STUDY OF VEHICULAR TRAFFIC CONGESTION IN THE SEKONDI-TAKORADI METROPOLIS

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ABSTRACT

Sekondi-Takoradi Metropolis, the Western Regional capital of Ghana, faces severe vehicular traffic congestion due to the influx of people into the Metropolis because of the recent discovery of crude oil in some environs of the Region. This has resulted in rapid and uncontrolled development by an unacceptable level of disparity in transportation demand and supply scenario. This research paper presents the traffic volume count, survey of road geometry and calculation of flow capacity. Secondary data was collected from the Department of Urban Roads Sekondi-Takoradi. The study revealed that Kwesimetim to Ajep link, the core link of the city was found as the busiest link, whereas, the Kwame Nkrumah circle was found to be the most congested zone depicting a maximum average traffic volume at a rate of 3138 Veh/h and 3985 Veh/h for the AM and PM peak periods respectively. Two vehicular traffic congestion peaks at 6:00AM to 9:00AM and 4:00PM to 7:00PM were identified in the study. A traffic growth rate of 1.51% was identified. The Roadway Congestion Index of 3.18 indicated the severity of traffic congestion in the Sekondi-Takoradi Metropolis.

1.0 INTRODUCTION

The forces that draw inhabitants to congregate in large urban areas also lead to intolerable levels of traffic congestion on urban streets. The Sekondi-Takoradi Metropolis is the third city in Ghana with a population of about 360,000 (Ghana Statistical Service, provisional results urban localities, 2002). Flaws in transportation system in the Sekondi-Takoradi Metropolis are now pronounced as severe traffic congestion (official website of Sekondi-Takoradi Metropolitan Assembly).

RELATED WORKS

2.0 Gravity-Based Models

These models are sometimes called Parameter Calibration models, and represent the original idea of establishing trip distributions. In these models, the entries of the Origin-Destination matrix are assumed to be a function of the traffic count and other parameters. Regression techniques and the flow conservation law are applied to calibrate the parameters such that the differences between observed volumes and established volumes are minimized. The models are divided into linear (Low, 1972; Holm et al., 1976; Gaudry and Lamarre, 1978) and nonlinear (Rolillhard, 1975; Hogbag, 1976) regression models.

2.1 Equilibrium Models

These models are based on the principle of user optimization of traffic flow, called the "Equilibrium Principle" or "Wardrop's Principle" (Wardrop, 1952). These include LINKOD (Nguyen, 1977a-b; Gur, 1980), SMALD (Kurth et al., 1979), and Linear Programming (Sivanandan, 1991; Sherali et al., 1994a-b).

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2.2 Entropy Models

Minimum Information and Maximum Entropy models are included in this group and can be converted to a type of gravity models. In these models, the probability of a particular trip distribution occurring is assumed to be proportional to the number of the states (entropy or disorder) of the system. The derived Origin-Destination table is purported to be the most likely one that is consistent with information such as length and free speed of the links contained in the link flows. The pioneers of these models, are Wilumsen (1978) and Zuylen (1978, 1979). Many improvements and combinations with other theories have been conducted (Easa, 1993b).

2.3 Statistical Models

The Statistical models take into account inaccuracies on the observed Origin-Destination flows, row and column sums and traffic counts. This group includes the Constrained Generalized Least Squares model (McNeil, 1983), and Constrained Maximum-Likelihood models (Walting and Maher, 1988). Another model, called MEUSE, standing for Matrix Estimation Using Structure Explicitly (Bierlaire and Toint, 1995), which uses both historic data and parking data as input, can be partially included in this subgroup.

2.4 Neural Network Models

Muller and Reinbardt (1990) introduced the neural network approach to determine Origin-Destination trip table from traffic counts. The procedure in this approach includes "learning" and "optimization" components. The model may be mathematically described as a directed graph with three characteristics. (i) a state of variable associated with each node; (ii) a weight assigned to each link; and (iii) a transfer function defined for determining the state of each node as a function of its bias and weights of its incoming links. Yang, Akiyamma and Sasaki (1992) adopted a feed-forward neural network for synthesising Origin-Destination flow for a four-way intersection and a short freeway segment. Chin, Hwang and Pei (1994) described a neural network model for generating Origin-Destination information from flow volumes.

3.0 PROPOSED METHODOLOGY

The methodology used to study the Vehicular Traffic congestion in the Sekondi-Takoradi Metropolis is described below:

(i) Selection of study area within the jurisdiction of Sekondi-Takoradi Metropolitan Assembly
(ii) Zoning of the study area, which include wards within the Metropolis for effective analysis of the traffic situation
(iii) Data on type of vehicular count (i.e. Master Station Classification Count, Screen Line Classification Count and Turning Movements Counts) based on the link volume count, intersection volume count, link width and intersection dimension were obtained from the Department of Urban Roads, Sekondi-Takoradi.
(iv) Various indices such as the Roadway Congestion index were employed to quantify the overall vehicular traffic volume within the Metropolis.

