

Impact of On-Street Parking on Traffic Flow Characteristics

Diganta Boro¹, M.A. Ahmed² and Ankur Goswami³

¹M.Tech Scholar, Department of Civil Engineering, National Institute of Technology, Silchar (Assam)

²Department of Civil Engineering, National Institute of Technology, Silchar (Assam)

³M.Tech Scholar, Department of Civil Engineering, National Institute of Technology, Silchar (Assam)

E-mail: ¹diganta3998@gmail.com, ²ali.mokaddes@gmail.com, ³a_goswami21@yahoo.in

Abstract—For any developing city in India, traffic management is an important concern to accommodate the increased number of vehicles per day. The main problem existing is that the traffic is not homogeneous but mix mode type with a vast range of vehicles plying on it (i.e. bus, truck, car, auto cycle rickshaw etc.) without separation. Growing business activities in major Central Business District (CBD) areas has attracted more population and bunched up without expansion. As a result of which congestion is created. Every year the vehicular ownership increases but to accommodate that number of vehicle road infrastructure is limiting. Parking is one of the serious problem that the developing cities of India are facing due to the increasing vehicular traffic. The increased number of vehicle ownership & Mall within the CBD area has also brought into the picture of requirement of parking. Lack of which has forced the vehicle to park on-street and when this parking demand exceeds during the peak hour this also cross the parking limit. Which is why, the road space for vehicular movement is decreased and hence the speed & capacity of the prevailing roadways is decreased and it cannot satisfyingly allow the traffic to flow causing the traffic congestion, unwanted delay, accidents etc. In this paper it is tried to enlighten the impact of On-Street Parking on Traffic flow characteristic in the main CBD area of Silchar city.

Keywords: Central business district, On-Street parking, Silchar, Traffic flow characteristics, K-means clustering, parking load factor, PCU.

1. INTRODUCTION

Parking is one of the major problems that are created by the increasing road traffic. It is an impact of transport development. Shortages of parking space, complaints about high parking tariffs and congestion due to visitors in search for a parking place are only a few examples of everyday parking problems. Many cities and urban areas recognize these problems, but the solution proves to be very complicated. However, important data about the actual parking capacity and use of parking is absent in most cities. The lack of hard data regarding parking capacity and the use of parking makes it difficult to fully understand the real problem and develop effective policies. Compared to other subjects concerning transport and mobility our knowledge about parking, the

problems that arise from parking and the exact effects of parking policy is quite limited. [Kadiyali, 1987]. Thus it is difficult to develop effective parking policies. Some of the problems associated with on-street parking are as follows:

- a. **Congestion:** Parking takes considerable street space leading to the lowering of the road capacity. Hence, speed will be reduced; journey time and delay will also subsequently increase. The operational cost of the vehicle increases leading to great economical loss to the community. This is common in case of mixed type of parking system.
- b. **Accident:** Careless maneuvering of parking and un-parking leads to accidents which are referred as accidents. Common type of parking accidents occur while driving out a car from the parked area, careless opening of doors of the parked cars and while bringing in the vehicle to the parking lot for parking.
- c. **Environment pollution:** They also cause pollution to the environment because stopping and starting of vehicle while parking and un-parking results are noise and fumes. They also affect the aesthetic beauty of the building because car parked at every available space creates a feeling that building rises from plinth of cars. Sometimes they obstruct ambulance, fire fighting vehicles etc. Also they block the road and access to building.
- d. **Obstruction to the traffic flow:** Due to on-street parking there is an obstruction to the traffic flow. Speed of the traffic flow is severely affected and hence unwanted delay. Thereby it also affects the practical or ideal capacity of the roadway.

Traffic Flow Characteristics

Traffic flow is complex phenomenon. It requires little more than casual observation while driving on a freeway to discover that as traffic flow increases, there is generally a corresponding decrease in speed and vice-versa. The basic flow characteristics of roadway are Speed, Capacity & Level of Service (LOS) which are inter-related and depends on

various factors affecting it. [Tom V. Mathew and K. V. Krishna Rao]

- a. **Capacity:** Capacity analysis is fundamental to planning, design and operation of roads. It is defined as the maximum number of vehicles, passengers, or the like per unit time, which can be accommodated under given conditions with a reasonable expectation of occurrence. It is expressed in terms of units of some specific thing (car, people, etc). Capacity is probabilistic measure and it varies with respect to time and position.
- b. **Speed of the flow:** The speed of the vehicles over a particular route may fluctuate widely depending upon several factors such as geometric features, traffic conditions, time, place, environment and driver. *Spot speed* is the instantaneous speed of the vehicle at a specified section or location. *Average speed* is the average of spot speeds of all vehicles passing a given point on the highway. It may be calculated as $V_{avg} = \frac{\sum V_i}{n}$, where V_i is observed instantaneous speed of i^{th} vehicles, kmph and n is the number of vehicle observed.

