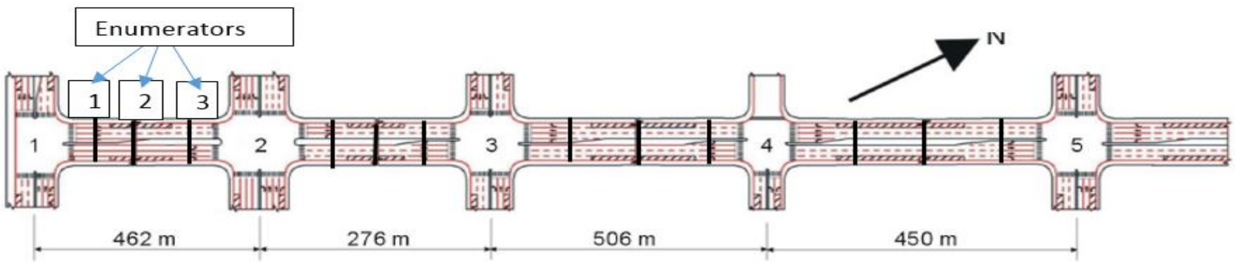

Fig. 3. Example of segment division at the selected location during data collection

B. Determination of Road Capacity and Level of Service

Road capacity is the function of traffic volume and speed. Thus, the variation of stream characteristics on the road will affect the road capacity and its level of service. To measure the effect of traffic volume and speed, capacity curves were drawn by plotting the graphs between traffic volume (vehicle/hour) on the x-axis and corresponding traffic speed (km/hour) on the y-axis at each segment of the selected mid-block. The road capacity at each segment of the mid-block was then evaluated from the plotted graphs. The degree of freedom (v/c ratio) for each 15-minute consecutive interval was then determined for each segment of the selected mid-block, as shown in Table II. Later, by considering the Highway Capacity Manual (2000) guidelines for degree of freedom, the level of service of the road was evaluated at each segment for every 15-minute consecutive interval. The results obtained from the evaluations indicate that the level of service was very poor with the level of service F at each segment during peak hours for the majority of the peak period. It was also observed to be average to poor levels of service D and E during the majority of non-peak hours. This indicates that the impact of traffic congestion is high during peak hours in the study area and is normal during half-peak hours.

Table II: Mabrathail mid-block – road capacity and level of service

	Segment 1				Segment 2				Segment 3				Segment 4			
Time	volume	capacity	v/c	Los	Volume	capacity	v/c	Los	volume	Capacity	v/c	Los	volume	capacity	v/c	Los
8-8.15	1976	2410	0.8	E	1240	2565	0.4	C	1704	1815	0.9	E	2168	1790	1	F
8.15-8.30	1804	2410	0.7	D	1116	2565	o.4	C	2196	1815	1	F	2364	1790	1	F
8.30-8.45	2256	2410	0.9	E	2096	2565	0.8	E	2272	1815	1	F	2410	1790	1	F
8.45-9.00	1684	2410	0.7	D	1832	2565	0.7	D	1972	1815	1	F	1928	1790	1	F
9-9.15	2212	2410	0.9	E	2008	2565	0.7	D	2220	1815	1	F	2100	1790	1	F
9.15-9.30	2396	2410	0.9	E	1636	2565	0.6	D	1752	1815	0.9	E	1976	1790	1	F
9.30-9.45	2224	2410	0.9	E	1748	2565	0.6	D	1812	1815	1	F	1900	1790	1	F
9.45-10	1708	2410	0.7	D	1496	2565	0.5	C	1508	1815	0.8	E	2000	1790	1	F
10-10.15	2024	2410	0.8	E	1602	2565	0.6	D	1844	1815	1	F	2028	1790	1	F
10.15-10.30	1920	2410	0.8	E	1932	2565	0.7	D	1924	1815	1	F	1980	1790	1	F

