Urban Trip Rate Modeling for the Recently Expanded Areas: A Case Study of Surat

¹Siddharth Siddhpuria ²Aathira Das ³Darshan Mehta ⁴Haresh Golakhiya

^{1,3,4}Assistant Professor ²Research Scholar

^{1,3,4}Department of Civil Engineering ²Department of Transportation & Planning Engineering
¹Dr. S & S. S. G. G.E.C, Surat, Gujarat, India ²SVNIT,Surat ³S.S.A.S.I.T, Surat, Gujarat, India ⁴G.E.C., Dahod, Gujarat, India

Abstract

The rapid urbanization in our metropolitan cities has resulted in simultaneous expansion of cities in spatial dimension. The impact is also on the city infrastructure required for various sectors including transportation. There is significant growth in vehicles population which has eventually air influenced travel pattern, trip length and trip rates .the present study highlights the trip rate generation in recently expanded city areas based on survey home interview data carried in city to capture socio economic and households characteristics .an attempt has been made to develop a multi leaner regression model to predict the likely household trip on daily basis.

Keyword- Urbanization Category Analysis, Multiple Linear Regression, Population, Trip Rates, Urban

I. INTRODUCTION

Transportation in dictionary terms has been defined as 'to carry from one place to another'. Though this definition is short and seems non-technical, but it captures the essence of what transportation is all about. Definition in a more technical manner; transportation can be defined as the medium through which 'demand and supply' interact with each other. The demand being referred herein can be of economic as well as social in nature. The demand and supply can be of goods, services opportunities and people. Therefore transport systems are meant and built in order to serve people in undertaking their economic, social and cultural activities. In this way the transportation becomes an essential part of human life and urban planning. Generally four stage urban transportation planning is adopted in forecasting the urban travel demand. The four stages are trip generation, trip distribution, modal split and traffic assignment operated in sequence. As such the trip generation is the best for the subsequent processes. Trip generation are majored in number of trips per household per day or number of trips per capita per day. The trips generation depends on number of factors such as household's characteristics, socio-economic base and land use pattern these factors vary from place to place and within the place. The model adopted for trip generations belongs to mainly two categories i.e. Category analysis and Regression analysis. Now a day research workers are employing soft computing techniques. However here Multiple Linear Regression techniques is adopted to build MLR-TGM for prediction the urban trip rates on the home interview survey data carried in fast growing industrial Surat city as study area. Section one covers the study objectives and study area profile, where as section two focuses on survey data and analysis. The model building is covered in section three.

II. STUDY OBJECTIVES

- To study the extended area of Surat with reference to household characteristics.
- To develop the multi linear regression model for the prediction of urban trip urban trip rate for Extended Area (TEA) of Surat city

III.STUDY AREA

A. City Brief

The Surat city located in the south Gujarat region has an area of 112.28 Sq.Km with a population of 24.33 lakhs as per census 2001. Before expansion city had 66 census wards. In 2006 city had added 35 villages having area of 214.24 Sq.Km with population of 4.42 lakhs. Area of city has been increased to 326.52 Sq.Km with population of 28.76 lakhs and 101 number of census wards. Surat is the fast growing industrial and second largest city of state of Gujarat. It is located on main corridors of national highway and western railway in between Bombay and Ahmedabad cities. Therefore has been selected as the study area for carrying out travel demand forecasting as well as trip generation analysis the urbanization rate of cities highest in Gujarat to the tune of 55% owing to higher rate of migration taking place in view of the rapid industrial growth in the vicinity of the city.

The city, its extended area after the city expansion in 2006 and the SUDA boundary are as shown in figure.1. Now the city has spread over 326 Sq.Km area with population of nearly 45 lakh (2011 census).



Fig. 1: Location of Surat City

B. Demographic Profile

The city of Surat has grown in five decades is presented in the following table. In five decades population has moved from 2.23 lakh. To 24.34 lakh. Higher decadal growth is observed during 1981-1991 and 1991-2001.the decadal growth is more than 60% during these two decades. The city density has moved 139 PPHA to 217 PPHA from 1971 to 2001.