2. BRIEF ON SILCHAR CITY TRAFFIC FLOW CHARACTERISTICS

Silchar is the headquarters of Cachar district in the state of Assam in India. It is 343 kilometers south east of Guwahati. It is the 2nd largest town of the state in terms of population and municipal area.

Existing Traffic condition of Silchar city

Traffic-jam in Silchar town has assumed serious dimension and the problem seems to get acute with the passing of days. The ever increasing population and with that the vehicular traffic has created a situation where the congestion on important junctions and points hold up movement of all sorts of vehicles for unusual times, posing inconveniences for all. The problem has been compounded by the fact that the roads have remained narrow and the prospect of widening them is remote.

Parking takes considerable street space leading to the lowering of the road capacity. Hence, speed is reduced, journey time and delay will also subsequently increase. In this paper it is tried to relate between the traffic flows characteristics such as speed, capacity with increasing of on-street parking. Goldighi mall site has been selected for the study.

3. SCOPES & OBJECTIVES

Objectives

- a. To study the existing traffic flow characteristics (video graphic survey & spot speed reading).
- b. To study existing parking condition by license plate patrol survey.

- c. To formulate the relation between parking load and traffic flow characteristics.
- d. To provide strategic planning for the betterment of parking facility and thus reduce traffic congestion.
- e. To propose for betterment of road geometry in places where on-street parking has been provided and proper management of on-street parking.

Scopes

- a. It will provide an idea on importance of need for the parking facility in the CBD area and incorporation of future projections.
- b. Need for enforcement of strict laws for illegal parking.

4. LIMITATIONS

- a. The survey has been carried out only on working days (from Monday to Friday) of the week. A detailed parking study spread over longer duration of time would have yielded more reliable results.
- b. More number of parking problems are especially due to unauthorized street vendors in CBD areas which has forced to park anywhere to get food or domestic items; a detailed survey is not carried out.
- c. Mixed mode of traffic flow ranging from various sizes of vehicles, motorized and non-motorized type of vehicle has added more problems in classifying the actual data for the study.

5. METHODOLOGY

Stepwise methodology is mentioned as follows:

- a. Literature review of the study made by many scholars on various aspect of solving parking problems and policies were carried out.
- b. Reconnaissance survey was carried out for selection of sites for study.
- c. Existing parking condition and traffic flow were thoroughly discussed and studied.
- d. Video-graphic survey was carried out to find the traffic volume count of the city.
- e. License plate survey was carried out to understand the number and types of vehicle parked on-street.
- f. Spot speed study was carried out after every 15 minutes to understand the variation in flow characteristics.
- g. Data were analyzed using suitable method as explained below.

h. It is very important to know the type and nature of vehicle plying on the roadway before any further consideration to be made on design perspective of any city. 5 normal working days were taken for study purpose and data collected. On the basis of which, the traffic composition of Silchar city near Goldighi mall on an average is shown in the *fig. 2*.

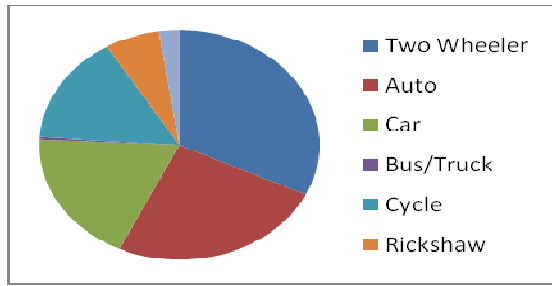


Fig. 2: Traffic composition in Goldighi Mall (in percentage, %)

Spot Speed

At each 15 minutes interval spot speed was recorded for different vehicles through the road section. Radar gun was used for spot speed record. Around 10 – 12 different vehicles speed was recorded as per vehicle distribution on the road as shown in fig. 2.

Traffic Volume Count

Video-graphic survey was done for traffic volume count. 10 minutes data was recorded at each one hour interval. As the influence of different types of vehicle on the capacity of through urban road is different, it is necessary to convert the same into some equivalency factors. Therefore, it was then converted to PCU value as per IRC 86:1983 as shown in table 1. The 10 minutes count data is then converted to hourly value.

