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Development of Model for Prediction of Parking Demand at Railway Station - A Case Study of Surat City

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Abstract —*Due to economic and social activities, the regional growth is increased. In cities, the commuters are moving for earning, education and social activities and vice-versa. It is necessary to provide transportation facilities to fulfill the current and future demand. It is observed that economic condition is also rapidly increased in the last few years and it increases the vehicular ownership in the urban area. The authority needs to provide parking facilities for reducing congestion. At railway station and bus station, the rate of growth of daily commuters is high. It is observed from the study that the adequate parking facilities are not available. The daily commuters tend to park their vehicles on the street and reduce the walking distance. It increases the traffic congestion, high energy consumption, deterioration of environment and delay. The parking policies play a vital role in overall development of city and station areas. In the present study, the model is developed to forecast the demand from the growth rate of different type of vehicles in the city as well as the evaluation of adequacy of parking facilities to meet the future parking demand. The model is developed for Surat city of Gujarat state. It caters very high traffic of daily commuters. The data are collected for analyzing the existing parking requirement and available parking. The proposed model predicts parking demand with more accuracy for the mega city of developing country like India.*

Keywords-*Traffic management, Parking problems, Parking demand, Parking forecasting*

I. INTRODUCTION

Traffic management is the biggest challenge for an authority. In developing countries, the rate of traffic is increasing every year in the urban area. Due to rapid urbanization and increased growth rate of vehicles, the congestion increases. Unplanned urbanization and transport facilities cause parking issues. A substantial portion of urban land is required for parking of vehicles. Due to the non-adherence to parking standards set by the planning agencies in the building rules, parking on the kerb of the road has become a common phenomenon throughout the city roads. In the absence of adequate parking facilities, on street parking system is adopted, which hinder the traffic movement, reduce capacity of urban roads and increase accident proneness. Inadequate parking facilities result in decrease of road capacity and many negative side effects such as air and noise pollution. Beside these, it also causes economic consequences by losing time and fuel, loss of productivity, high energy consumption and increase in accident rates. Hence, parking facilities are to be planned and designed to provide a better level of service to the people. In the present study,existing parking facilities and its future demand at Railway station are determined. The estimated traffic demand at railway station also depends on types of trains, frequency and arrival rate. In the preset study, forecasting model for parking demand is developed. It can be used for planning of adequate parking lots for the commuters at railway station.

II. OBJECTIVE OF THE STUDY

Followings are the objective of the present study:
1) To collect the data of existing parking facilities at the railway station
2) To collect the data of trend of parking lots used by the daily commuters
3) To develop the model for estimating parking demand for Surat railway station
4) To suggest remedial measures to fulfill the future parking demand

2.1 Background

Parking demand depends on people's social activities, economic activities and others. Detailed and accurate analysis of social economic and other matters regarding the planned area play an important role of parking demand forecasting model. Bendtsen (1967) investigated the relation between the number of parking spaces available and the number of trips to and from the town center. He found a close correlation between availability of parking spaces and the number of trips in Danish and American towns. The study also shows that impact of parking on the environment. He concluded that especially due to cruising for parking off-street parking creates about 40% less emission than curb-side parking.This means that 100 off-street parking vehicles give about the same emissions as 50-70 vehicles parking at the curb-side.Anderson and de Palma (2006) investigated the economies of pricing parking for efficient traffic management. Button (2006) identifies as the major problem of parking policy that resources are allocated according to time and not according to money.Rodier and Shaheen (2007) estimated parking needs on rapid transit system.The many models for the parking forecasting are available. The present study is aimed to develop the model for predicting parking based on the demographic data, traffic data, and train frequency.

III. METHODOLOGY

Many factors like nos of commuters, time of journey, train arrival rate, facilities at railway stations, psychlogical behaviour of commuters, fatigue etc. affect to the parking demand at the railway station. The estimation of traffic demand is crucial for ensuring proper space management in the crowded area. It is necessary to establish a relationship between mos of parking required and other appropriate variables.

The present study is an attempt to forecast the parking demand based on the available demographic data, traffic data, train/passenger frequency etc. In view of the more flexible influencing factors, such as development strategy of urban transportation and parking managment systems.Followiong variables are considered for the development of prediction model for parking demand.

