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Determining the Road Traffic Severity in a Developing City: A Case Study at Sekondi-Takoradi

François Mahama[1*], Akuamoah Worlanyo Saviour[1], Noble Kuadey[2] and Solomon Yemidi[1]

[1]*Department of Mathematics and Statistics, Ho Polytechnic, P.O.Box HP 217, HO, Ghana.*
[2]*Department of Computer Science, Ho Polytechnic, P.O.Box HP 217, HO, Ghana.*

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Abstract

Traffic saturation in both pedestrian and vehicular situations is common on all the principal streets of Sekondi-Takoradi Metropolis. The situation has become to a large extent unbearable to the inhabitants of the city. In the study, the following surveys were conducted: Manual Classification Count, Intersection Count, Screenline Classification Count, Parking Studies, Pedestrian Studies, Travel Time Studies, Mode of Travel and Waiting Times Surveys. The study revealed that traffic variation factors were almost the same at the designated classified Stations, Agona Nkwanta Road recorded the highest vehicular traffic during the AM and PM peak periods, and the busiest intersection during the AM peak period was the Sekondi Road / Takoradi Polytechnic Road. The highest pedestrian AM hourly volume of 2861ped/hr was recorded at Ashanti Road. The Ahanta Road registered the highest (2662 ped/hr) in pedestrian volume for the PM peak period. The highest Congestion Severity Index of 65.74 minutes delay per kilometer travelled and 86.82 minutes delay per kilometer travelled were identified for the AM and PM peak periods respectively at the Takoradi Market Circle Round About. Buses were the frequently used mode of transport for most commuters in the city.

Keywords: Traffic; pedestrian; congestion; screenline; congestion severity index.

**Corresponding author: E-mail: championwolla@yahoo.com, statisticalmagic@yahoo.com;*

1 Introduction

Cities are the powerhouses of economic growth for any country. Traffic congestion occurs when a volume of traffic or modal split generates demand for space greater than the available road capacity; this point is commonly termed saturation. There are a number of specific circumstances which cause or aggravate congestion; most of them reduce the capacity of a road at a given point or over a certain length, or increase the number of vehicles required for a given volume of people or goods. For the purpose of economic activities, it is imperative to facilitate movements. Traffic and transportation problems in Sekondi-Takoradi are noticeable with the increasing demands for the movement of goods and services within the city. The city expanded dynamically without any planning and control due to the rapid socioeconomic changes. The Metropolis is the nucleus of the Western Region of Ghana and plays a big role in controlling the economic development of not only the Region but also the entire Nation at large. The Region is endowed with huge reserves of natural resources such as; crude oil, timber, diamond, gold and other mineral resources. It contributes immensely to the food basket of the Ghanaian economy with its rich cocoa farms which are exported for foreign exchange. Due to lack of proper planning and control over land use activities, people from various parts of the country have moved to the city and made it a place for residential, business and commercial activities. Therefore, there is high migration rate of persons and vehicles into the city. Such rapid and uncontrolled developments have created an unacceptable level of disparity in transportation demand and supply situation, which have resulted in traffic congestion in both pedestrian and vehicular cases. To reach at an equilibrium level between the demand and the supply of transport and traffic system, it is required to implement traffic engineering and transport planning measures on the basis of scientific studies to reduce the delay in traffic, the man hours lost due to road traffic congestion and determine an index which would serve as a basis for determining the congestion severity of the Metropolis.

2 Related Works

2.1 Definition of traffic congestion

Traffic congestion is the phenomenon of increased disruption of traffic movement on an element of the transport system, observed in terms of delays and queuing, that is generated by the interactions among the flow units in a traffic stream or in intersecting traffic streams. The phenomenon is most visible when the level of demand for movement approaches or exceeds the present capacity of the element and the best indicator of the occurrence of congestion is the presence of queues [1]. [2], note that the occurrence of congestion in all transportation facilities may be accounted for by three features that characterise travel demand and supply. The reasons are that demand varies over time, supply is relatively fixed over long time periods and output is not storable.