License Plate Survey

License plate survey was carried out at Goldighi mall area throughout the day. (i.e. from 9 am to 8 pm). At every 15 minutes interval patrol survey was made and number plate was noted down. The number and type of vehicle parked were separately noted. The total no. of vehicle parked at each 15minutes interval were then converted to PCU values as per IRC 86:1983) as shown in table 1.

Table 1: PCU values as per IRC 86:1983 (Geometric Design Standards for Urban Roads in Plain)

No.	Category	PCU value
1	Car, Jeep, Auto-rickshaw, tempo, Van	1.00
2	Bus, Truck, Tractors	3.00
3	Motor cycle, Scooter, Cycle	0.50
4	Cycle-rickshaw	1.50
5	Hand Carts	1.50

For simplicity, the total number of vehicle parked in 15 minutes interval are than transformed to 0-1 scale and named as parking load factor. 1 being the maximum total number of PCU vehicle parked in 15 minutes and vice-versa.

These parking load factor were than plotted with respect to spot speed. The result obtained were scattered data without

any conclusion of definite pattern. Then the same data set were clustered by using K-means method of clustering.

Explanation on clustering

Patterns can also be put into groups based on the values of their attributes. Such groups are called clusters, and the process of forming cluster is called clustering. Clustering is a search for hidden patterns that may exist in data-sets. The process has often been found to be useful in the explanatory stages of researching a domain to learn how patterns in the domain can be clustered. After we have clustered some given patterns, we may consider each cluster to be a class. Clustering techniques are applied in many application areas such as data analyses, pattern recognition, image processing, and information retrieval. [Žalik, Rizman., 2008]

Method of clustering

For study the impact of On-Street Parking on Traffic Flow Characteristics we have two-dimension data and we are applying K-means clustering for getting pattern or observing impact. K-Means is a typical clustering algorithm for study of pattern because of its simplicity and speed in execution. It partitions the data-set into k clusters. Each cluster is represented by cluster centre also called centroid. K-Means computes the squared distances between the inputs (also called input data points) and centroids, and assigns inputs to the nearest centroid. An algorithm for clustering N input data points $x_1, x_2, x_3, \dots, x_N$ into k disjoint subsets $C_i, i=1, \dots, k$, each containing n_i data points, $0 < n_i < N$, minimizes the following mean-square-error (MSE) cost function:

$$J_{MSE} = \sum \sum \|x_t - c_i\|^2 \tag{1}$$

X_t is a vector representing the t-th data point in the cluster C_i and c_i is the geometric centroid of the cluster C_i . Finally, this algorithm aims at minimizing an objective function, in this case a squared error- function, where $\|x_t - c_i\|^2$ is a chosen distance measurement between data point x_t and the cluster centre c_i . The k-means algorithm assigns an input data point x_t into the i th cluster if the cluster membership function $I(x_t, i)$ is 1. [Žalik, Krista Rizman, 2008]

$$I(x_t, i) = \begin{cases} 1 & \text{if } i = \arg \min (\|x_t - c_j\|^2) \ j=1, \dots, k \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

Here $c_1, c_2, c_j, \dots, c_k$ are called cluster centers. For example,

Table 2: Set of 5 patterns that are to be clustered

Name of pattern	Values of attributes	
	A1	A2
X1	1.00	1.00
X2	2.00	3.00
X3	3.00	1.00
X4	4.00	4.00
X5	5.00	2.00

Study the five patterns X1 to X5 and the values of their numeric attributes A1 and A2 in *table 2*. It is not necessary to know what the attributes mean: only their values need to be considered. Intuitively put the five patterns in two clusters such that the patterns within a cluster are more similar to one another. It might help to first represent each pattern as a point in the A1-A2 coordinate space as shown in *fig. 2*.

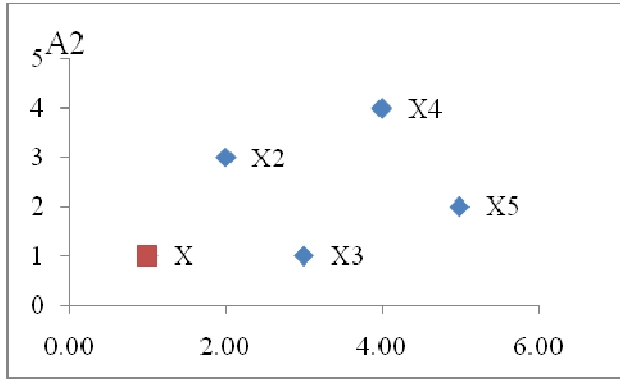


Fig. 2: Representing each pattern given in table 2 as a point in the A1-A2 coordinate space.