- Population
- No. of two wheeler parked
- No. of cars parked
- No. of commuters
- No of trains

IV. DATA COLLECTION

The study includes the data collection from primary sources and secondary sources. The fact-finding survey is carried out at the field. It includes the data collection of nos of parking lots and category of vehicles parked at the railway station. The demographic data and no of trains running through Surat railway station are collected from secondary sources. The space availability and utilization for parking was physically observed on site. The data are collected in the standard format after reconnaissance survey.The study includes details existing parking area, demand& supply of parking, Willingness to pay survey etc. Detailed survey is carried out during peak and off – peak hours. The actual size of vehicles parked is also measured. The provision of parking area, required parking as per actual demand and future requirements has been worked out. The sensitivity analysis also carried out for the considered parameters. The analysis shows that the east side (front side) of the railway station is more congested due to higher rate of parking of two wheelers and four wheelers. It is observed that the proper rules and regulation are not followed by commuters, whichleads to the more difficulties in space management. Due to the main entry of old city and location of ST depot in the nearby area, the commuters are encouraged to park their vehicles in the eastern side of the railway station. The data summarized in Table 1 are used for model development.

Table 1 : Data Collection

Year	Population in lacs X_1	No. of parked cars (in thousands)	No. of parked Two wheelers (in thousands)	Total parked vehicles X_2 (in thousands)	Total vehicles parked per day (in thousands)
2008	43	35	262	297	1967
2009	45	35	264	299	2101
2010	48	36	265	301	2234

2011	51	36	265	301	2368
2012	54	37	264	301	2500

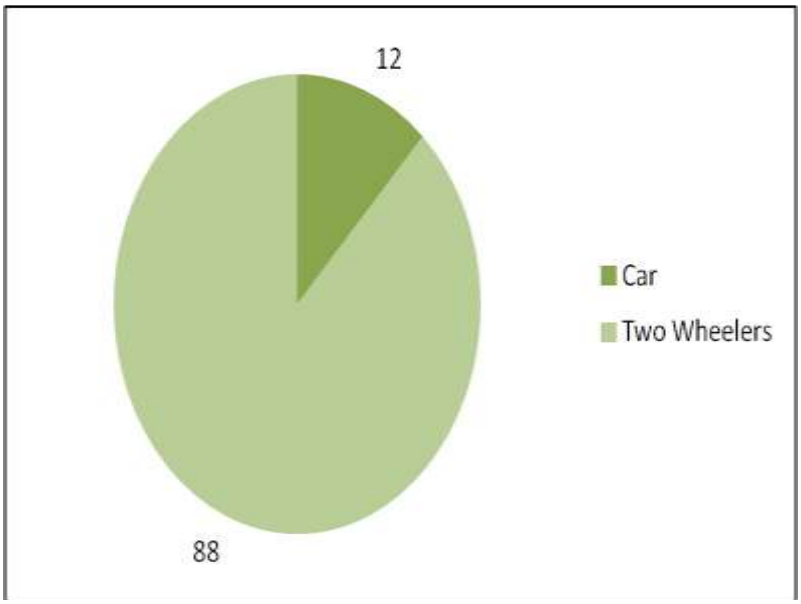

Figure 1 : Percentage of space occupied by Car and Two Wheelers

Figure 1 indicates that 12% of parking lots are occupied by car and 88% of parking lots are utilized by two wheelers. It also shows that majority of parking lots are utilized on daily basis by the commuters.

4.1 Development of Models

Regression analysis is widely used for developing a prediction model. Regression analysis is also used to know the significance of various parameters considered and to establish the relationships between parameters. In the present study, the regression model is developed using population and vehicular traffic as independent variable. Total Number of parked vehicles and populations are considered as dependent variable and total no of vehicles per thousand populations is considered as independent variable. The following modelsare developed for estimating future parking demand.

Model 1

$Y = 46.7X_1 + 6.6X_2 - 2003.4$ (1)

Where,

Y = Number of vehicles parked per year

X_1 = Population in lac per year.

