Forecasting Future Traffic Trend by Short-Term Continuous Observation

Vikas Mendi¹ and I Srinivasula Reddy²

¹Assistant Professor, Department of Civil Engineering, RV College of Engineering, India
²Research Scholar, Department of Water Resources and Ocean Engineering, NITK Surathkal, India
E-mail: sr0863699@gmail.com

Abstract. Annual Average Daily Traffic (AADT) is a key parameter to understand the traffic flow rates, traffic density and to design any highway. Generally, short period observed traffic data mainly depends on that season in which the traffic surveys were conducted, which may be high or low compared to the other seasons. So, the behavior of seasonal variation of traffic must be considered for the AADT analysis. These seasonal variations can be found out using the past recorded data of that selected location. But in the case of a location where the past annual traffic data is not available, an alternative method is required to calculate the seasonal variation of the traffic data. The present study deals with the analysis of seasonal variation factors to estimate the AADT from the fuel sale data collected from the nearby petrol stations at the traffic survey point. This work explains how Annual Average Daily Traffic (AADT) can be estimated from a week’s limited traffic data when there is a scarcity of automatic traffic data collecting systems.

1. Introduction

Traffic volume often measured concerning Annual Average Daily Traffic (AADT), is an important output of traffic monitoring systems [1]. Annual Average Daily Traffic (AADT) can be defined as the average amount of a year’s traffic that passes through a certain location of the corridor. Information on (AADT) is essential for assessment of parameters majorly to be considered in highway planning, fuel-tax revenue projections, and pavement design [2].

David Albright [3], studied the history of estimating and evaluating annual traffic volume statistics in a report published by Transportation Research Record 1305, stated that in the 1930s the only mode of traffic survey available was the manual counting. In the early 1940s, the changeover to mechanical methods of traffic measurements simplified the process of traffic measurement. In the 1950s and 1960s, many authors and researchers proposed theoretical methods to perform traffic studies and traffic summary statistics. The procedures that were developed at that period were debatable at times, also cemented themselves strongly in the collection of traffic data for at least three decades.

Conventionally, AADTs can be estimated for most of the corridors by conducting short-term surveys (STTCs or coverage counts) and by applying some expansion factors which may be derived from Permanent Traffic Counts (PTCs) [4]. The Federal Highway Administration Traffic Monitoring Guide [5] recommends to various bodies
involving and managing transportation systems about the design of effective monitoring systems, depending on the amalgamation of transportable counters used for a few days (Short Period Traffic Counts, or SPTCs) or at least one week (Seasonal Traffic Counts, or STCs) per year, and Automatic Traffic Recorders (ATRs) which give Permanent Traffic Counts (PTCs).

Generally, the collection of traffic data can be done by manual counting or automatic data recording computerized systems located at the required places of the corridor. The data collection through manual counting is hectic work to recruit people and monitor the counting team throughout the year. The data collection through automatic counting systems involves money and collecting data without flaws is a challenging job. So the observation of annual traffic data may not prove economical for the developing countries like India. Estimation methods for calculation of the AADT from the known seasonal traffic data of a particular location of the corridor are required and this method of approach is acceptable all over the world [6]. The present study focuses on the estimation of AADT from the traffic data of consecutive seven days of a year.

The traffic growth depends on several factors such as the economy of the country as well as the state economy, population growth, local industrial growth, economic status of the population, etc. Generally, the growth rate of public transport depends on population growth and commercial traffic growth depends on the growth of industries connecting the particular corridor.

2. Study Area and data collection
Traffic surveys were conducted on NH 8A (presently NH 47) locating a station having a distance of 28 kilometers from Ahmedabad city, near a village named Rajoda, Ahmedabad district, Gujarat state, India. The considered traffic survey point is the main station on the corridor which is a major transport national highway between north Gujarat & adjacent states and south Gujarat.

![Fig. 1: Location of the traffic count survey point on the corridor.](image_url)

The traffic data was collected by manual counting method. The data was collected by counting the vehicles in prescribed formats containing both passenger traffic and goods traffic vehicle segregation. The passenger traffic format contains cars (white board and yellow board separately), buses (minibus, RTC buses, private buses and school buses separately) and tata magic. The goods traffic format contains light goods vehicles, two-axle, three-axle and multi-axle vehicles. The data was collected continuously throughout the day and night for seven consecutive days of September month, year 2012.

