Operational Performance Analysis of Signalized Intersections: A Case Study of Lahore

Usman Hameed[1] and Hafiz Usman Ahmed[2]

1. Corresponding Author. Research Assistant, Transport Planning Unit, Transport Department, Government of Punjab, Lahore, Pakistan.
   Email: usmanhameed32@gmail.com

2. Secretary District Regional Transport Authority Kasur, Transport Department, Government of Punjab, Lahore, Pakistan.
   Email: hafizusmanahmedsiddiqui@gmail.com

Abstract

Owing to ever-increasing motor vehicle population, congestion at intersections is a major problem. Effective control mechanism at intersections can help manage traffic and reduce its adverse effects significantly. City of Lahore, having the highest number of vehicles in Punjab, Pakistan faces enormous congestion issue. Consequently, vehicles face delay and enhanced travel times at signalized intersections. In this regard, this study is carried out to evaluate operational performance of two major signalized intersections in urban centre of Lahore. SIDRA Intersection, a traffic analysis tool widely used for traffic performance evaluation studies, is used for analysis.

Keywords: Operational Performance, Signalized Intersection, SIDRA intersection, Delay.

1. INTRODUCTION:

Intersections are amongst the primary components of road infrastructure that significantly affect traffic flow, environment and road safety especially in urban areas. Accordingly, effective control of these intersections is important as it is responsible for capacity, operational efficiency, delay and safety of the complete network (Tianzi et al. 2013).

Intersection operational efficiency is dependent on the existing traffic, road geometry and traffic control conditions (Ranjitkar et al. 2014). Based on control type, intersections can be of various types i.e. Signalized, Stop Control and Roundabouts etc. (Garber and Hoel, 2014). Signalized intersections are much effective in controlling traffic as they isolate traffic movements (Oskarbski et. al 2016).

Evaluation of transportation related projects is carried out through Measures of Effectiveness (MOEs) (Garber and Hoel, 2014). Multiple MOEs can be selected such as travel time, delay and queue length etc. For signalized intersections, Delay is a recommended MOE as per Highway Capacity Manual (HCM). (Manjunatha et al. 2013). Estimation of delay at signalized intersections has been studied by various researchers and using various methods. However, due to a number of affecting variables, study of delay at signalized intersections is still being conducted (Darma et al. 2005). Traffic Analysis and Simulation tools are widely used in traffic engineering studies due to their usability, reliability and economy. Due to effectiveness in evaluation, signalized intersections studies have also been carried out using these tools. (Tianzi et al. 2013). Operational efficiency of intersections is carried out to assess the situation of how good the intersections can handle the traffic demand.

The purpose of this research is to evaluate the operational efficiency of signalized intersections on two busy intersections of Lahore. Delay is used as a Measure of Effectiveness and recommendations are proposed to improve traffic flow and reduce congestion. Out of many available traffic analysis tools, SIDRA intersection is selected due to its reliability and usability.

2. METHODOLOGY:

2.1 Description of Study Area:

The study was carried out in the metropolitan city of Lahore (31.5204^{o}N, 74.3587^{o}E). Vehicle population in the city has increased from 1.70 Million in 2007 to 4.92 Million in 2016 (PDS, 2008 and PDS, 2017). Traffic congestion and travel time delays are major problems associated with city traffic. Traffic conditions are heterogenous and a larger share of vehicle fleet consists of private vehicles (90%) (PDS, 2017).

Two signalized intersections in urban centre of Lahore are selected for the study. Both the intersections are located on Queens Road, Lahore. Location of intersections is shown in figure 1.