Calculation for 1st Iteration

We calculate the distance based on coordinate points such as, if value (x_1, x_2) and (y_1, y_2) given points for 2 points on the two dimensional space, then distance between the points:

$$\text{Distance} = \sqrt{(x_1, x_2)^2 - (y_1, y_2)^2}$$

On the basis of above mentioned formulae, iteration is performed for given data sets.

$$\text{Distance } (x_1, x_2) = \sqrt{5}$$

$$\text{Distance } (x_1, x_3) = \sqrt{4} = 2$$

$$\text{Distance } (x_1, x_4) = \sqrt{18}$$

$$\text{Distance } (x_1, x_5) = \sqrt{17}$$

So the minimum distance is in between x_1 and x_3 . Therefore, x_1 and x_3 will merge and form one cluster. Now, we have to find centroid of the new cluster on the basis of equation (2). Hence, centroid of (x_1, x_3) we got is $[4, 0]$.

Table 3: 1st Iteration of K-mean clustering.

Name of pattern	Values of attributes	
	A1	A2
(X1, X3)	2.00	0
X2	2.00	3.00
X4	4.00	4.00
X5	5.00	2.00

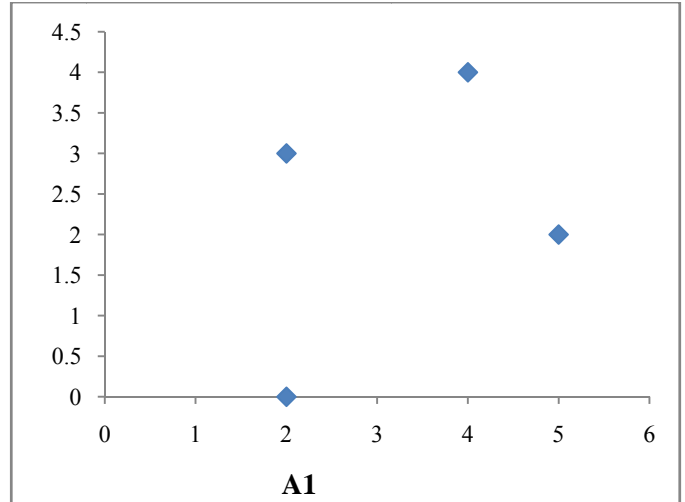


Fig. 3: Representing each pattern given in table 3 as a point in the A1-A2 coordinate space after 1st Iteration

Similarly, after 2nd Iteration, we get,

Table 4: 2nd Iteration of K-mean clustering.

Name of pattern	Values of attributes	
	A1	A2
(X1, X3, X2)	0	9
X4	4.00	4.00
X5	5.00	2.00

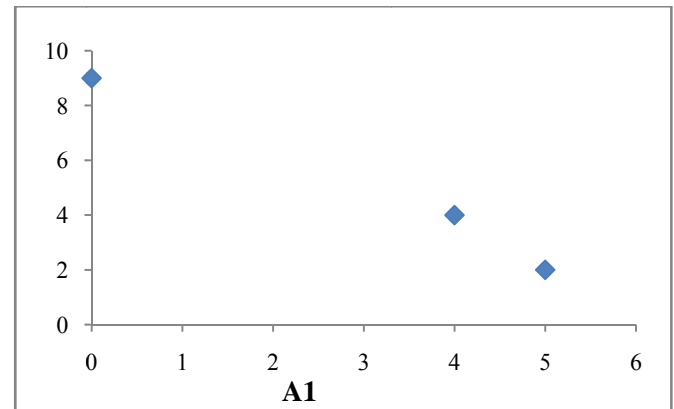


Fig. 3: Representing each pattern given in table 4 as a point in the A1-A2 coordinate space after 2nd Iteration

And the same will as follow.

The results obtained by adopting the k-means clustering method are given in *fig. 4*:

Road width at this reach is 6.5 m in average and is a one-way road. The peak traffic flow in this section is between 6:00 pm

to 7:00 pm. From the clustering data (see *fig. 4*), it is clearly observed that when on-street parking load has increased to 0.85 and above, the speed of the traffic flow has reduced to 14-16 km/h.