3. Methods and analysis
The estimation of AADT of any corridor involves the following stages: First, selection of location
to estimate the AADT which depends on application of estimated AADT, identification of major junction of the corridor is required in order to analyze the inflow and outflow traffic of the corridor and to fix the maximum traffic location if the objective is to predict the toll revenue of the corridor through AADT analysis. Second, preparation of traffic counting formats containing different types of vehicles which are flowing through the corridor. Third, counting the traffic round the clock of seven days and enquiring the reasons for abnormal traffic during to survey period if the traffic data is not reliable. Fourth, Collection of petrol and diesel sales data for Seasonal Variation Factor analysis, investigate the reason for major variations of fuel sales data to minimize the errors in Seasonal Variation Factors. Fifth, estimation of ADT and AADT from the collected data.

Massimiliano Gastaldi et al. [2] demonstrated method based on fuzzy theory that represents measures of uncertainty and road groups by fuzzy boundaries. Predefined road groups were assigned by road segment using Neural network methods. Nale Zhao et al., [7] proposed a working method for determining characteristics of traffic flow by the using toll data.

Study by Jung-Ah Ha and Ju-Sam Oh [8] estimated AADT from traffic volume data measured in short-term survey in a year using different methods and investigated more precise methods than previous studies which requires adjustment factors. The methods used can reduce error due to daily traffic variation while estimating AADT.

Joe Flaherty [9], Lee et al., [10] and Ha et al., [11] estimated AADT by clustering PTC points to apply adjustment factors. Ha et al., [12] proposed a method to assign them to the classified groups. The proposed method cannot reflect daily characteristics by group.

Lim et al., [13] analyzed different methods based on the same section, grouping of adjustment factors to estimate AADT of STC points and compared. The methods based on same section showed small error. Daily traffic variations cannot be reflected using this method even though monthly factors and weekly factors applied. In addition to the method applying adjustment factors AADT can be estimated using regression models, artificial neural networks and spatial statistics models.

Xia et al., [14] and Zhao et al., [15] performed multi-variate regression analysis to estimate AADT using spatial data. socio-economic variables and road characteristics were applied to the multi-variate regression analysis and found that the applied variables affect AADT. A spatial regression analysis was used by Eom et al., [16] and Heo et al., [17] to estimate AADT. Eom et al. [16] estimated the parameters of variogram using Euclidean distance in the application of spatial regression analysis (generalized kriging method). Instead of Euclidean distance Heo et al. [17] applied the shortest path to estimate the parameters of variogram which resulted improvement in accuracy of estimated AADT. Spatial statistics models (kriging models) were used by Kim [18], Selby et al., [19] and Ha et al., [12] estimate AADT. Traffic volume of nearby roads and traffic volume of the previous year were used as secondary variables in Kim's and Ha et al. studies respectively. These methods depends on the previous year traffic data, the present year data is not useful for estimation of AADT.

In the present study, traffic surveys were conducted for a week continuously which includes the daily traffic variations of weekdays and weekends days. The seasonal traffic variations were taken care by traffic seasonal variation analysis.

### 3.1. Seasonal Variation Factor (SVF)

The traffic on any corridor varies day to day and season to season in a particular year due many reasons like climatic conditions, yield of industries, festival season etc. The Seasonal Variation Factor (SVF) defines the variation of traffic on monthly basis or seasonal basis. The SVF can be found out from the available monthly traffic data of previous year; but alternative methods are required to calculate SVF when the data is not available. In the present study, traffic surveys were done for a duration of one week, so the monthly variation factors were estimated from the fuel sale
data collected from nearby petrol stations. Both the petrol and diesel sales data of previous one year was collected for the analysis. Fuel sales in the month (September) when the traffic surveys were done was taken as base month; to calculate the SVF of the rest of the months of that particular year and the detailed summary of the SVF are presented in Table 1 below.

| Month   | Petrol (kL) | Seasonal Variation Factor | Diesel (kL) | Seasonal Variation Factor |
|---------|-------------|--------------------------|-------------|--------------------------|
| Aug, 2011 | 19.0        | 1.06                     | 88.0        | 1.57                     |
| Sep, 2011 | 18.0        | 1.00                     | 56.0        | 1.00                     |
| Oct, 2011 | 20.0        | 1.11                     | 85.0        | 1.52                     |
| Nov, 2011 | 13.0        | 0.72                     | 41          | 0.73                     |
| Dec, 2011 | 14.0        | 0.78                     | 51          | 0.91                     |
| Jan, 2012 | 16.0        | 0.89                     | 57          | 1.02                     |
| Feb, 2012 | 16.0        | 0.89                     | 47          | 0.84                     |
| Mar, 2012 | 17.0        | 0.94                     | 45          | 0.80                     |
| Apr, 2012 | 19.0        | 1.06                     | 50          | 0.89                     |
| May, 2012 | 20.0        | 1.11                     | 52          | 0.93                     |
| Jun, 2012 | 18.0        | 1.00                     | 59          | 1.05                     |
| Jul, 2012 | 16          | 0.89                     | 58          | 1.04                     |

The selection of SVF depends on the type of the vehicle. The SVF obtained from the petrol sales data was used for the estimation of two wheel vehicles as they consume only petrol. All the goods vehicles and buses consume diesel so the SVF obtained from the diesel sales data was used for the estimation of the same. But the cars run with petrol and diesel. So the average SVF obtained from the petrol and diesel sales data was used for the estimation of cars.