2.2 Traffic congestion measurement

Francois and Willis [3], Schwart et al. [4], Lomax et al. [5] proposed several techniques that may be employed in studying and quantifying congestion. According to a review conducted by [5] these techniques could be generally classified under *highway capacity manual (HCM)* measures; *queuing-related* measures; and *travel time-based* measures respectively. Of these three, the *travel time-based* measures are the commonly used methods in studying travel time, travel speed and delay. This is because they are easy to understand by both professionals and the travelling public. Also their flexibility makes it easy to describe traffic conditions at various levels of resolutions in both space and time. Not surprisingly, it is said that, ‘an increasing number of transportation agencies are switching to travel time measures to monitor and manage congestion’ [6]. [6] Propose the need to compute representative speed values by aggregating the data at the segment level first. This approach enabled them to reduce the huge volumes of data and made it possible to produce simplified reports out of them. They then proceeded to devise several equations that could be used to aggregate the data. One of such equations which calculate the *average* travel time per segment is stated thus:

$$\bar{t}_i = \frac{1}{m_i}\sum_{j=1}^{m_i} t_{L_j} = \frac{1}{m_i}\sum_{j=1}^{m_i}\frac{L_i}{u_{ji}} = L_i\frac{1}{m_i}\sum_{j=1}^{m_i}\frac{1}{u_{ij}}$$

where m_i is the number of runs (or sample size) per segment; L_i is the length of each segment and U_{iJ} is the *j*th speed record associated with segment *i*.

3 Methodology

For this study, previous reports from the Department of Urban Roads (DUR), Sekondi-Takoradi Metropolis were acquired. Based on those reports, data have been collected from the following surveys for the year 2014: Manual Classification Count, Intersection Count, Screenline Classification Count, Parking Studies, Pedestrian Studies, Travel Time Studies, Mode of Travel and Waiting Times Surveys.

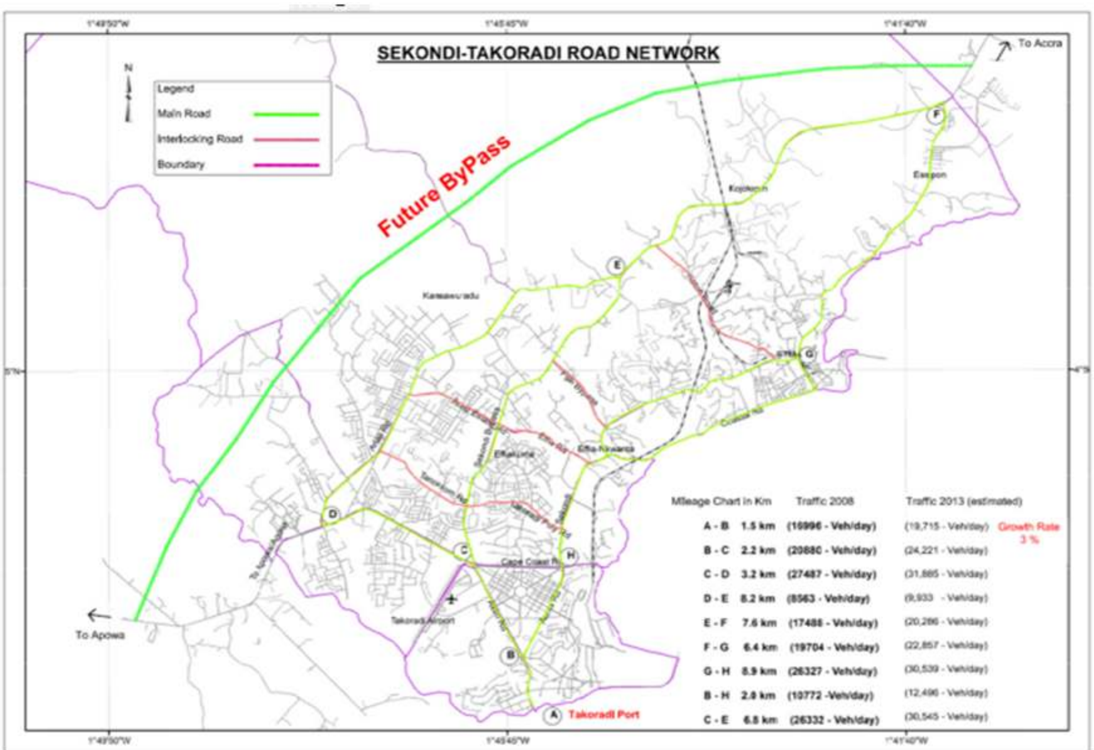

Fig. 3.1. Map showing the road network of Sekondi-Takoradi metropolis
Source: [7]

3.1 Study area transportation network

The study was designed to determine the hourly traffic volume on principal road networks. The data collection procedure took the numerical inventory of the road network as the number of road-way intersections or nodes, number of road links to be analyzed, connectivity of the nodes to and from road links including length of each link in kilometer. For each individual link the number of lanes available in one direction, number of ways, average speed of all types of vehicles in the link, average speed of each individual type of vehicle in the link etc were considered for input. The information about the road network was obtained from DUR Sekondi-Takoradi. A total of 212.9km of road was selected for the present study.

Only the main roadway links, which are normally used for inter zonal movements was taken into consideration in this study.