6. RESULTS: GOLDIGHI MALL

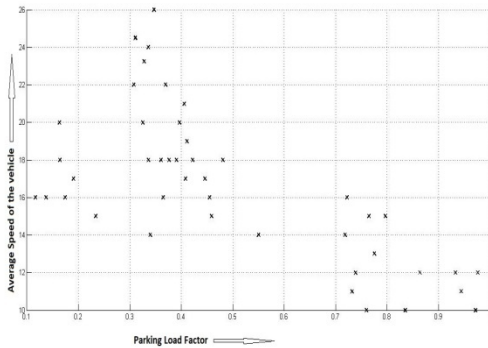


Fig. 4: Spot Speed vs. Parking load factor at Goldighi mall

This is due to the heavy traffic load and lowering of road width due to on-street parking. The traffic volume capacity also is being reduced due to decrease in speed of the flow. It is the point when physically congestion has occurred on this reach.

Experiment performed on MATLAB 7.11.0 R2010b, System Windows 8.1 processor, 4 GB RAM.

The *table 5* shows the effect of on-street parking on the traffic flow as per *fig. 3*.

Table 5: Categorized data on traffic volume, average spot speed & parking factor

Time	Total traffic volume PCU/hr	Avg. spot speed	Parking load factor
9:00 - 10:00	1530	24	0.1 - 0.2
10:00 - 11:00	1722	26	0.3 - 0.4
11:00 - 12:00	2124	22	0.4 - 0.5
12:00 - 13:00	1878	20	0.6 - 0.8
13:00 - 14:00	1770	18	
14:00 - 15:00	1770	20	
15:00 - 16:00	1728	20	
16:00 - 17:00	1680	18	
17:00 - 18:00	1698	16	
18:00 - 19:00	1650	16	
19:00 - 20:00	1548	14	

The same way parking load at different location varies and with a certain limit it starts affecting the traffic flow characteristics. Hence, it is clear that there is direct or indirect relation between Parking Demand & Supply and Traffic Congestion. It is very much important to manage on-street parking so as to minimize the above effect and to keep under controlled condition.

The following are the main conclusive results and analysis that has been made:

- Goldighi mall is located in main CBD hub area and draws many visitors for shopping and other recreational events. The parking lot allotted is very few in numbers and doesn't meet the parking demand.
- On-street parking is available only for two-wheelers and can accommodate around 50 numbers but the demand is more.
- Though it is a one-way traffic, the road section is very narrow to allow the heavy traffic. On-street parking takes considerable street space leading to lowering of road capacity and causes congestion and unwanted delay to the road users.

7. CONCLUSION

Similar type of study could be made with more data to understand the effect of on-street parking on traffic flow characteristics due to parking supply failure to meet the demand for parking. This study is completely made with consideration of the above mentioned sites only; different site locations can have different load and traffic characteristics which can have a considerable effect on the results. There are various other factors that affect the traffic flow such as pedestrian, slow moving vehicles, cycle rickshaws, and cycle. All the factors were not included in the study; it requires more data and analysis.

REFERENCES

- Dr. Tom V Mathew, IIT Bombay "Parking Statistics & License Plate Method of Survey"
- SUBRAMANI, T "Parking Study on Main Corridor in Major Urban Centre", IJMER, Vol. 2, Issue.3, May-June 2012)
- "Parking Demand and Supply" (Final Report, Feb 25, the TRANSPO Group, Inc. 1999)
- "Parking Demand Analysis" (MTA Metro – North Railroad, North White Plains Section Feb 2005, Fleming. Gannet)
- Huammei Qin, Qing Xiao, Hongzhi Guan, Xiaosong Pan. "Analysis on the Parking demand of the Commercial Buildings Considering the Public Transport Accessibility by taking Commercial Building in Beijing as an example (Beijing Key Laboratory of traffic Engineering, Beijing University of Technology, Beijing 100123, China
- Žalik, Krista Rizman. "An efficient k'-means clustering algorithm." Pattern Recognition Letters 29.9 (2008):1385-1391.
- Chakrabarti, Sandip and Mazumdar, Taraknath "Behavioural Characteristics of Car Parking Demand: A case study of Kolkata" Institute of Town Planner, India Journal 7-4, 01-11, October – December 2010)
- Thompson, Russell G. and Richardson , Anthony J., "A Parking Search Model" Nov 1996 revised)
- Khanna, S. K. & Justo, C. E. G. "Highway Engineering Text Book"
- C. Jotin Khisty, B. Kent Lall, "Transportation Engineering text book".
- L.R. Kadiyali, Traffic Engineering and Transportaion Planning, Khanna Publisher, New Delhi, 1987]
- IRC 86:1983 (Geometric Design Standards for Urban Roads in Plain)**