3.1 ZONING OF THE STUDY AREA FOR ANALYSIS

The area under consideration was divided into five zones as follows:

(i) Zone 1: Areas in and around the Takoradi Market Circle
(ii) Zone 2: Paa Grant roundabout near New Takoradi and the Takoradi Polytechnic traffic light junction.
(iii) Zone 3: Effiakuma traffic light popularly known as Number Nine traffic light.
(iv) Zone 4: Tanokrom traffic light also known as Pipe Anor traffic light.
(v) Zone 5: Kwame Nkrumah Circle which is popularly referred to as Ajep roudabout.

The map of the study area (Sekondi-Takoradi) is as shown in figure 3.1

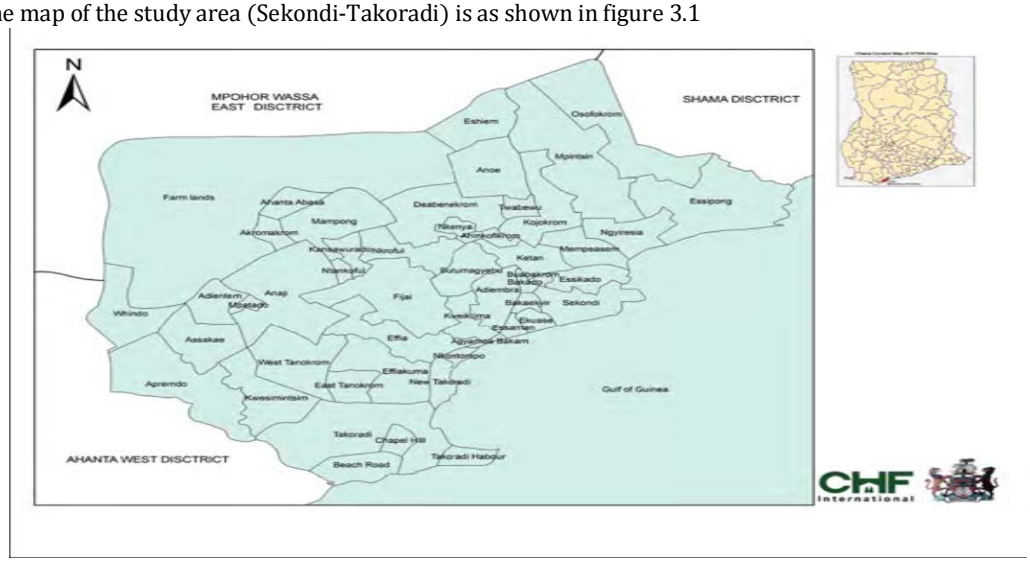

Figure 3.1 Map of the study Area

3.2 VEHICULAR VOLUME COUNT

In the study, the extent of variation of traffic flow was ascertained by carrying out twelve-hour (6:00-18:00) weekday counts at five intersections such as Takoradi market circle, Paa Grant roundabout, Number nine, Pipe Anor and Ajep. By analyzing the twelve-hour volumes, the period of peak flows are assessed. Traffic volume counts were performed at major intersections and important links only in the period of peak flows as assessed by a twelve-hour traffic volume count. The traffic volume is expressed as passenger car unit per hour. The following are the types of vehicular traffic counts that were conducted:

(i) Master Station Classification Count
(ii) Screen line Classification Counts
(iii) Turning Movements Counts

3.3 WAYS TO QUANTIFY CONGESTION

A number of studies have been carried out by a number of researchers and professional organizations to develop Congestion Indices. For regional analysis such type of indices cannot be used directly but the theme can be translated from a particular scope to a broader perspective. The congestion indices mostly used to study traffic congestion are:

(i) Roadway Congestion Index (RCI)
(ii) Travel Rate Index (TRI)
(iii) Volume-Capacity Index (VCI)
(iv) Congestion Severity Index (CSI)

Due to insufficient data, only the RCI was employed to study the vehicular traffic situation in the Sekondi-Takoradi Metropolis. RCI can be computed by the equation below

$$\text{RCI} = \frac{\sum \frac{(Vehicle\ per\ Peak\ Hour)}{(Link\ Capacity)} * (Vehicle\ per\ Peak\ Hour * Link\ Lengt\ h)}{\sum (Vehicle\ per\ Peak\ Hour * Link\ Lengt\ h)}$$

Here the RCI stands as the network weighted average volume capacity ratio, which indicates the index value of extra vehicle kilometre travel needed due to congestion in peak hours.

4.0 DATA ANALYSIS AND DISCUSSION OF THE STUDY

Data was collected from Department of Urban Roads, Sekondi-Takoradi. The results of the data obtained have been summarized into tables and graphs to clarify the Vehicular traffic and transport patterns in the Metropolis.