X_2 = Total Vehicles per thousand population per year.

$R^2 = 0.998$

Model 2

$Y = 22.2X_1 - 0.4X_2$ (2)

Where,

Y = Number of vehicles parked per year

X_1 = Population in lac per year.

X_2 = Total Vehicles per thousand population per year.

$R^2 = 0.999$

4.2 Validation of Developed Models

The 't' test is performed on the developed model (1) and (2). The statistical validation is summarized in Table 2.

Table 2 Validation of developed Models

Independent Variable	Observed 't'	
	Model 1	Model 2
X_1	15.33	22.2
X_2	1.94	-0.45
Critical 't'	4.30	3.18

It is observed from Table 2 that 't' observed is higher than 't' critical for variable 'X_1'. It can be concluded that population is significantly affecting to the parking demand at the railway station.

4.3 Forecast of inputs and model output

In this study, data for the duration from year 2008 to 2012 are collected. Future population (X_1) is calculated using the following equation.

$$P_n = P_0 (1+r)^n \quad (3)$$

Where,

P_0 = Present population in thousand

r = growth rate as 5.8%

Future vehicles, variable (X_2) are calculated based on the growth rate of 6.2 % for 2wheelers and 7.2% for cars. The parked vehicle per day is estimated using equation (3).

Table 3 : Data used for model

Year	Population per year (in thousands) X_1	Total parked vehicles X_2 (in thousands) X_2	Total vehicles parked per day Y	Total vehicles parked per year
2013	56	302	2632	960551
2014	59	303	2763	1008430
2015	62	304	2894	1056163
2016	64	304	3024	1103768
2017	67	305	3154	1151261
2018	70	305	3284	1198655
2019	72	306	3414	1245961
2020	75	306	3543	1293189

V. DEMAND – SUPPLY ANALYSIS

In this study, the analysis of demand and supply for parking facilities is carried out using the data of vehicle parked for particular duration, hourly variation. The capacity of various parking lots is determined. Considering similar trend, prediction of peak parking demand is calculated.

(1) Do - Nothing Case :

From the analysis, it is found that there is a gap between demand and supply of parking facilities at the railway station. It is mentioned in Table 4.

Table 4 : Demand – Supply Gap

Year	Parking Demand in peak hours (Per Day)	Parking lot Allotted (Per Day)	Gap in Parking Demand and Supply (Per Day)	Load Factor	Total Parking Demand (Per Day)
2013	922	610	312	1.50	2632
2014	967	610	357	1.58	2763
2015	1013	610	403	1.66	2894
2016	1059	610	445	1.74	3024
2017	1104	610	494	1.81	3154
2018	1150	610	540	1.88	3284
2019	1195	610	585	1.96	3414
2020	1240	610	630	2.03	3543

It is observed from Table 4 that load factor is continuously increasing from year 2013 to 2020. If the load factor is more than 1.50, the current condition is critical. In Do- Nothing case, the gap between demand and supply will be increased in future.

(2) **Do – Something :**

According to survey and analysis, it has been found that the present parking lots is not adequate to fulfill the future demand. In the present case, the authority should adopt alternative on street parking lots. Due to non – availability of open land, it is desirable to adopt Multi – storied parking. It is suggested to carry out study on economic analysis and methods for generating revenue to sustain the cost of construction, maintenance and operational cost of Multi – stories parking.

VI. SUMMARY AND CONCLUSION

The parking plots for the vehicles of daily commuters are essential at the railway station. The present study has focused on the parking demand supply analysis for the railway station of Surat city of Gujarat state. The Surat is situated on the main broad gauge line from Delhi to Mumbai. It is observed from the study that parking space availability is about 50% compare to its present requirement. The model is developed for predicting the future parking demand considering the population and category of vehicles parked at present. The regression analysis shows the excellent relationship between total parked vehicles and population of the city. It is suggested to consider the variable like no of passengers travelling on daily basis, types of train, land use pattern etc.for the analysis. The classified data of passengers may be giving some highlights or correlation with the type of vehicle come to pick up the passengers.The separate demand of taxi and auto models also can be workout in future.

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