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10.30-10.45	1944	2410	0.8	E	1896	2565	0.7	D	1996	1815	1	F	1976	1790	1	F
10.45-11	1888	2410	0.7	D	1874	2565	0.7	D	1870	1815	1	F	1964	1790	1	F
11-11.15	1748	2410	0.7	D	1912	2565	0.7	D	1992	1815	1	F	2212	1790	1	F
11.15-11.30	1814	2410	0.7	D	1822	2565	0.7	D	1840	1815	1	F	2008	1790	1	F
11.30-11.45	2108	2410	0.8	E	1960	2565	0.7	D	2100	1815	0.9	E	1948	1790	1	F
11.45-12	1844	2410	0.7	D	1772	2565	0.6	D	1796	1815	1	F	2092	1790	1	F
12-12.15	1800	2410	0.7	D	1648	2565	0.6	D	1960	1815	1	F	1932	1790	1	F
12.15-12.30	1860	2410	0.7	D	1744	2565	0.7	D	1820	1815	1	F	1828	1790	1	F
12.30-12.45	1840	2410	0.7	D	1800	2565	0.7	D	1840	1815	1	F	1808	1790	1	F
12.45-1	1716	2410	0.7	D	1736	2565	0.6	D	1776	1815	1	F	1745	1790	0.9	E
1-1.15	1672	2410	0.6	C	1544	2565	0.5	C	1544	1815	0.9	E	1648	1790	0.9	E
1.15-1.30	1630	2410	0.6	C	1492	2565	0.6	D	1492	1815	0.8	E	1562	1790	0.8	E
1.30-1.45	1576	2410	0.6	C	1582	2565	0.6	D	1582	1815	0.8	E	1904	1790	1	F
1.45-2	1542	2410	0.6	C	1676	2565	0.6	D	1904	1815	0.8	E	1896	1790	1	F
2-2.15	1680	2410	0.7	D	1714	2565	0.6	D	1764	1815	1	F	1912	1790	1	F
2.15-2.30	1620	2410	0.6	C	2012	2565	0.7	D	2012	1815	0.9	E	1940	1790	1	F
2.30-2.45	1660	2410	0.6	C	1960	2565	0.7	D	1905	1815	1	F	1990	1790	1	F
2.45-3	1756	2410	0.7	D	2212	2565	0.8	E	1912	1815	1	F	1925	1790	1	F
3-3.15	1744	2410	0.7	D	1928	2565	0.7	D	1928	1815	1	F	2304	1790	1	F
3.15-3.30	1709	2410	0.7	D	2313	2565	0.9	E	1920	1815	1	F	2230	1790	1	F
3.30-3.45	1806	2410	0.7	D	2416	2565	0.9	E	2044	1815	1	F	2352	1790	1	F
3.45-4	1890	2410	0.7	D	2176	2565	0.8	E	2176	1815	1	F	2288	1790	1	F
4-4.15	1926	2410	0.8	E	2280	2565	0.9	E	1963	1815	1	F	2364	1790	1	F
4.15-4.30	2313	2410	0.9	E	2360	2565	0.9	E	2168	1815	1	F	2260	1790	1	F
4.30-4.45	2016	2410	0.8	E	2218	2565	0.8	E	2320	1815	1	F	2380	1790	1	F
4.45-5	2012	2410	0.8	E	2230	2565	0.8	E	2006	1815	1	F	2215	1790	1	F
5-5.15	2144	2410	0.8	E	2315	2565	0.9	E	2252	1815	1	F	2136	1790	1	F
5.15-5.30	2089	2410	0.8	E	2342	2565	0.9	E	2182	1815	1	F	2340	1790	1	F
5.30-5.45	2165	2410	0.9	E	2416	2565	0.9	E	2265	1815	1	F	2280	1790	1	F
5.45-6	2124	2410	0.8	E	2268	2565	0.8	E	2259	1815	1	F	2278	1790	1	F
6-6.15	2235	2410	0.9	E	2170	2565	0.8	E	2176	1815	1	F	2310	1790	1	F
6.15-6.30	2436	2410	1	F	2269	2565	0.8	E	2180	1815	1	F	2308	1790	1	F
6.30-6.45	2098	2410	0.8	E	2315	2565	0.9	E	2207	1815	1	F	2293	1790	1	F
6.45-7	2385	2410	0.9	E	2287	2565	0.9	E	2182	1815	1	F	2284	1790	1	F

C. Analysis of the level of Congestion

According to the Tomtom's Traffic Index, Congestion levels can be divided into four forms:

i. No congestion: <15% reduction in traffic speed
ii. Low congestion : 15%-25% of reduction of speed
iii. Medium congestion : 25%-50% of reduction of speed
iv. High congestion : >50% of reduction in speed

In the present study, traffic indices in accordance with Tomtom's were calculated to assess and analyze the traffic congestion at the selected mid-block location.