4.1 TRAFFIC FLOW CHARACTERISTICS

Results of the traffic flow characteristics for the Master Stations in Sekondi-Takoradi Metropolis are as shown in Table 4.1.The table indicates the average AM-peak and PM-peak volumes, the average daily 12-hour volumes, average 24-hour volumes and the various traffic variation factors based on the average 24-hour totals. The results show that the average 12-hour daily flows at the Master Stations form more than 68% of the total average of the 24-hour flow.

Table 4.1: Traffic Flow Characteristics at the Master Stations in Takoradi

Descriptor	MS1 Liberation road, Near Obuasi Road	MS2 Sekondi Road, Near Goil Station	MS3 Sekondi By-Pass, Near Tanokrom	MS4 Agona Nkwanta Road, West of PTC	MS5 Kansaworado /Apramdo By-pass, Near St Francis School Junction	MS6 Axim Road, Near Air Force Base
AM Peak-Hour Volume	730 (7.40%)	1756 (6.67%)	1590 (6.04%)	2108 (7.67%)	735 (8.58%)	1616 (7.74%)
PM Peak-Hour volume	839 (8.50%)	1769 (6.72%)	1643 (6.24%)	1946 (7.08%)	606 (7.08%)	1643 (7.87%)
12-Hour (06:00-18:00) Weekday Total Volume	7879 (79.90%)	19753 (75.03%)	18008 (68.39%)	20236 (73.62%)	6510 (76.02%)	16298 (78.06%)
24-Hour Weekday Total Volume	9862 (100.00%)	26327 (100.00%)	26332 (100.00%)	27487 (100.00%)	8563 (100.00%)	20880 (100.00%)

From Table 4.1, MS4 (Agona Nkwanta Road, West of PTC) recorded the highest 24-hour traffic of 27487 veh/day, followed by MS3 (Sekondi By-Pass, Near Tanokrom) with 26332 veh/day, MS6, MS1 and MS5 respectively. MS4 registered the highest AM-peak and PM-peak of 2108 (7.67%) and1946 (7.08%) respectively for the morning and evening. The AM and PM peak flows of station MS2, however registered the second highest AM and PM peak flows recording 1756 and 1769 per day for the morning and evening period respectively.

4.2 HOURLY TRAFFIC DISTRIBUTION

The Excel output in Table 4.2 and Figure 4.1 show the hourly distribution of traffic during the 24-hour count at the Master Stations in Sekondi-Takoradi.