Figure 1: Location of Intersections on Queens Road, Lahore

2.2 Data Collection:

Traffic survey was conducted for a period of 16 hours at both the intersections. For the purpose of traffic analysis, following data was collected:

- Road inventory
- Traffic Volume & Composition
- Directional Distribution
- Signal timings and Phasing data

Manual classified counting technique was used for traffic volume study. Road inventory survey was carried with the help of measuring tape. Signal timing and average speed at intersection approaches were measured with the help of stopwatch. Satellite imagery of both intersections is shown in figure 2:

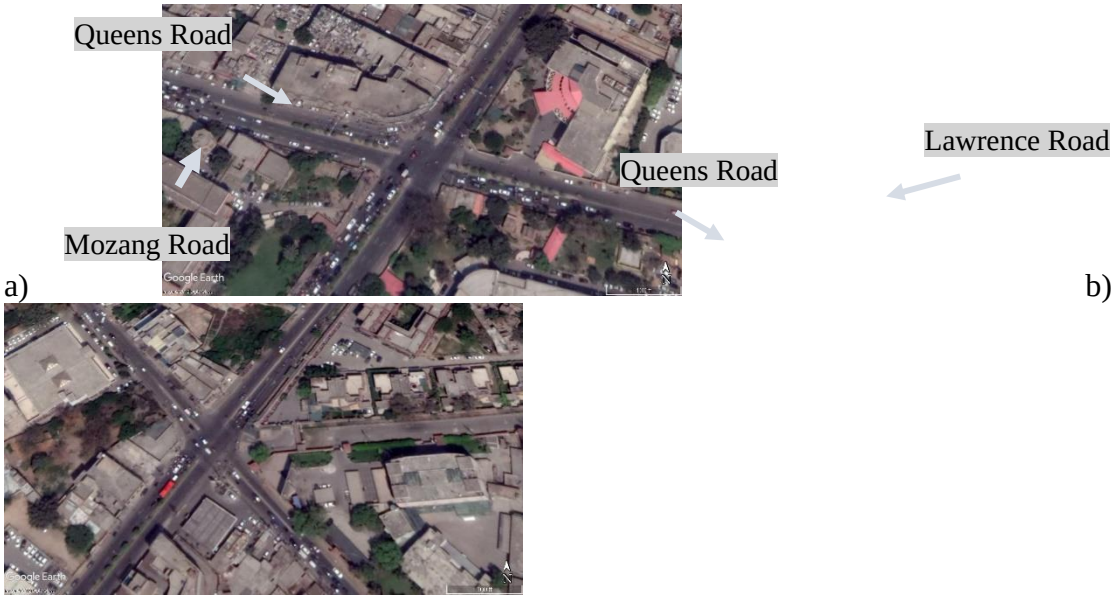


Figure 2: Satellite Image of Intersections, a. Ganga Ram Chowk, Queens Road and b. PSO Chowk, Queens Road

2.3 Traffic Analysis:

SIDRA Intersection was used to assess operational efficiency of intersections. SIDRA is a traffic modelling tool used for lane by lane analysis of intersections having different control types and lane configuration. Measure of effectiveness (MOEs) including delay, queue length, capacity and emissions are estimated based on inbuilt traffic models and iterative approximation method. (Parakash et al. 2014). SIDRA intersection uses path trace method to measure vehicular delay. Delay estimated in SIDRA is an aggregate of geometric delay, queuing delay, stopped delay, acceleration and deceleration delay (Sisiopiku and Oh, 2001).