Census Year	Status	Area (sq.km.)	Total Population	Density (Person/HA)
1951	М	8.18	2,23,182	272
1961	М	8.18	2,88,026	352
1971	МС	33.85	4,71,656	139
1981	МС	55.56	7,76,656	139
1991	МС	111.16	14,98,817	134
2001	МС	112.28	24,33,785	216
Table 1.	Donulatio	n Donaity	on Ca Vm of Sunat	$C_{ity}(1001, 2001)$

Table 1: Population Density per Sq. Km. of Surat City (1901-2001). Source: www.suratmunicipal.com. M = Municipality, MC = Municipal Corporation,

C. Population Distribution

The demographic profile of population distribution of the seven city zones in 2001 is shown in Table 2 copy 34 central zone is densely populated with 506 PPHA followed by east zone with 419 PPHA.

		Area	Year 2001			% Decadal Growth
Sr. No.	Sector	(sq.km.)	Pop ⁿ (in lakh)	Density (ppha)	% of total Pop ⁿ	(1991-2001)
1	Central	8.18	4.13	505.62	16.99	-4.37
2	South-West	14.96	2.02	134.96	8.29	97.52
3	South	35.11	6.52	185.79	26.8	85.31
4	East	13.86	5.81	418.79	23.85	87.46
5	North	20.54	3.35	163.21	13.78	90.25
6	West	19.63	2.51	127.56	10.29	97.13
	Total	112.28	24.33	216.76	100	62.29

Table 2: Sector Wise Population, Area and Density (1991-2001).

Source: Surat Municipal Corporation

Sector No.	Sector Name	Area (Sq.Km)	Population (2001)	Density in (ppha)
2	North (katargam)	15.823	82110	51.89
3	East (Varachha)	22.284	130381	58.51
4	South-East (Limbayat)	11.782	62696	53.21
5	South (Udhna)	35.745	8789 <i>3</i>	24.59
6	South-West (Athva)	93.952	42798	4.56
7	West(Rander)	31.653	36664	11.58
TOTAL		214.24	442542	20.95





Fig. 2: Extended area of Surat city in 2006

IV. FIELD SURVEYS

Home –Interview Survey (HIS) method survey is one of the most reliable types of surveys for collection of socio-economic and travel data. The information on a travel pattern like number of trips made, purpose of trip, travel mode, and information on house hold characteristics like type of dwelling units, number of residents, age, sex, vehicle ownership, number of drivers, family income is collected in the HIS. The home interview survey were carried in all the six extended sectors as shown in figure.2

A. Design of Questionnaire

The questionnaire designed to collect the information is broadly divided into two parts as follows and discussed below.

1) Household Characteristics

In this part, location of household, form of dwelling unit, number of residents, occupation of working members, numbers of school and college going members, number of vehicles owned by the family, activities of family members are collected.

2) Travel Particulars

Travel related data like purpose wise trips like work, school and recreation and other purposes is collected.

B. Sample size

Obtaining the desired information from a part of the population is sample. Survey has been carried out only for outer growth area (extended area) of Surat city having an area of 211.23 Sq.Km. Home interview survey is carried out in all in all extended areas. Total 982 samples are collected.

V. SOCIO ECONOMIC CHARACTERISTICS

A. Households Structure

Here, family size, numbers of working members and school going members are the three household parameters in the present study the household size varies from 1 to 18 that reflect on presence of joint family household's structure but majority of the households are having family size between 3 and 7. On average family size is of 5.36in total extended area. The highest family size is observed in Katargam and Rander area to the tune of 5.57. The percentage wise the family size structure is given below and same is express in Fig. 3.

Family Size	1	2	3	4	5	6	7+
%	1	2	8	28	28	16	18



Fig. 3: Family size Structure of TEA

As far as working members in the family is concern is 1.57 to 1.98. South-East zone i.e. is Limbayat has highest working members of 1.98 per family. Similarly the average school going members are varying from 0.78 to 1.56 and it is lowest in Udhna industrial area as shown in the table 4. These parameters have significant impact on trip rates.

Sector No.	Min. H.H Size	Avg. H.H Size	Avg. Working Member	Avg. School Going Member
2	2	5.57	1.88	1.39
3	3	5.37	1.57	1.56
4	1	5.40	1.98	1.17
5	1	5.14	1.80	0.78
6	2	5.28	1.65	1.23
7	1	5.50	1.88	1.32
TEA*	1	5.36	1.77	1.23

Table 4: Households structure

The average HH size, avg. working member and avg. school going members in households are 5.36, 1.77 and 1.23 respectively.