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D. Multiple Regression Models

Different Multiple Regression Models were developed by considering the percentage of reduced speed as the dependent variable and the factors associated with traffic congestion such as traffic volume with composition and road geometry as independent variables by using SPSS Software. Multiple regression models were developed for Medium Congestion level and Heavy Congestion level at each segment of the selected Mid-block and are as given below.

1) ***For Reduction in Speed between Segment 1 to Segment 2***

a) Medium Congestion Situation

Model 1:

$$\% \, of \; Reduction \; in \; Speed \; (\% \, of \; RS) = 40.025 + 0.006 \, (Volume) - 2.227 \, (Road \; width) \quad (1)$$

R Square = 0.807, F Value = 7.919, Significance Value = .003

b) High Congestion Situation

Model 2:

$$\% \, of \; Reduction \; in \; Speed \; (\% \, of \; RS) = 78.086 + 0.003 \, (Volume) - 4.055 \, (Road \; width) \quad (2)$$

R Square= 0.782, F Value = 3.859, Significance Value =.007

2) ***For Reduction in Speed between Segment 1 to Segment 3***

a) Medium Congestion Situation

Model 3:

$$\% \, of \; Reduction \; in \; Speed \; (\% \, of \; RS) = 52.959 + 0.004 \, (Volume) - 3.486 \, (Road \; width) \quad (3)$$

R Square = 0.786, F Value = 3.654, Significance value = 0.001

b) High Congestion Situation

Model 4:

$$\% \, of \; Reduction \; in \; Speed \; (\% \, of \; RS) = 76.105 + 0.003 \, (Volume) - 4.989 \, (Road \; width) \quad (4)$$

R Square = 0.985, F Value = 66.086, Significance Value = 0.005

3) ***For Reduction in Speed between Segment 1 to Segment 4***

a) Medium Congestion Situation

Model 5:

$$\% \, of \; Reduction \; in \; Speed \; (\% \, of \; RS) = 32.689 + 0.008 \, (Volume) - 2.430 \, (Road \; width) \quad (5)$$

R Square = 0.821, F Value = 9.143, Significance Value = 0.012

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b) High Congestion Situation

Model 6:

$$\% \ of \ Reduction \ in \ Speed \ (\% \ of \ RS) = 55.649 + 0.003 \ (Volume) - 1.510 \ (Road \ width) \quad (6)$$

R Square = 0.965,   F Value = 34.961,   Significance Value = 0.002

E. Development of Graphs for Medium and High Congestion Situations

Different graphs were plotted from the above models for both medium -and high-congestion situations. The graphs were plotted by considering Traffic Volume on the x-axis and the percentage of Reduction in Speed on the y-axis. The outcomes of the above models indicate that for a given traffic situation on the road, a relationship exists between Traffic Volume, Road width, and percentage of Reduction in Speed. The results indicate that for a given traffic volume, the % of speed reduction decreases as the road width increases. Similarly, for a given road width, the percentage of speed reduction increases as the traffic volume increases. Fig. 4 to 9 and Table III show the variation of deceleration for different traffic situations and road widths.