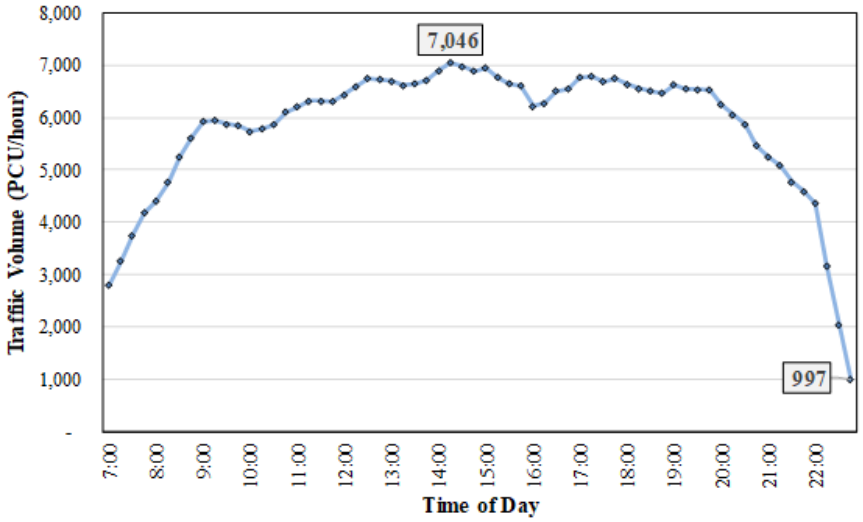
Firstly, Geometry of intersections was outlined based on road inventory data. Afterwards, traffic volume and directional distribution data for each approach was entered into the analysis tool. SIDRA Intersection is unable to differentiate different vehicle types. For that purpose, traffic composition is converted into a single entity termed as Passenger Car Units (PCUs). To estimate traffic for 2023, a growth rate of 3.5% is used. For the purpose of analysis, PCUs for peak hours were used. The peak hours and traffic volume in peak hour for both intersections have been mentioned in Figure 3. Results including Delay at present scenario i.e. 2019 and for future i.e. 2023 was estimated.

3. RESULTS:

3.1: Traffic Volume distribution throughout the Day

16-hour traffic count survey data reveals the fluctuation in traffic flow throughout the day. A time series analysis shown in figure 3 depicts the traffic volume fluctuation in these 16 hours.

a.



b.

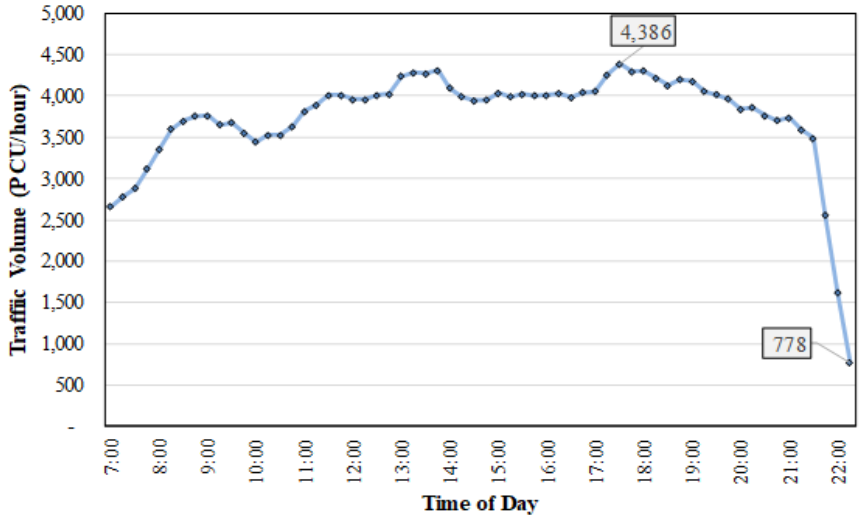
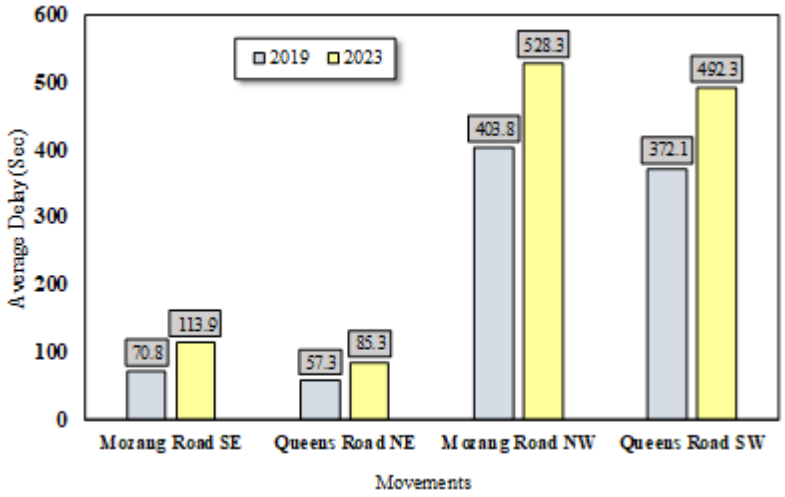