VI. TRAVEL CHARACTERISTICS

A. Vehicle Ownership Pattern

The information gathered for the household ownership of vehicles viz bicycle, two-wheeler and four-wheeler is analysed sector wise and presented in Table 5. It is observed that two wheeler ownership in the households is in the range of 1.26 for Sector 4 (South- East- Limbayat) to 1.53 for Sector-2 (North-Katargam) showing that every household possesses more than one 2-wheeler. Households' of four-wheeler is also quite high with minimum one household out of five households in Sector 4 (South- East-Limbayat) possessing a car, whereas two households out of five households have cars in Sector 2 (North-Katargam) and Sector 6 (South-West-Athva). The highest no. of bicycles/HH is observed at 0.56 bicycle / hh in the 7th sector (Rader). Out of average 2.21 vehicles owned per family, 65% are two wheelers reflecting them as the major mode of city passenger travel. Share of the vehicles is 19% bicycle, 65% of two wheelers and 16% cars in the extended area.

Sector No.	Bicycle	2 W	4 W	Avg. Vehicle	Avg. Motorized Vehicle
2	0.52	1.53	0.42	2.47	1.94
3	0.44	1.4	0.38	2.22	1.78
4	0.41	1.26	0.20	1.87	1.47
5	0.27	1.38	0.30	1.95	1.68
6	0.41	1.51	0.42	2.34	1.94
7	0.56	1.44	0.27	2.27	1.71
TEA	0.43	1.43	0.35	2.21	1.75

Table 5: Household Vehicle Ownership Pattern

B. Observed Purpose Wise Trips

Table 6 and Fig. 4 gives the purpose wise trip generation at the sector level and for the entire TEA. Survey states that the total trips/household/day are ranging between 7 to 9 at sector level. The average trip generated/household/day is 8.22 out of which 7.61 trips/household/day are for work and education purpose while 0.61 trips/household/day is for shopping, recreation and other purposes Fig. 4 shows the maximum average trips /day/ household in North sector (Katargam). The minimum total daily family trip is observed in 5th sector i.e. South (Athva) sector.

Sector No.	Trips /H.H / Day					
Secior No.	Work	School	Other	Total		
2	4.61	3.80	0.63	9.04		
3	4.16	4.14	0.65	8.94		
4	4.74	2.64	0.57	7.95		
5	4.97	1.84	0.66	7.48		
6	4.39	2.62	0.53	7.54		
7	4.77	3.51	0.66	8.94		
TEA	4.58	3.03	0.61	8.22		

Table 6: Purpose wise Trips/HH/Day

The graphical presentation of purpose wise trip generation is given in Fig 4. The percentage distribution of purpose wise trips is shown in Table 6. The maximum purpose wise trips generated are nearly 56 % for work purpose in TEA. The maximum 66 % of work purpose trips are observed in 5th sector i.e. South (Athva) sector.



Fig. 4: Household Daily Trips for Sectors

VII. DEVELOPMENT OF URBAN TRIPRATE MODEL

A. Input Variables

1) Family Size

Generally with higher family size the trip generation rate is observed to be increasing due to more number of potential travelers. However sometimes trip rate may decrease with higher family size depending on the age structure of the family members consisting relatively more old age persons and young.

2) Number of Working Members

The number of working members in a family makes direct, additive & major influence on the trip generation rate of a family. The data for current study very well reflects this phenomenon.

3) Vehicles Owned

As the convenience of travel is better provided by the personal vehicle, it commonly observed that higher the number of vehicles owned by a family, more will be the trips generated for purposes other than compulsive purposes of work and education and vice versa.

B. Model Structure

Multiple Linear Regression Technique (MLR) has been applied here, where number of trips/hh/day is dependent variable and above inputs mentioned are independent variables. The model works on least square error logic.

The general form of the regression equation is:

 $y = a_0 + a_1x_1 + a_2x_2 + a_3x_3 + \dots + a_nx_n$

Where, y is the Dependent variable; x_1 , x_2 , x_3 ,..., xn are independent variables; a_0 , regression constant, and a_1 , a_2 , a_3 are regression coefficients.

The application of the Multiple Linear Regression technique is based on the following assumptions:

- All the independent variables are fairly independent.
- All the variables are continuous and normally distributed.
- A linear relationship exists between the dependent variable and the independent variables.