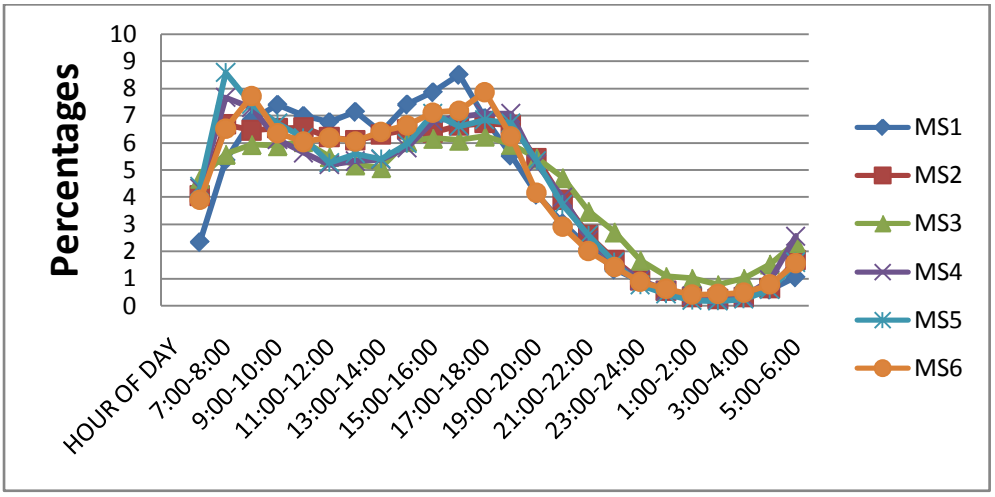

Figure 4.1: Percentage hourly Distribution of Traffic in Sekondi-Takoradi

Table 4.2: Percentage Hourly Distribution of Traffic

HOUR OF DAY	MS1		MS2		MS3		MS4		MS5		MS6	
	% TOTAL	% CUM	% TOTAL	% CUM	% TOTAL	% CUM	% TOTAL	% CUM	% TOTAL	% CUM	% TOTAL	% CUM
6:00-7:00	2.35	2.35	4.05	4.05	4.69	4.69	4.33	4.33	4.39	4.39	3.9	3.9
7:00-8:00	5.35	7.7	6.67	10.72	5.57	10.26	7.67	12	8.58	12.97	6.52	10.42
8:00-9:00	6.84	14.54	6.45	17.17	5.93	16.19	7.3	19.3	7.41	20.38	7.74	18.16
9:00-10:00	7.4	21.94	6.53	23.7	5.89	22.08	6.13	25.43	6.71	27.09	6.37	24.53
10:00-11:00	6.99	28.93	6.55	30.25	6.04	28.12	5.63	31.06	6.18	33.27	6.04	30.57
11:00-12:00	6.76	35.69	6.2	36.45	5.49	33.61	5.2	36.26	5.27	38.54	6.2	36.77
12:00-13:00	7.14	42.83	6.08	42.53	5.18	38.79	5.33	41.59	5.59	44.13	6.06	42.83
13:00-14:00	6.39	49.22	6.3	48.83	5.08	43.87	5.38	46.97	5.41	49.54	6.41	49.24
14:00-15:00	7.41	56.63	6.48	55.31	6.04	49.91	5.82	52.79	5.96	55.5	6.64	55.88
15:00-16:00	7.86	64.49	6.38	61.69	6.16	56.07	6.8	59.59	7.08	62.58	7.12	63
16:00-17:00	8.5	72.99	6.62	68.31	6.09	62.16	6.95	66.54	6.6	69.18	7.19	70.19
17:00-18:00	6.91	79.9	6.72	75.03	6.24	68.4	7.08	73.62	6.84	76.02	7.87	78.06
18:00-19:00	5.53	85.43	6.66	81.69	5.94	74.34	7.08	80.7	6.72	82.74	6.25	84.31
19:00-20:00	4.09	89.52	5.42	87.11	5.44	79.78	5.22	85.92	5.33	88.07	4.16	88.47
20:00-21:00	3.03	92.55	3.9	91.01	4.71	84.49	3.99	89.91	3.72	91.79	2.91	91.38
21:00-22:00	2.14	94.69	2.61	93.62	3.47	87.96	2.43	92.34	2.6	94.39	2.01	93.39
22:00-23:00	1.34	96.03	1.68	95.3	2.71	90.67	1.59	93.93	1.6	95.99	1.43	94.82
23:00-24:00	0.9	96.93	0.94	96.24	1.67	92.34	0.95	94.88	0.77	96.76	0.88	95.7
0:00-1:00	0.5	97.43	0.55	96.79	1.07	93.41	0.57	95.45	0.43	97.19	0.62	96.32
1:00-2:00	0.35	97.78	0.31	97.1	1	94.41	0.37	95.82	0.2	97.39	0.41	96.73
2:00-3:00	0.26	98.04	0.25	97.35	0.77	95.18	0.28	96.1	0.18	97.57	0.43	97.16
3:00-4:00	0.31	98.35	0.31	97.66	1	96.18	0.35	96.45	0.24	97.81	0.48	97.64
4:00-5:00	0.6	98.95	0.65	98.31	1.53	97.71	0.95	97.4	0.6	98.41	0.78	98.42
5:00-6:00	1.05	100	1.68	100	2.32	100	2.57	100	1.6	100	1.57	100
TOTAL NO. OF VEHICLES	**9862**		**26327**		**26332**		**27487**		**8563**		**20880**	

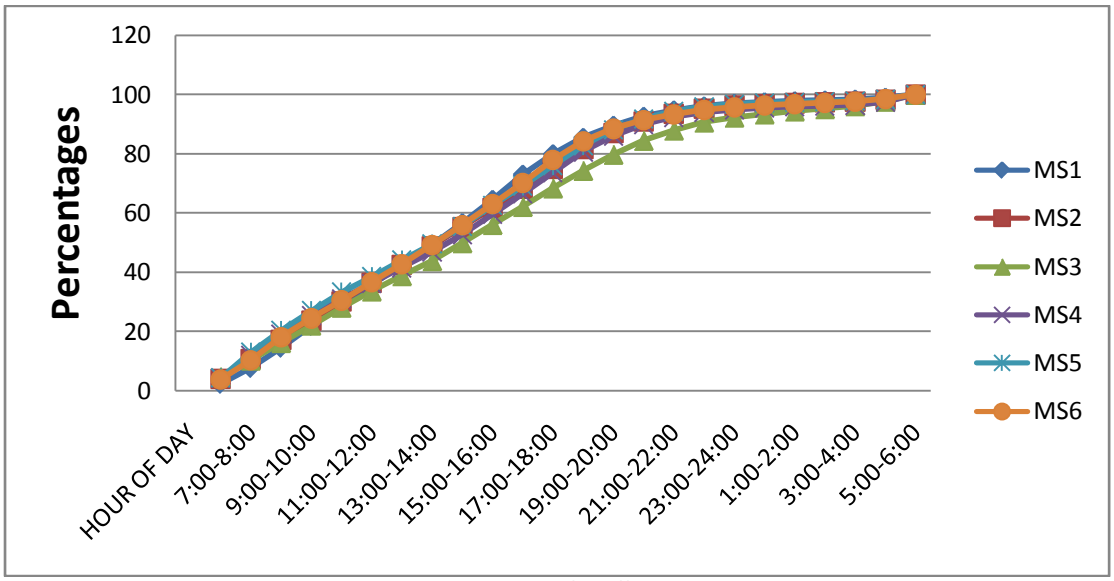

Figure 4.2: Cumulative Percentage Hourly Distribution of Traffic in Sekondi-Takoradi