3.2. Passenger Car Units (PCU)
Traffic contains different types of vehicles flowing with different speeds and different space consumptions. The estimation of this traffic requires a common unit to represent all the vehicle...
types flowing in the corridor. Passenger Car Unit (PCU) is a metric unit to measure the total traffic flowing through the corridor in terms of one single passenger car unit. The conversion of different vehicle modes to PCU requires a conversion factor which depends on rate of flow of that particular vehicle type.

Gecchele et al.,[20] proposed fuzzy set theory and tried to represent the fuzzy boundaries of road groups and uncertainty measures to address the difficulty of classifying a particular type of vehicle into groups in the given road section. However, the conversion factors used for the present study are tabulated below (IRC 64: 1990 [21]).

**Table 2: Passenger car unit conversion factors of different vehicle types. [21]**

| Passenger vehicles | PCU factor | Goods vehicles | PCU factor |
|--------------------|------------|----------------|------------|
| Bike               | 0.5        | LCV            | 1.5        |
| Auto               | 1          | Mini LCV       | 1          |
| Car/Jeep/Tatamagic| 2          | 2 Axile / 3Axle| 3          |
| Bus                | 3          | Multiaxile     | 4.5        |
| Minibus            | 1.5        | HEM            | 4.5        |
| Cycle              | 0.5        | Tractor        | 1.5        |
| Cycle rickshaw     | 2          | Tractor with trailer | 4.5 |

### 3.3. Calculation of ADT and AADT

The traffic analysis was carried out using one-week data collected at selected location in the corridor. The data was collected in various classes of goods and passenger vehicles as detailed in Figure 3. The data was collected on hourly basis; continuously, for one week. The average hourly vehicular traffic of one-week is depicted in Figure 3. From the average hourly vehicle data, it was observed that the total traffic at night was less compared to day time and goods traffic was more than the passenger traffic at night.

**Fig. 3: Average hourly vehicle traffic calculated from one-week data.**

The analysis was done using MATLAB to calculate each component of the analysis. ADT and AADT values of the selected location of year 2013 were calculated as illustrated below: [22]
The Average Daily Traffic (ADT) was calculated using the equation (1),
Here, \( C_{ijk} \) = Number of vehicles of \( i^{th} \) vehicle type, \( j^{th} \) hour and \( k^{th} \) day
\( ADT_i \) = Average Daily Traffic if \( i^{th} \) vehicle type

\[
ADT_i = \frac{1}{7} \left( \sum_{k=1}^{24} \left[ \sum_{j=1}^{7} C_{ijk} \right] \right) \quad \ldots \quad (1)
\]

The Annual Average Daily Traffic (AADT) was calculated using the equation (2),
Here,
\( W_{PCU_i} \) = Weight factor of \( i^{th} \) vehicle type to convert into passenger car units
\( W_{SVF_{ij}} \) = Weight factor of \( i^{th} \) vehicle type and \( j^{th} \) month to consider the seasonal variation
\( n \) = Number of vehicle type data collected
\( ADT_i \) = Average Daily Traffic if \( i^{th} \) vehicle type
\( AADT_{Total} \) = Total AADT in passenger car units

\[
AADT_{Total} = \frac{1}{12} \left( \sum_{j=1}^{12} \left( \sum_{i=1}^{n} W_{PCU_i} W_{SVF_{ij}} ADT_i \right) \right) \quad \ldots \quad (2)
\]

4. Results
The comparison of ADT and AADT is shown in Figure 4. The calculated ADT is less compared to the estimated AADT, this is due to the variation of traffic in different months. The ADT calculations does not include the seasonal variation effect, ADT purely depends on the observed data in that particular week, the analysis may go wrong if the observed data is abnormal due to disturbances in local activities. So to estimate the AADT analysis of seasonal traffic variations are very important.