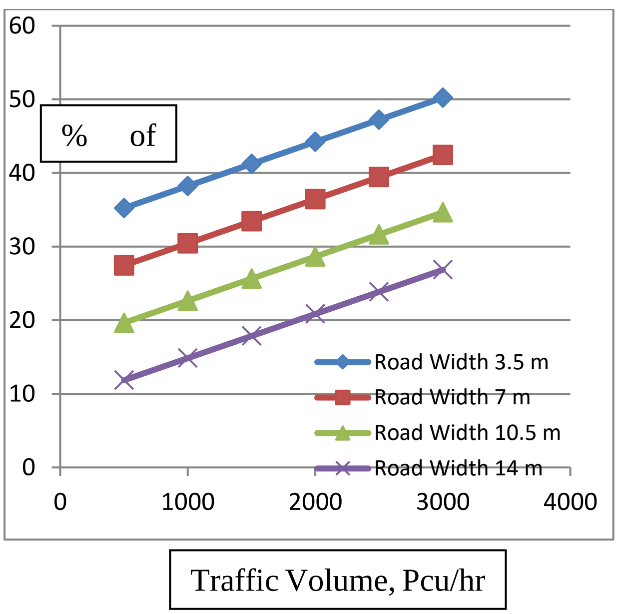

Fig. 4. Segment 1 to 2 – Medium Congestion

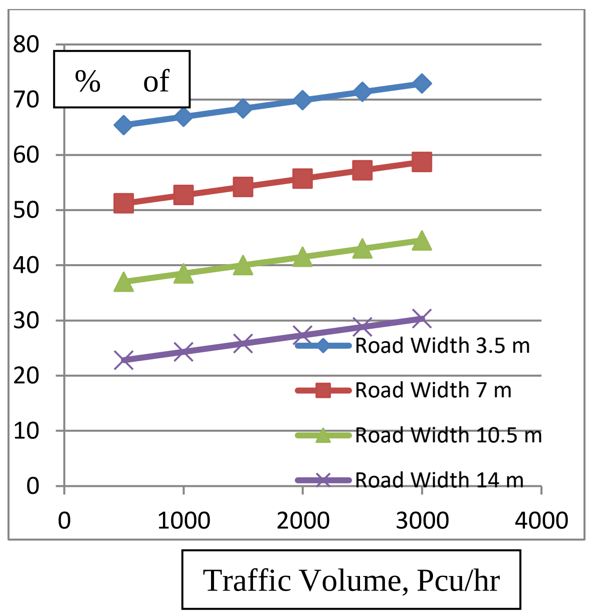

Fig. 5. Segment 1 to 2 – High Congestion

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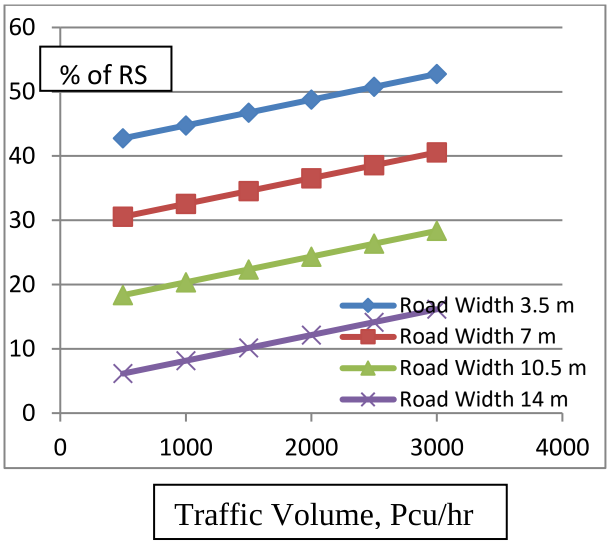