4.3 TRAFFIC COMPOSITION

Table 4.3 shows the results of the traffic composition at the six Master Stations in Sekondi-Takoradi. As shown from the traffic data obtained, taxis recorded the highest percentage of traffic followed by private cars at all the Master Stations. MS1 (Liberation Road, Near Obuasi Road) registered the highest percentage of taxis, which was 58.55% of the total traffic, followed by MS2 with 46.04%, MS4 recording 44.11%, MS5 (42.07%), MS3 (38.17%) and MS6 (31.81%) respectively. The traffic compositions by vehicle type are also shown in Table 4.4. The traffic composition by vehicle type is also shown in Figure 4.3 whereas Figure 4.4 depicts percentage composition of vehicles by Master Stations.

Table 4.3: Percentage Composition of Traffic at Master Stations in Sekondi-Takoradi

Station	Bicycles	Motor Bikes	Taxis	Cars	Pickup/Van /4WD Vehicles	Small Bus	Medium Bus/Mammy Wagons	Large Bus	Light Truck	Medium Truck	Heavy Truck	Truck Trailer	Extra Large Truck And Others
MS1	5.26	3.11	58.55	19.77	9.98	2.02	0.20	0.10	0.53	0.34	0.02	0.01	0.11
MS2	2.30	2.48	46.04	19.36	10.49	14.49	1.15	0.50	1.34	0.55	0.23	1.06	0.01
MS3	5.55	3.46	38.17	12.46	5.94	27.44	2.91	0.79	1.48	0.58	0.46	0.58	0.18
MS4	4.50	2.24	44.11	17.31	10.10	15.90	1.23	0.51	1.74	0.56	0.64	1.14	0.02
MS5	6.42	3.10	42.07	20.63	12.76	5.08	1.49	0.30	4.98	0.85	0.83	1.41	0.07
MS6	6.33	3.64	31.81	22.31	17.99	9.11	1.73	1.73	1.92	0.80	0.75	1.79	0.08

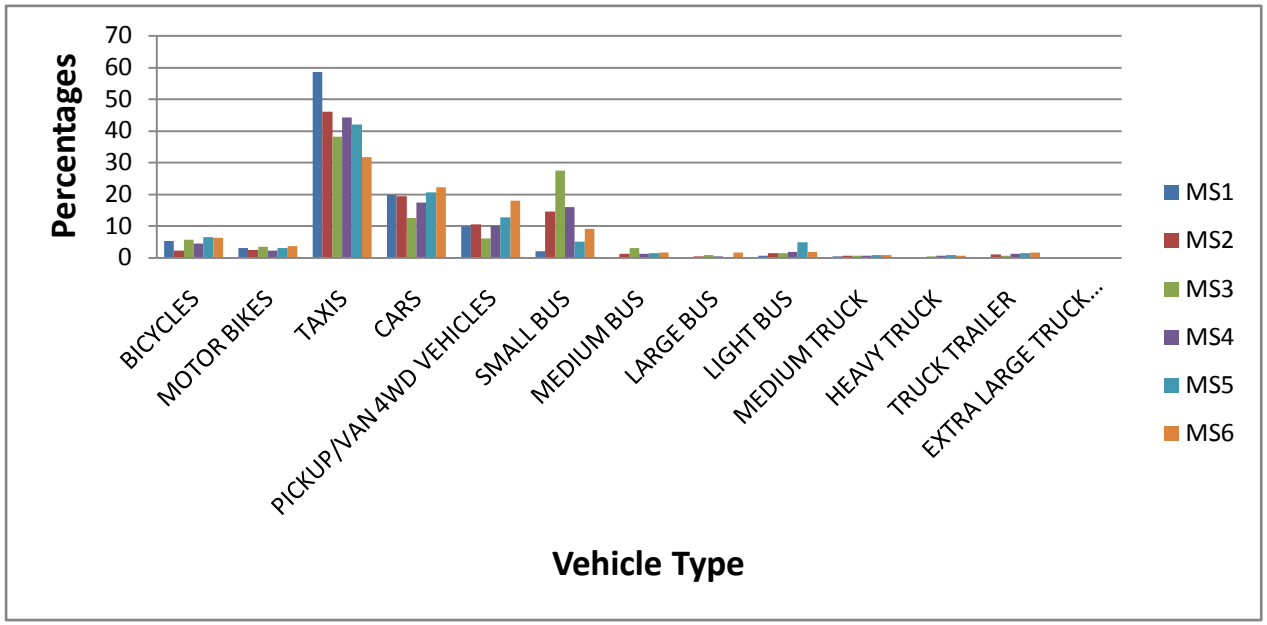

Figure 4.3: Percentage Composition of Traffic by Vehicle type at the Master Stations in Sekondi-Takoradi