3.2 Pedestrian survey

In Ghana, walking is very significant in urban areas as pedestrians form the largest single road-user group in terms of the total number of trips. Huge number of pedestrians may aggravate the traffic congestion if sufficient foot path is not available for the movement of pedestrians. Considering the importance of pedestrian activities, pedestrian counts were undertaken at 15 minutes intervals for duration of 12 hours, on one weekday per location within the Metropolis.

3.3 Congestion severity index (CSI)

Based on the data gathered, only the Congestion Severity Index (CSI) was used to determine the severity of the traffic situation for the year 2014 in the Metropolis.

$$\text{CSI} = \left(\frac{Total\ Delay\ (Vehicle-hours) per\ \ Peak\ Hour}{Total\ Vehicle-Kilometer\ Travel\ in\ Thousand\ per\ Peak\ Hour}\right)$$

It indicates the loss of Vehicle-hour per Thousand Vehicle-Kilometer travel in Peak Hour. It can easily be converted to delay per vehicle-km travel. CSI value increases exponentially with increasing population. It means that the increase rate of CSI remain slower up to the time required to fully saturate the network, then it increase abruptly.

4 Analysis and Results of the Study

Results of the survey are summarized in tables and graphs to clarify the road traffic and congestion severity in the Sekondi-Takoradi Metropolis. The analysis of the various field studies are outlined below.

4.1 Variation factors for manual classified count per station in Sekondi-Takoradi

From the 7-day, 24 hour manual classified count, an average 24 hour daily traffic was calculated using Excel. The total average 24 hour traffic for each classified Station was divided by the average total 12 hour count to obtain the Variation Factor (VF) for the various Stations.

Fig. 4.1 shows the variation factors obtained at the various classified Stations.

Considering the Variation Factors for the descriptor (*12hrs to 24hrs)* at all classified Stations in Fig. 4.1, it is clear that the change in variation is almost the same for all stations. The descriptor *(AM Peak-Hour to 24 hrs)*, showed appreciable level of changes in the Variation Factors with Sekondi By-Pass having the highest VF of 16.56 and Apramdo By-Pass having the least (11.65). Sekondi By-Pass registered the highest VF (16.03) for the descriptor *(PM Peak-Hour to 24 hrs)* whiles Liberation Road had the least (11.76). The VF's for the descriptors: *Typical 1 hr: AM Flows to 24 hr Flows and Typical 1 hr: PM Flows to 24 hr Flows*, recorded higher (17.75 and 16.42) values for Agona Nkwanta Road and Sekondi By-Pass respectively. On the whole, the changes in variation for the various descriptors at the Manual Classified Count per station showed slight changes in variation.

4.2 Screenline traffic volumes in Sekondi-Takoradi

Screenline counts were undertaken at 28 stations in Sekondi-Takoradi. [8] determined the peak hour periods for both AM (06:00-09:00) and PM (04:00-07:00) for the Metropolis. The traffic data obtained from the screenline counts were analysed to determine the total 3 hour AM peak period and 3 hour PM peak hour period. The summary results of the traffic volumes at the screenline stations for the periods are represented in Fig 4.2. From the graph, Agona Nkwanta Road recorded the highest 3 vehicular hours peak traffic during the AM and PM period with peak volume of 5286 vehicles and 6666 vehs/hr respectively, followed by Liberation Road with 4829 vehicles and 4342 vehicles for the AM and PM peak volumes respectively. African Beach Hotel Road recorded the least peak volume for the AM and PM with corresponding values of 321 vehicles and 475 vehicles respectively.

4.3 Intersection counts

Intersection counts were undertaken at 33 number designated intersections. The traffic data obtained from the counts were analysed for the assessment of the junction capacity and traffic safety. The summary results at the designated intersections during the peak hours (i.e. 06:00AM- 09:00AM and 04:00PM- 07:00PM) have been presented in Fig. 4.3.

From the calculation of peak hour flows, it was realized that the intersection with the largest peak hour volume in Sekondi-Takoradi was 4601 vehs/hr and this occurred at the Sekondi Road/Takoradi Poly Road intersection in the morning, followed by 4244 vehs/hr in the evening which occurred at Sekondi By-Pass/Ntankoful Road Junction.

The AM and PM Peak hour volumes obtained at all the junctions studied are shown in Fig. 4.3.

4.4 Parking studies

Data obtained from the parking studies was analysed to determine the average duration and number of vehicles that used the facility. This was done to determine the demand for on-street parking in the Central Business District (CBD). The summary results of the parking studies are shown in Table 4.1.