Fig. 6. Segment 1 to 3 – Medium Congestion

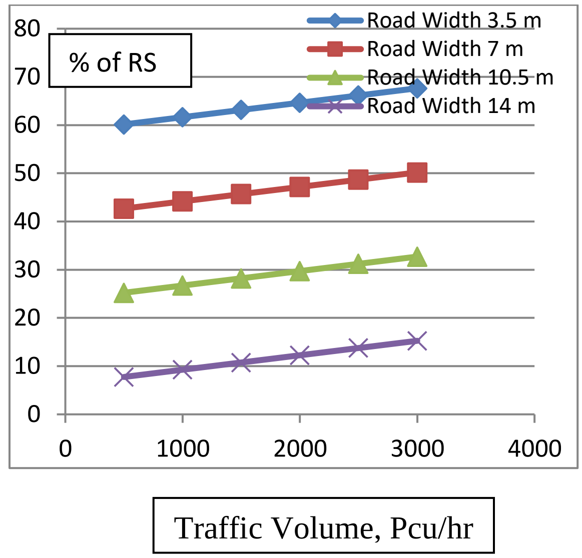

Fig. 7. Segment 1 to 3 – High Congestion

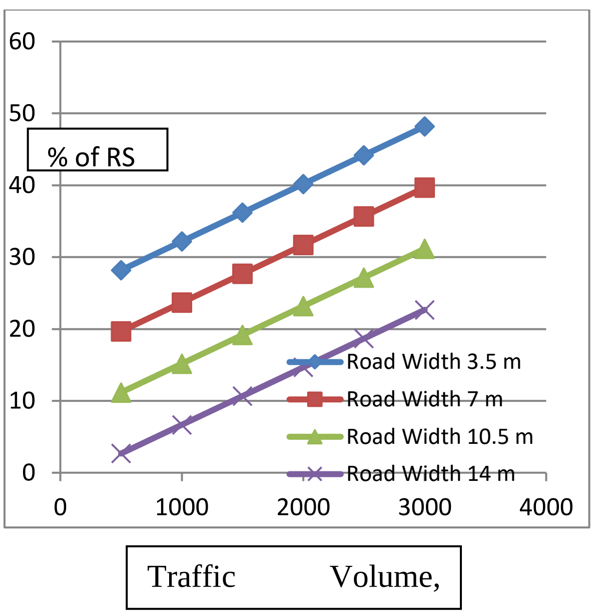

Fig. 8. Segment 1 to 4 – Medium Congestion

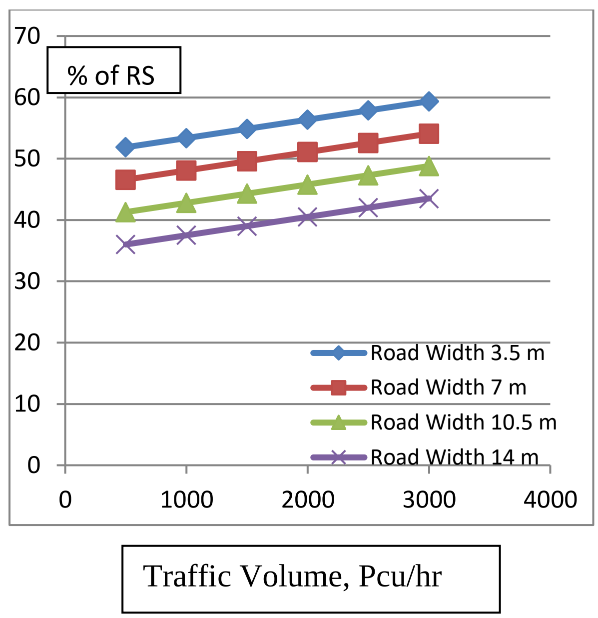

Fig. 9. Segment 1 to 4 – High Congestion

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Table III: % of reduction in speed under different traffic situations & road widths–from models

Segment / Situation	% of RS - Road width 7 m	% of RS - Road width 10.5 m	% of RS- Road width 14 m
For a Traffic Volume: 2000 Pcu/hr			
1 to 2 – Medium Congestion (Model 1)	37	28	21
1 to 2 – High Congestion (Model 2)	56	41	27
1 to 3 – Medium Congestion (Model 3)	35	24	12
1 to 3 – High Congestion (Model 4)	48	30	16
1 to 4 – Medium Congestion (Model 5)	31	23	15
1 to 4 – High Congestion (Model 6)	51	45	40

V. CONCLUSION

Traffic congestion is a complex situation in Addis Ababa city that makes the traffic volume decline on the road. Due to this effect, the speed of the vehicles, road capacity, and level of service decrease correspondingly, whereas travel time, travel cost, and traffic delay increase harmoniously. The acceleration and deceleration of the vehicles change due to congestion levels in the city which accelerate air pollution on roads. The present study was conducted to analyze the effect of traffic congestion on traffic stream characteristics in Addis Ababa city. The traffic data was collected at four different segments on the selected Mebrathail mid-block, at every 15-minute consecutive interval, for 10 hours. The percentage of reduction in speed at different segments was evaluated by considering the speed variations at each segment in the selected midblock. Different Multiple Linear Regression models were developed for each segment by considering the % of reduction in speed as the dependent variable and the traffic volume and road width as independent variables. The results indicate that for a road width of 7 m to 14 m with a traffic volume of 2000 Pcu/hr, the percentage of speed reduction varies between 12% to 37% for medium congestion levels and between 16 % to 56% for high congestion levels.

VI. RECOMMENDATIONS

- For a road width of 6m having a traffic speed of 50 km/hr, the traffic volume shall be limited to 1750 pcu/hr and is 2900 pcu/hr for a road width of 8m and for the same speed
- Restrict on-street parking at all the segments in the study location to reduce further the effect of traffic congestion level

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