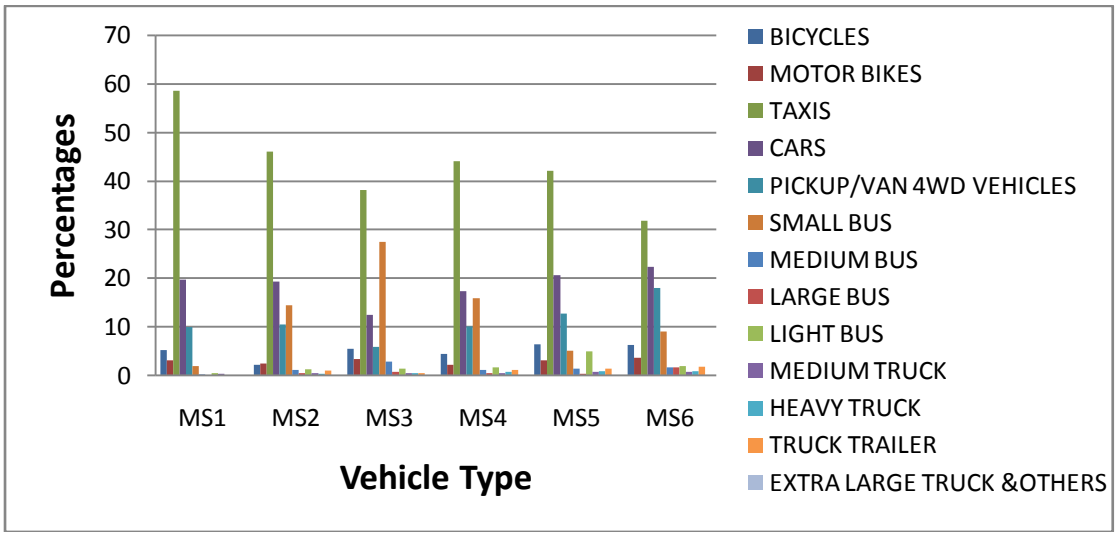

Figure 4.4: Percentage Composition of Vehicles by Master Stations (Both Directions)

4.4 TRAFFIC GROWTH RATES AT MASTER STATIONS

Table 4.4: Traffic Growth Rates at Master Stations in Sekondi-Takoradi

Location	Adjusted 24-Hour Volume		% Increase	% Annual Growth Rate
	Traffic Data in the year 2003	Traffic data in the year 2008		
MS1	-	9862	-	-
MS2	28504	26327	-7.64	-1.57
MS3	23757	26332	10.84	2.08
MS4	-	27487	-	-
MS5	-	8562	-	-
MS6	17150	20880	21.27	4.01

Two of the Master Stations (MS3 and MS6) experienced positive traffic growth and MS2 experienced negative growth while information for comparison of the other Master Stations (MS1), MS4 and MS5) was unavailable. The highest growth rate was r=4.01% occurring at MS6 on the Axim Road, near Air force Base, followed by r=2.08% at MS3 on the Sekondi By-pass Road, near Tanokrom. A negative growth rate of r= -1.57% occurred at the MS2 on the Sekondi Road, near the Goil station. From the three Master stations, the traffic growth rate for Sekondi-Takoradi generally experienced a positive growth rate of r=1.51%.

4.5 LINK VOLUME COUNT

Traffic volumes were obtained for 20 links in the period of peak flows (6:00AM-9:00AM and 4:00PM-7:00PM) and compared with the actual capacity of those links. Table 4.6 represents the hourly average traffic volume expressed as PCU/h and the volume/capacity ratio at different links. The highest traffic volume was found in Kwesimetim to Ajep link (6567 PCU/h) whereas the lowest was observed at New site to Number nine link (1306 PCU/h). However, the highest volume/capacity ratio was observed as 5.47 in Kwesimetim to Ajep link whereas the lowest was observed as 1.09 atnew site to Number nine link. At all the links, motorized vehicles were dominant.