Table 4.1. Characteristics of on-street parking in the Metropolis

Station	Area	Average Parking period (minutes)	Maximum accumulation	Number of vehicles that used the facility
PS1	Liberation road	52	95	635
PS2	John Sarbah road	71	98	878
PS3	Kitson road	122	84	657
PS4	Collins avenue	53	141	1002
PS5	Kintampo road	98	177	1346
PS6	Ashanti road	103	248	1729
PS7	Market circle	24	188	1212

From the table, it was realized that PS6 had the most vehicles parked along it followed by PS5 and the route with the least vehicles parked along it being Liberation Road whilst the highest and least average parking durations were 122 minutes and 24 minutes on the Kitson Road and Market Circle respectively.

4.5 Pedestrian studies

The pedestrian data obtained was analysed to determine the pedestrian volumes at crosswalks during the peak periods. 10 number stations in the Metropolis were considered for the count. Fig. 4.4 is a display of the pedestrian characteristics in terms of volume in the city.

Ashanti Road recorded the highest pedestrian AM hourly volume of 2861 ped/hr whiles the highest pedestrian crossing hourly volume during the PM period occurred on the Ahanta Road with 2662 ped/hr.

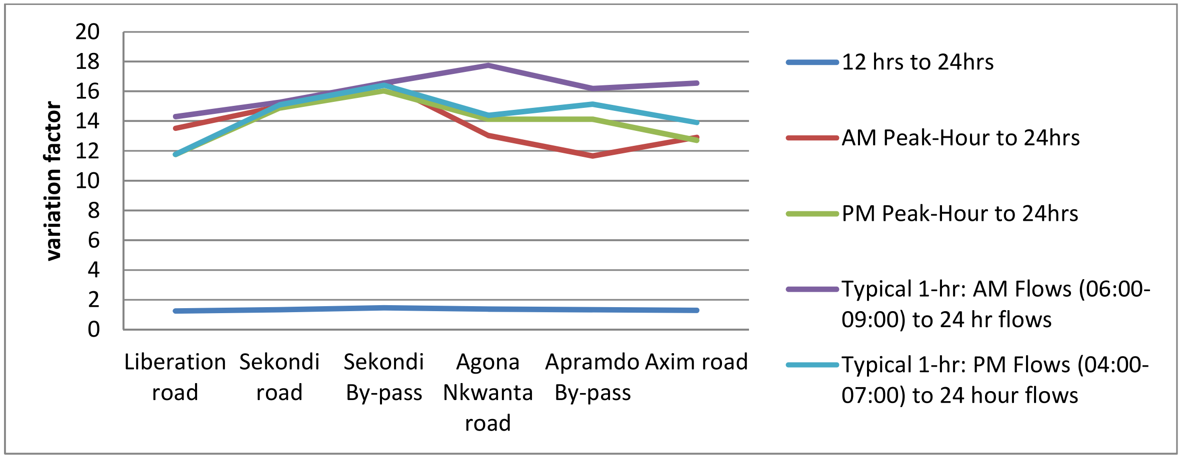

Fig. 4.1. Traffic variation factors for manual classified count per station in Sekondi-Takoradi