Figure 3: Time Series Analysis of Traffic Volume, a. Ganga Ram Chowk, Queens Road and b. PSO Chowk, Queens Road

At Sir Ganga Ram Hospital chowk, traffic volume is higher in the middle of the day and traffic in AM peak and PM peak hours is relatively lower. Peak volume was recorded between 2:15 -3:15 pm. At PSO Chowk, traffic volume is also greater in middle of the day, however, maximum peak recorded was between 5pm - 6pm.

3.2 SIDRA Intersection Analysis:

Geometry of the intersections shown in Figure 2 was outlined in SIDRA intersection. PCU values were used for calculation of Delay. Delay analysis for existing scenario 2019 and future scenario 2023 is performed which is presented in figure 4.



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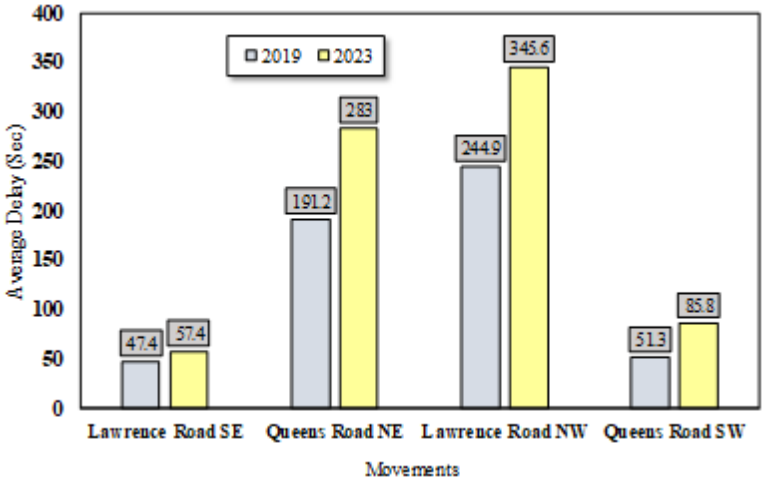

b.

Figure 4: Delay Results in Peak Hour, a. Ganga Ram Chowk, Queens Road and b. PSO Chowk, Queens Road

Results show that delay in existing and future conditions are much higher than acceptable levels. Table 1 displays a comparison of maximum and minimum values of delay on both intersections and acceptable value of delay. It can be seen that even the minimum value is above the acceptable limit of delay. Main reasons of excess delay include absence of signal optimization, abundance of private transport, poor driving behaviour and on street parking near intersections.

Table 1: Comparison of Estimated and Acceptable Delay

Year	Intersection	Approach Delay (sec/veh)		Acceptable Delay (sec/veh) as per Level of Service C (HCM, 2010)
		Max.	Min.	
2019	Ganga Ram Chowk	408.8	57.3	≤ 35
	PSO Chowk	244.9	47.4	
2023	Ganga Ram Chowk	528.3	85.3	
	PSO Chowk	345.6	57.4	

4. CONCLUSIONS AND RECOMMENDATIONS:

Conclusions and Recommendations for the case study are as follows:

- Delay results show that intersections are unable to cater traffic demand in peak hour for both intersections.
- Signalized Junctions i.e. Ganga Ram Chowk and PSO Chowk may be optimized for smooth flow of vehicles.
- Traffic composition in study area is heterogenous and consists mainly of private vehicles. If private transport is replaced by some percentage of public transport, traffic volume can be reduced up to certain level and delays could be reduced.
- On street parking should be prohibited near junctions to incorporate the peak hour traffic.
- The study could be further extended by simulating mitigation measures and applying more comprehensive tools like PTV Vissim and Paramics Discovery.

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