Table 4.8: Comparison of Actual Volume to the Link Capacity

LINK NAME	ACTUAL VOLUME(PCU/H)	CAPACITY (PCU/H)	VOLUME/ CAPACITY RATIO
PAA GRANT → MARKET CIRCLE	3822	1200	3.19
AJEP →MARKET CIRCLE	2659	1200	2.22
AXIM ROAD → MARKET CIRCLE	3715	1200	3.1
HARBOUR ROAD → MARKET CIRCLE	4277	1200	3.57
NEW TAKORADI→PAA GRANT	1430	1200	1.2
HARBOUR ROAD→PAA GRANT	1565	1200	1.3
T-POLY JUNCTION→PAA GRANT	5327	1200	4.44
AJEP→PAA GRANT	2680	1200	2.23
ANAJI→NUMBER NINE	3089	1200	2.57
FIJAI→NUMBER NINE	4059	1200	3.38
TANOKROM→NUMBER NINE	3193	1200	2.66
NEW SITE→NUMBER NINE	1306	1200	1.09
T-POLY→TANOKROM	3228	1200	2.69
ANAJI→TANOKROM	3378	1200	2.82
AJEP→TANOKROM	3639	1200	3.03
KWASIMETIM→AJEP	6567	1200	5.47
AXIM ROAD→AJEP	4089	1200	3.41
EFFIA-NKWANTA→T-POLY JUNCTION	3653	1200	3.04
SEKONDI→EFFIA-NKWANTA	4377	1200	3.65
FIJAI→EFFIA-NKWANTA	1816	1200	1.5

4.6 Average Traffic Volume Count per Zone in the Period of Peak

FLOWS

From Table 4.6 and Figure 4.5, the Zone with the highest traffic volume count during the morning (AM) peak hours was recorded at Zone 5 followed by Zone 1, Zone 4, Zone 2 and Zone 3 respectively. Zone 5 still recorded the highest in the evening (PM) peak hours followed by Zone 4, Zone 1, Zone 2 and Zone 3 respectively.

Table 4.6: Summary results of Average Traffic Volume per Zone

Name of Zone	Zone Description	Average AM Peak Hour Volume	Average PM Peak Hour Volume
Zone 1	Areas in and around Takoradi Market Circle	2267	2180
Zone 2	Paa Grant roundabout and T-Poly Junction	1919	1705
Zone 3	Effiakuma traffic light	1414	1346
Zone 4	Tanokrom traffic light	2089	2369
Zone 5	Kwame Nkrumah circle	3138	3985

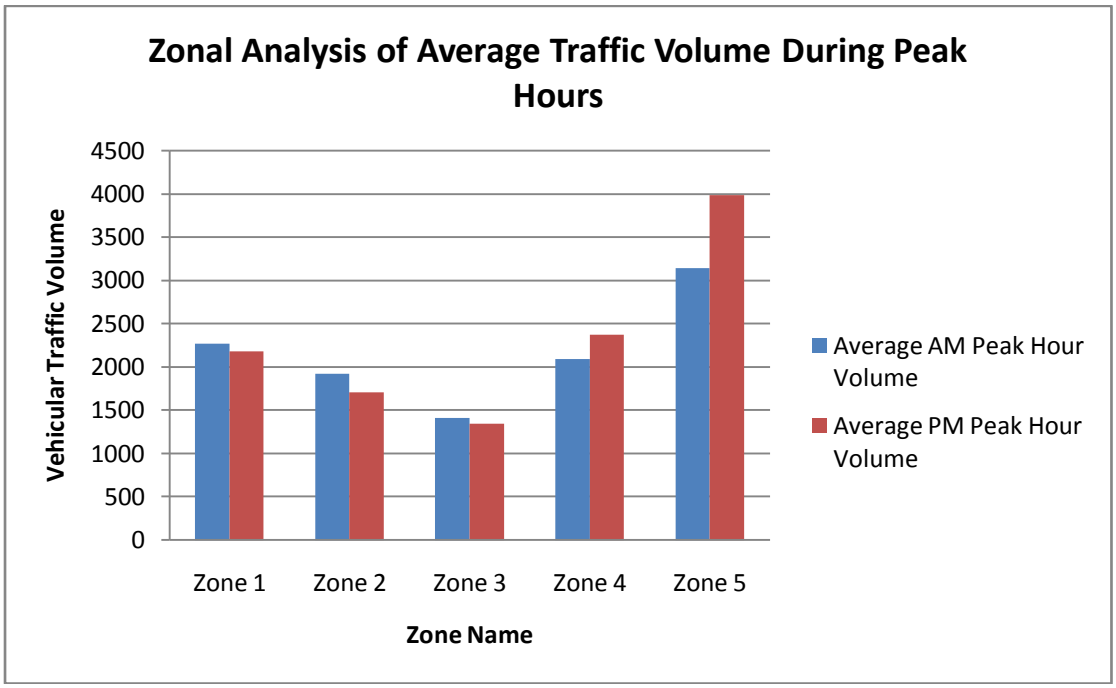

Figure 4.5: Average Traffic Volume per Zone During Peak Hours

4.7 ROADWAY CONGESTION INDEX (RCI)

The Roadway Congestion Index (RCI) was found to be 3.18 for the selected road network using Excel shown in Table 4.7. An RCI of 3.18 to indicates the severity of the traffic congestion situation within the Metropolis.