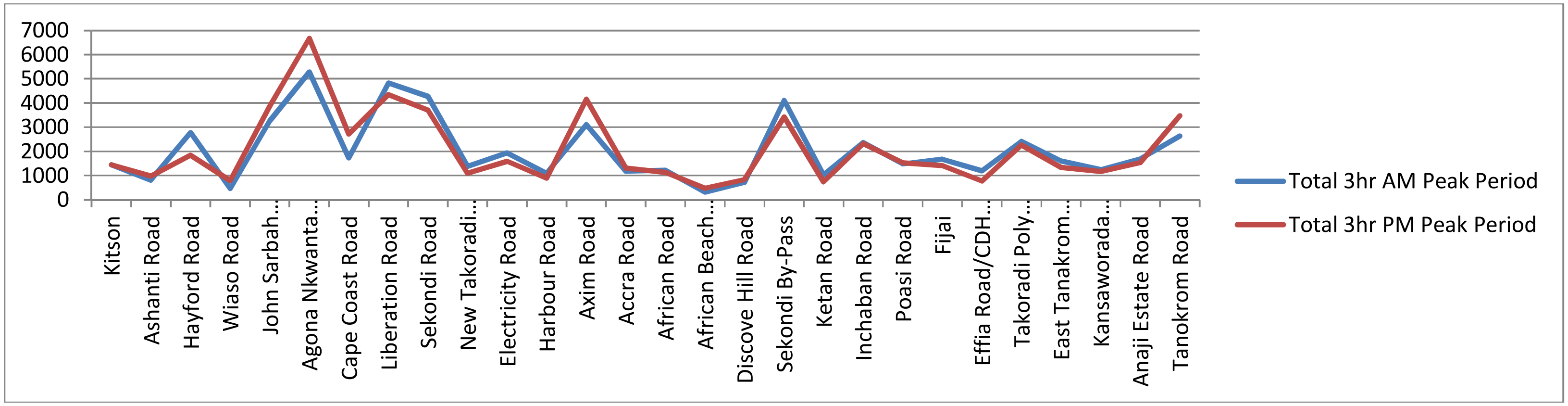

Fig. 4.2. Total 3hour AM and PM peak periods

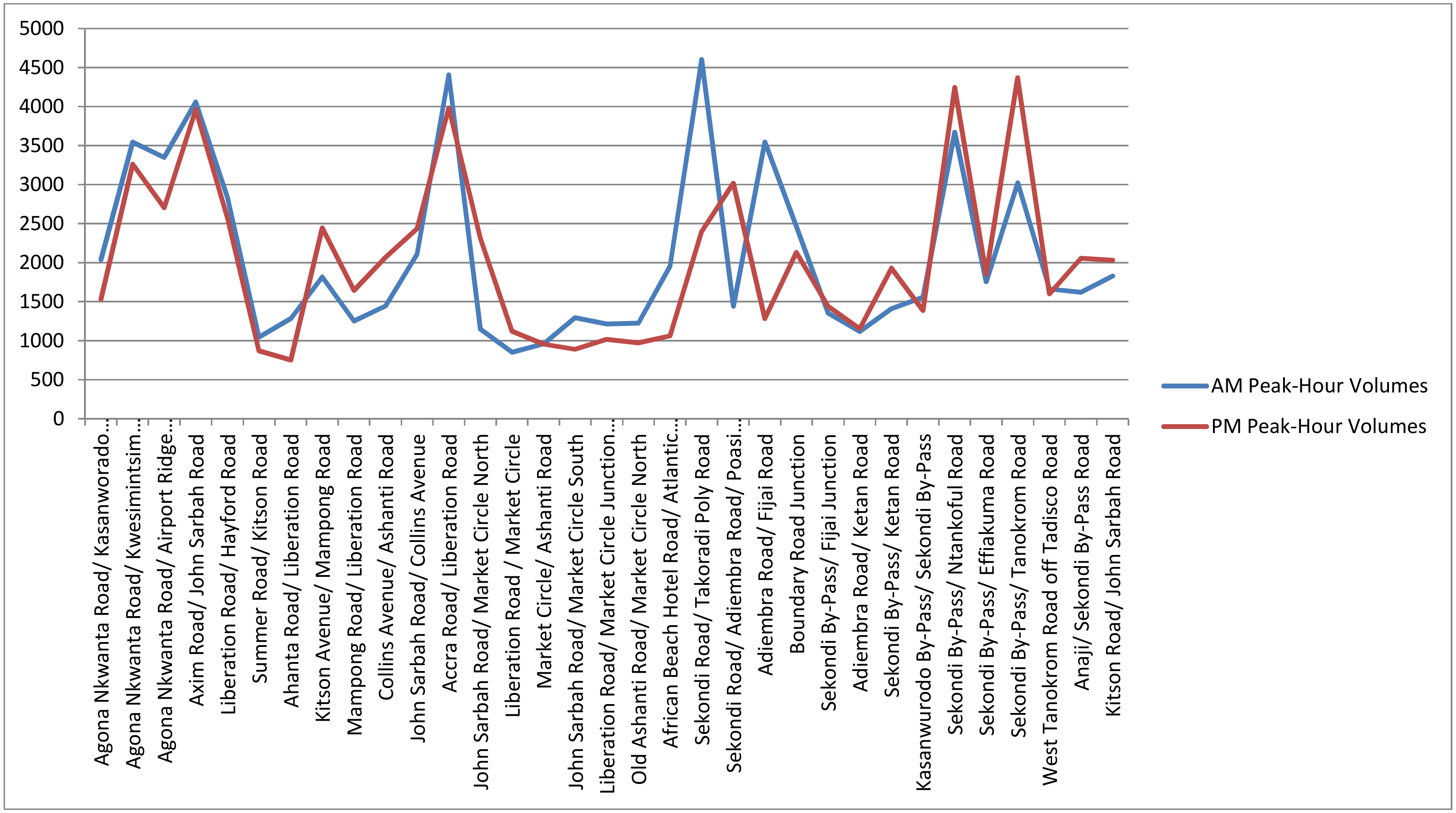

Fig. 4.3. Intersections count during the peak hours

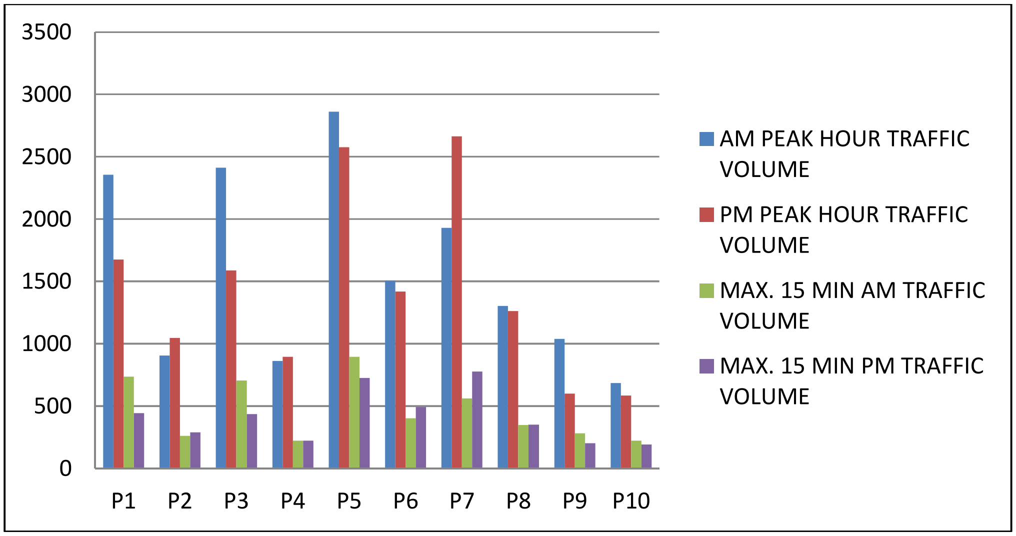

Fig. 4.4. Peak pedestrian volume count in the metropolis

4.6 Congestion severity index (CSI) on selected roads and travel times during the peak periods

Tables 4.2 and 4.3 show summary results of travel times and CSI during the AM and PM peak periods respectively in the Metropolis. From the summary results, the lowest operating speeds of 1.91 km/hr for the AM peak period and 1.21 km/hr for the PM peak period both occurred at the Market Circle Round about. Poasi route recorded the highest operating speed of 18.84 km/hr and 13.99 km/hr for the AM and PM peak periods respectively. The highest CSI values for both the AM and PM peak periods in the year 2014 was recorded at the Market Circle Round About. It indicates that on the average 65.74 minutes delay per kilometer travel occurs at the Market Circle Road About during the AM peak hour and 86.82 minutes delay per kilometer travel occurs during the PM peak hour at the same location. Poasi Road recorded the least CSI values for both the AM and PM peak periods.

Table 4.2. Summary results of travel times and CSI during the AM peak period