![Fig. 4: Comparison of ADT and AADT at the selected location of the corridor.](image)

Gujarat Infrastructure Development Board along with LEA Associates South Asia Pvt. Ltd., New Delhi had conducted traffic surveys in the year 2007 at a location 15 km away from the present point of study of the same corridor (NH 8A) [23]. They determined the AADT of the year 2007 by conducting surveys of one week duration and estimated the future AADT till the year 2040 (Figure 5). From the projected AADT of 2007 traffic has reached 33605 PCUs in 2012 which is very
closer to the estimated AADT obtained (34632 PCUs) from the present study.

![Graph](image)

**Fig. 5**: Estimated AADT from the year 2007 traffic data (Gujarat Infrastructure Development Board) [23].

5. **Conclusions**

By comparing the AADT estimated from 2007 traffic data by Gujarat Infrastructure Development Board (35424 PCU in 2013), the obtained AADT from the present analysis (34632 PCU) is having good aggregation.

The day time total traffic is more compared to night time traffic but the goods traffic is more at night time compared to passenger traffic in the present study area.

From the estimated ADT and AADT, it is concluded that the seasonal effect is more on the traffic in the present study area.

Data can be used to predict the future AADT which is useful to calculate the revenue can be generated from that particular corridor.

**Notations/abbreviations**

AADT = Annual Average Daily Traffic  
ADT = Average Daily Traffic  
AHVT = Average Hourly Vehicle Traffic  
LCV = Light Cargo Vehicle  
PCU = Passenger Car Unit  
SVF = Seasonal Variation Factor

**References**

[1] Giuseppe Grande, Steven Wood, Auja Ominski and Jonathan D Regehr 2017 *Transportation Research Record: Journal of the Transportation Research Board* 2644 30–38.

[2] Massimiliano Gastaldi, Riccardo Rossi, Gregorio Gecchele and Luca Della Lucia 2013 *Elsevier Procedia - Social and Behavioral Sciences* 87 279 – 291.

[3] David Albright History of estimating and evaluating annual traffic volume statistics technical report *Transportation Research Record* 1305.

[4] Ming Zhong, Ehsan Bagheri and Jim Christie 2012 *Elsevier Procedia - Social and Behavioral Sciences* 43 607 – 617.

[5] Federal Highway Administration (FHWA) *Traffic Monitoring Guide* 2013.

[6] Traffic Data Collection and Analysis 2004 *Roads Department, Ministry of Works and Transport Roads Department, Private Bag 0026, Gaborone, Botswana.*

[7] Nale Zhao, Tongyan Qi, Lei Yu, Juwen Zhang and Pengpeng Jiang 2014 *Elsevier Procedia - Social and Behavioral Sciences* 138 632 – 640.
[8] Jung-Ah Ha and Ju-Sam Oh 2014 *Journal of Emerging Trends in Computing and Information Sciences* 5(7)
[9] Joe Flaherty 1993 *Transp. Res. Rec.* 1410 93-99.
[10] Lee S J, N C Baek and H J Kwon 2002 *Journal of Korean Society of Transportation* 20(6) 59-68.
[11] Ha J A and S C Oh 2012 *The Journal of the Korea Institute of Intelligent Transportation Systems* 11(2) 10-20.
[12] Ha J A, T Y Heo, S C Oh and S H Lim 2013 *The Journal of the Korea Institute of Intelligent Transportation Systems* 12(1) 1-14.
[13] Lim S H and J S Oh 2004 *Journal of Korea Society of Civil Engineers* 24 19-29.
[14] Xia Qing, Fang Zhao, Zhenmin Chen, L David Shen and Diana Ospina 1999 *Transp. Res. Rec.* 1660 32-40.
[15] Zhao F and S Chung 2001 *Transp. Res. Rec.* 1769 113-122.
[16] Eom J K, M S Park, T Y Heo and L Funtsinger 2006 *Transp. Res. Rec.* 1968 20-29.
[17] Heo T Y, M S Park, J K Eom and J S Oh 2007 *The Korean Journal of Applied Statistics* 20(3) 459-473
[18] Kim H Y 2010 *Journal of the Korean Association of Geographic Information Studies* 13(4) 138-147.
[19] Selby Brent and Kara M Kockelman 2011 Spatial Prediction of AADT in unmeasured locations by universal kriging the 90th Annual Meeting of the Transportation Research Board
[20] Gecchele G, Rossi R, Gastaldi M and Kikuchi S 2012 *Transp. Res. Rec.* 2308 148-156.
[21] IRC 64: 1990: guidelines for capacity of roads in rural areas
[22] Giuseppe Grande, Steven Wood, Auja Ominski, and Jonathan D Regehr 2017 *Transportation Research Record: Journal of the Transportation Research Board* 2644 30–38.
[23] Manual of specifications and standards for six laning of national highways through public private partnership, *Department of Road Transport and Highways*, Government of India 2008