Table 4.7: Calculation of RCI

COL 1	**COL 2**	**COL 3**	**COL 4**	**COL 5**	**COL 6**	**COL 7**	**COL 8**
LINK NAME	**ACTUAL VOL. (PCU/H)**	**CAPACITY (PCU/H)**	**LINK LENGTH (KM)**	**COL 2* COL 4**	**COL2/ COL 3**	**COL 5* COL 6**	**RCI= $\sum COL7/ \sum COL5$**
PAA GRANT → MARKET CIRCLE	3822	1200	0.55	2102.1	3.19	6695.19	
AJEP →MARKET CIRCLE	2659	1200	0.7	1861.3	2.22	4124.33	
AXIM ROAD → MARKET CIRCLE	3715	1200	0.43	1597.45	3.1	4945.44	
HARBOUR ROAD → MKT.CIRCLE	4277	1200	0.8	3421.6	3.56	12195.15	
NEW TAKORADI→PAA GRANT	1430	1200	0.65	929.5	1.19	1107.65	
HARBOUR ROAD→PAA GRANT	1565	1200	0.48	751.2	1.3	979.69	
T-POLY JUNCTION→PAA GRANT	5327	1200	0.25	1331.75	4.44	5911.86	
AJEP→PAA GRANT	2680	1200	1.31	3510.8	2.23	7840.79	
ANAJI→NUMBER NINE	3089	1200	0.4	1235.6	2.57	3180.64	3.18
FIJAI→NUMBER NINE	4059	1200	1	4059	3.38	13729.57	
TANOKROM→NUMBER NINE	3193	1200	0.38	1213.34	2.66	3228.5	
NEW SITE→NUMBER NINE	1306	1200	0.3	391.8	1.09	426.41	
T-POLY→TANOKROM	3228	1200	0.6	1936.8	2.69	5209.99	
ANAJI→TANOKROM	3378	1200	0.46	1553.88	2.82	4374.17	
AJEP→TANOKROM	3639	1200	0.23	836.97	3.03	2538.11	
KWASIMETIM→AJEP	6567	1200	0.57	3743.19	5.47	20484.61	
AXIM ROAD→AJEP	4089	1200	0.42	1717.38	3.41	5851.97	
EFFIA-NKWANTA→T-POLY JUNCTION	3653	1200	0.35	1278.55	3.04	3892.12	
SEKONDI→EFFIA-NKWANTA	4377	1200	0.64	2801.28	3.65	10217.67	
FIJAI→EFFIA-NKWANTA	1816	1200	0.57	1035.12	1.51	1566.48	
TOTAL				37308.61		118500.34	

5.0 CONCLUSIONS

The following findings and observations were made during the study:

(i) The most heavily trafficked Master Station in Sekondi-Takoradi was MS4, located on the Agona Nkwanta road west of PTC R/A. It recorded a 12-hour weekday traffic of 20236 vehs/day and 24-hour traffic of 27847 vehs/ day.

(ii) The highest peak hour traffic volumes of 2108 vehs/ hr and 1946 vehs/ hr was registered at MS4 during the AM and PM peak periods respectively. These peak hour volumes constituted 7.67% and 7.08% of the traffic during the AM and PM periods respectively.

(iii) Taxis were the modal class of vehicle types in Sekondi-Takoradi, followed by Private cars, small vehicles and medium vehicles. Taxis were also the most popular modes of travel with a percentage composition ranging from 58.55% and 31.81% at the Master stations.

(iv) Generally, the total hourly distribution of traffic at the Master Stations in Sekondi-Takoradi increases rapidly from 6:00AM to 8:00AM. It then gradually increases to 18:00PM and then begins to decrease gradually till 4:00AM after which it increases again to 6:00AM. The cycle then begins again.

(v) The highest growth rate of r= 4.01% occurred at MS6, Axim Road, Near Air-force Base and the lowest rate was r= -1.57% occurred at MS2, Sekondi Road, Near Goil Station.

(vi) The busiest intersection in Sekondi-Takoradi under the study were T27 (Sekondi road and Takoradi Poly Junction, which registered the highest peak volume of 4533 veh/ hr during the AM peak volume and T38 (Sekondi By-pass and Tanokrom road), which registered the highest peak volume of 4303 veh/ hr during the PM volume

(vii) Zone 5 recorded the highest in the Average AM Peak Hour volume followed by Zone 1, Zone 4, Zone 2 and Zone 3. Zone 5 still recorded highest in Average PM Peak Hour volume followed by Zone 4, Zone 1, Zone 2 and Zone 3.

(viii) The Roadway Congestion Index (RCI) of 3.18 was found for the selected road network within the Metropolis. A 3.18 RCI indicated the severity of traffic congestion in Sekondi-Takoradi metropolis.

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