Route	**Length (Km)**	**Average peak time (minutes)**	**Average peak operating speed (Km/hr)**	**Average impedance (min/km)**	**Highest average delay time (minutes)**	**CSI**
Market circle to Harbour	2.5	16.23	9.24	6.49	12.23	4.89
Market circle round about	0.65	20.43	1.91	31.43	42.73	65.74
West liberation road	1	9.51	6.31	9.51	10.58	10.58
Poasi road	4	12.74	18.84	3.19	7.24	1.81
Axim road	1.95	8.82	13.27	4.52	6.88	3.53
Sekondi by-pass	8.6	51.7	9.98	6.01	74.26	8.63
Sekondi road	2.96	15.76	11.27	5.32	58.37	19.71
Kitson avenue	0.6	7.66	4.7	12.77	35.82	59.7
Kasanwurado-Aperamdo by-pass	7.5	32.38	13.9	4.32	21.54	2.87
Agona- Nkwanta road	3.4	19.23	10.61	5.66	47.46	13.96

Table 4.3. Summary results of travel times and CSI during the PM peak period

Route	Length (Km)	Average peak time (minutes)	Average peak operating speed (Km/hr	Average impedance (min/km)	Highest average delay time (minutes)	CSI
Market circle to Harbour	2.5	22.65	6.62	9.06	17.22	6.89
Market circle Round about	0.65	32.34	1.21	49.75	56.43	86.82
West liberation road	1	9.85	6.09	9.85	14.25	14.25
Poasi road	4	17.16	13.99	4.29	10.24	2.56
Axim road	1.95	14.25	8.21	7.31	7.28	3.73
Sekondi by-pass	8.6	56.31	9.16	6.55	78.41	9.12
Sekondi road	2.96	47.35	3.75	16	65.47	22.12
Kitson avenue	0.6	15.36	2.34	25.6	41.2	68.67
Kasanwurado-Aperamdo by-pass	7.5	43.85	10.26	5.84	34.38	4.58
Agona-Nkwanta road	3.4	27.48	7.42	8.08	52.14	15.34