The input variables noted from the field surveys carried in the city extended areas in seven sectors are regressed with reference to household trips per day using Excel software as

$$y = -0.177 + 0.728x_1 + 1.361x_2 + 0.924x_3$$
 (R² = 0.681)

y- Households trips/day,

X1-Family Size, X2-Nos of Working Members, X3-vehicle Ownership

 R^2 of 0.681 is reasonably acceptable

C. Sector wise Model Trip Rate Prediction

With the help of regression model trip rates are developed. The model gives trip rate per household per day. Sector wise trip generation generations are based on the trip rate. The number of trips generated in a zone or sector depends upon the zonal or sectorial trip rates and population. Table 7 provides particulars of the mean values of the trip rate input at Sartor and TEA level. These inputs when employed through trip generation model, the zonal trip rates are generated and the same are shown in Table 8 and Fig.5 Trip rates are varying from 1.49 trips pcpd to 1.56 trips pcpd. The East Sector (Varachha) and South-East Sector (Limbayat) have shown low trip rates because of relatively lower socio-economic status of the population in general. On the other hand Sector 2 (North Sector Katargam) and 5 (South-West Sector Athava) have shown higher trip rates because of higher vehicle occupancy are in these sectors due to better socio-economic conditions.

	Avg.	Avg. Nos. of Working	No of
Sector No	Family size	Members / HH	Vehicles / HH
2	5.57	1.88	1.94
3	5.37	1.57	1.78
4	5.40	1.98	1.47
5	5.14	1.80	1.68
6	5.28	1.65	1.94
7	5.50	1.88	1.71
TEA	5.36	1.77	2.23

Table 7: Sector Wise Mean Attributes Value.

Sector No.	Trips /HH/Day	Avg. Family Size	Trip PCPD
2	8.67	5.57	1.56
3	8.01	5.37	1.49
4	8.06	5.40	1.49
5	7.92	5.14	1.54
6	8.2	5.28	1.55
7	8.34	5.5	1.52
TEA	8.74	5.36	1.63

Table 8: Trip Rates of Total Extended Area by MLR-TGM



Fig. 5: Sector Wise Trip Rates by MLR-TGM

VIII. CONCLUSION

Urban trip generation is one of the basic steps in urban travel forecasting and provides the platform for trip distribution, modal split and traffic assignment in four stage urban transportation planning process. Category analysis, regression analysis are important approaches in trip generation modelling. As category analysis need huge data set and exhaustive surveys the urban planners adopt the regression modelling approach. The present study has developed MLR-TGM model considering family size, number of working members and vehicle ownership as the major inputs. The model is further used to predict the trip rates for all the six study sectors of the city. MLR-TGM can further be employed to predict the likely numbers of trips generated in all the study sectors in future for short and medium term basis.

REFERENCES

- [1] Khisty, C. Jotin., and Lall, B. Kent. (2005). "Transportation Engineering", Prentice Hall of India Private Limited, New Delhi.
- [2] Khanna, S.K., and C.E.G. Justo. (1997). "Highway engineering", Nem Chand and Bros; Roorkee (U.P)
- [3] Kadiyali, L.R. (1997). "Traffic Engineering and Transportation Planning", Khanna Publishers, New Delhi.
- [4] Joshi G.J., Katti, B.K., and Tailor, R, M. (2006). "Trip rate analysis for a metropolis city of Indian Context", Published by American Society of Civil Engineering's, Chicago, Illinois.
- [5] Joshi G. J., Katti, B.K., and Mehta, Parul. (2005). "Rail Passenger Travel Demand Modeling With Reference To South Gujarat Region", (Vol. 2. No.4: 2005-Page- 6-13) ITPI Journal, New Delhi.
- [6] Douglas, A. A., and Lewis, R. J. (1971). "Trip Generation Techniques for category Analysis", traffic Engineering and control, Vol. 12, No 10.
- [7] Banks, James. H. (2002). "Introduction to Transportation Engineering", Mc Graw Hill, New Delhi.
- [8] Saghani, M. (2003). "Mode choice travel behavior analysis: A Case Study of Surat City", MTRP Thesis SVNIT, Surat.
- [9] Tailor, R. M. (2002). "Metropolitan Travel Behavior Analysis: A Case Study of Surat City", MTRP Thesis SVNIT, Surat.