4.7 Mode of travel and waiting times by passengers in the city

Mode of travel and waiting times by passengers were investigated and the findings are shown in Figs. 4.5, 4.6 and 4.7. From Fig. 4.5, the frequently used mode of transport by passengers was bus, followed by walking, taxi, private car and others. Fig. 4.6 showed that the journey time to terminal by most passengers was below 15 minutes with the least time duration between 45- 60 minutes. Fig. 4.7 indicates that the waiting time in queues and vehicles by most passengers at terminal was almost evenly distributed over the durations. The highest waiting time was between 45- 59 minutes, followed closely by 15- 29 minutes and the least duration being over 90 minutes.

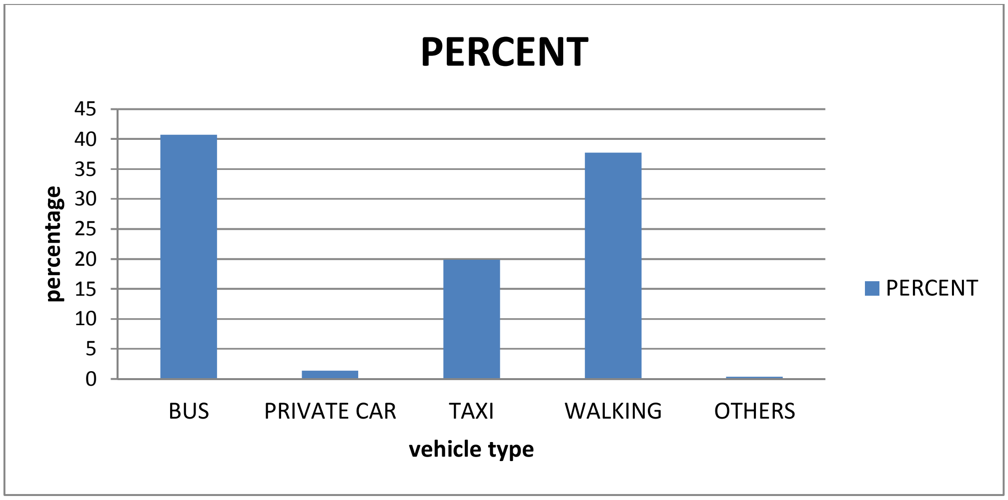

Fig. 4.5. Mode of travel by passengers to terminals in Sekondi-Takoradi

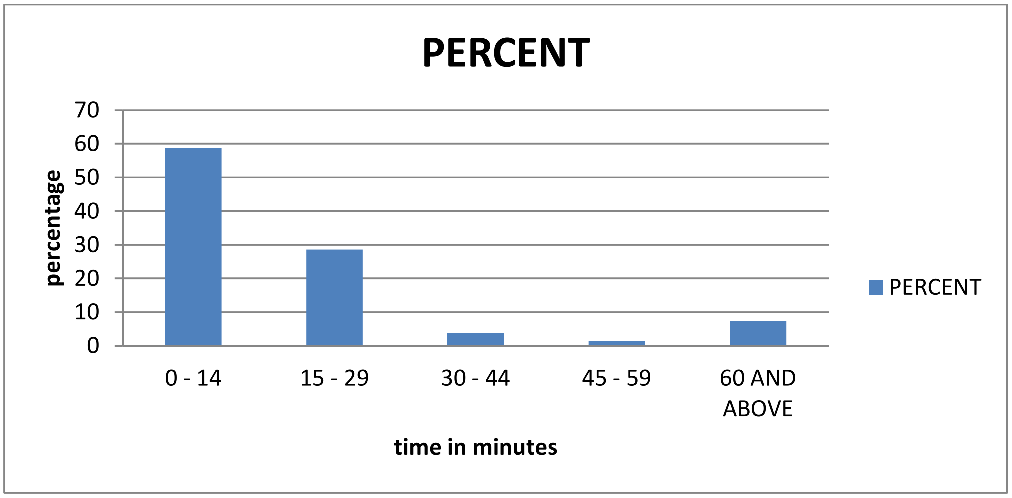

Fig. 4.6. Journey times to terminals in Sekondi-Takoradi

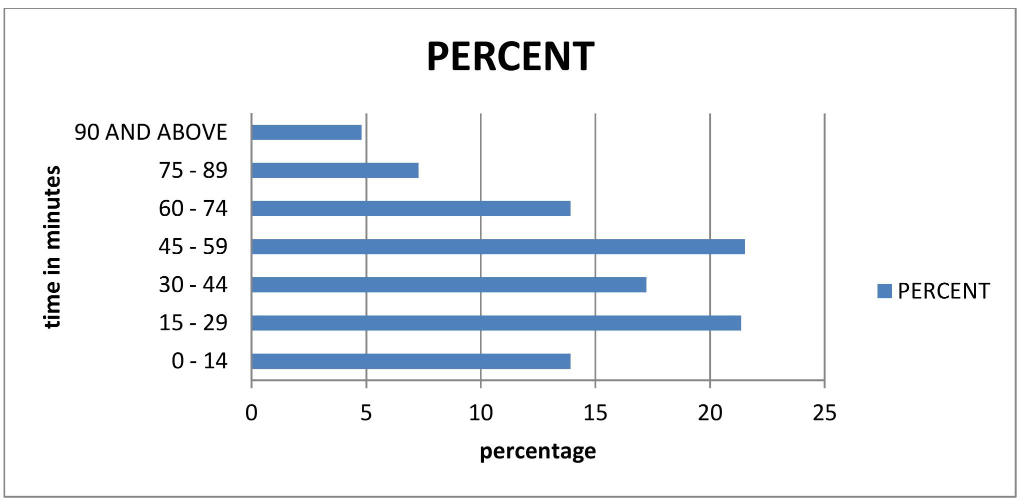

Fig. 4.7. Waiting times in queues and vehicles in Sekondi-Takoradi

5 Conclusions

1. Generally the traffic variation factors for the Manual Classified Stations in Sekondi-Takoradi did not differ very much from each other. Also the traffic patterns were similar in nature.
2. From the Screenline Count studies, Agona Nwanta recorded the highest 3hours peak traffic during the AM and PM periods with peak volume of 5286 vehs/hr and 6666 vehs/hr respectively.
3. The Intersection studies revealed that Sekondi road/ Takoradi Polytechnic junction had the highest peak hour volume of 4601 vehs/hr for the AM peak period whiles Sekondi By-pass/ Ntankoful road junction recorded the highest for the PM period with a value of 4244 vehs/hr.
4. From the parking studies in the Metropolis, Kintampo road had the most vehicles parked along it whiles Kitson road recorded the maximum parking during time of 122 minutes.
5. Ashanti road had the highest pedestrian AM hourly volume of 2861 ped/hr whiles the Ahanta road registered the highest pedestrian crossing hourly volume of 2662 ped/hr for the PM peak period.

6. The Market Circle Round About registered the highest CSI value of 65.74 minutes delay per kilometer travel for the AM peak period and 86.82 minutes delay per kilometer travel for the PM peak period. Lowest operation speed of 1.91 km/hr and 1.21 km/hr was recorded for both AM and PM peak periods at the same location.
7. The frequently used mode of transport by passengers in the city was by bus. The highest average journey time to terminal was 0 – 15 minutes and the maximum average waiting time in queues and vehicles was between 45 – 59 minutes.

6 Recommendations

1. Traffic management scheme/measures should be undertaken at the Central Business District (CBD) especially at the Takoradi Market Circle and the surrounding roads to improve traffic flow along that corridor
2. Intersection improvement designs should be undertaken at almost all vehicular intersection areas most especially the Sekondi Road/Takoradi Polytechnic junction, Sekondi By-pass/Tanokrom Road and its corridors to reduce delays and queues. Also, the efficiency of the Paa Grant Roundabout and its approaches in terms of delays, queues and capacity should be studied and analysed and if necessary redesigned to improve traffic flow.
3. As some of the roads are getting almost fixed, alternative actions for these roads should be taken. For example, the roads in and around the Takoradi Market Circle are almost in a fixed position and the widening of these roads is virtually impossible given the current trend of events. To develop these roads at the Market Circle, pressure would have to be extended to other sub-roads which are one way to two way to enable expansion works.
4. A crucial decision have to be made by Sekondi-Takoradi Metropolitan Assembly (STMA) to decentralize institutional and administrative premises to somewhat distant away from the Market Circle, resulting in significant reduction in congestion.
5. STMA can enforce some rules on developing high-rise infrastructure. In that case the high-rise building should obviously provide multistoried parking facilities to help prevent parking on major streets which are already constrained by vehicular capacity.
6. Apart from the narrow roads which was observed in the CBD of Sekondi-Takoradi, it would be essential for authorities to remove floating shops, mobile hawkers, artisans and temporary traders from roads and roadsides to help ease traffic congestion.

Competing Interests

Authors have declared that no competing interests exist.

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