Estimation of Average Daily Traffic (ADT) Using Short-Duration Volume Counts

M.D.D.V. Meegahapola¹, R.D.S.M. Ranamuka¹ and I.M.S. Sathyaprasad¹
¹Department of Civil Engineering
Faculty of Engineering
University of Peradeniya
Peradeniya
SRI LANKA
E-mail: dilaaashani@gmail.com

Abstract: The average daily traffic (ADT) is utilized as an important basic data in transportation and road sector to predict the future service level of the road based on the planned traffic volume and to determine the geometry of new roads. As the installation of traffic counters to obtain long duration volumes like ADT is expensive, carrying out a short duration survey and extrapolate the volumes to ADT would be more economical. Use of “Expansion Factor Method” to extrapolate short duration volumes to ADT will be discussed in this research. The analysis was carried out using 148 count stations located at national AA roads, dividing them into three categories based on their flow variations. The expansion factors for 1h, 2h, 3h, 4h, 5h and 6h durations and the best time interval to carry out the survey for each time duration were found. Using 37 locations the results obtained from the analysis were validated and the comparison between the actual ADT and the calculated ADT shows the results from the research are satisfactory.

Keywords: Average daily traffic, ADT, Short duration volume count, Expansion factors

1. INTRODUCTION

Estimates of annual average daily traffic (AADT) volumes are important in the planning and operations of state highway departments. These estimates are used in the planning of new construction and improvements of existing facilities, and, in some cases, in the allocation of maintenance funds. It is, therefore, important that any method used in obtaining the estimates provide data of sufficient accuracy for the intended use. This importance of having reliable and current data on traffic volumes at hand is generally recognized, and over the years data collection programs have tended to expand. This expansion has led to huge amounts of money being spent annually for the collection and analysis of traffic data. Renewed efforts are, however, now being made to reduce the annual expenditure on traffic counts while at the same time maintaining the desired level of accuracy.

The annual average daily traffic (AADT) is utilized as an important basic data in transportation and road sector. It predicts the future service level of the road based on the planned traffic volume and determines the geometry of new roads. The planned traffic volume serves as the basis of road planning, when AADT is used. In this regard, accurate calculation of AADT is required to construct the roads economically and facilitate traffic flow, while maintaining an appropriate level of traffic service.

The most accurate method for obtaining the AADT of a roadway segment is to install an Automatic Traffic Recorder (ATR) which can provide continuous traffic count coverage at selected locations with some sensor devices such as inductive loops and microwave radar sensors to count the total volumes continuously. However, as the installation and maintenance of permanent counters are expensive, the number of permanent counters is limited. An alternative approach to estimating AADT is to use portable counts, also called short-term, seasonal, or coverage counts, with different types of portable devices such as pneumatic road tubes and microwave radar sensors. The collected short-term volumes on the interested roads are then used to calculate Average Daily Traffic (ADT)
2. LITERATURE REVIEW

Three methods of estimating average daily traffic, named Expansion Factor Method, Regression Analysis and Neural Network Method were identified.

2.1. Ratio/Expansion factor Method

There are two conventional methods for estimating AADT from short period traffic counts: One of the earlier used methods was raised by Philips and Blake (1980). Phillips and Blake firstly defined a short period count as one continuous count of traffic at a site for a period of less than 24 hours. A two-stage process is utilized to estimate a daily and an annual total. The process for the expansion is based on a ratio method where the expansion factors are expressed as a ratio of traffic flows. Traffic data collected at the count stations provide traffic information on a monthly basis. This method is rather simple in computation and is easily understood and applied.

2.2. Regression Analysis

Another frequently used method for estimating AADT from short period counts is made use of the regression analysis. For most of the regression analyses, the average relationship between the dependent variable and the independent variables is assumed to be linear. A linear function is used because it is mathematically simple, and yet still provides an approximation to the real-world relationship that can be transformed to linear function. A simple regression equation is

\[ y = A + Bx \] (1)

where y is the estimated value of the dependent variable (AADT), x is the short period count at the selected station, A and B are the regression coefficients. Erhunmwensee (1991) compared the results between Phillips and Blake’s method and regression analysis approach and found that the regression analysis approach has better performance in terms of accuracy than Phillips and Blake’s method for the estimation of AADT from short period counts.

2.3. Neural Network Method

Neural networks are information-processing structures that consist of many simple processing elements (or “neurons”) with dense parallel interconnections. Each neuron can receive weighted inputs from many other neurons and can communicate with its outputs, if any, to many other neurons. Information is thus represented in a distributed fashion, across massive weighted interconnections. Neural networks make use of imperfect data, but do not need pre-determined formulae or rules. To implement a neural network model for parameter estimation, a set of samples is repeatedly presented to the network during a “training session”, and the system is supported to learn the relationship between the input and the desired output data.

3. METHODOLOGY

3.1. Introduction to the Expansion Factor Method

Among the methods of estimating ADT/AADT from short duration counts, what will be used in this study is “Expansion Factor Method”. This is because the data availability and what the final output will need to be, according to the research objectives. This is a simple method and the analysis is easy when compared with the other methods. These expansion factors are used to extrapolate short duration volume counts to Average Daily Traffic. Expansion factors are calculated considering time durations 1h, 2h, 3h, 4h, 5h and 6h. Also the time interval changes within the day. As an example for
1h time duration, the intervals would be 00.00 – 01.00, 00.15 – 01.15, 00.30 – 01.30 etc. and for 2 hour intervals; 00.00 – 02.00, 00.15 – 02.15, 00.30 – 02.30 etc. The expansion factor is expressed as a percentage of the volume of a particular time interval to the total volume during 24 hours.

\[
\text{Expansion Factor} = \frac{\text{Volume of a particular interval}}{\text{Total volume over 24 hours}} \times 100
\]  

(2)

3.2. Collection of Data

The raw data files (243 number) were collected from Road Development Authority. The files were having the extension ‘.ec0’ and needed to be converted into analyzable data. The MetroCount software was needed to be purchased from the provider and that software was used to obtain 15 minute interval counts. The count reports obtained from the software were exported into ‘.txt’ extension files. The traffic count data obtained at consecutive days were available for few days of a week or sometimes for few weeks in the count reports. So using a java program, the text files with available data were exported into excel sheets. The program was written only to extract the data taken on Wednesdays. If Wednesdays are not available, the data taken on Tuesdays and Thursdays were extracted. There were few files which didn’t contain any of these days’ data and some files had null data, may be because of an error in setting up the pneumatic tube detector. Some raw data files were unsigned and traffic data cannot be extracted from these unsigned files. Those were mailed to the MetroCount support unit and signed into ‘regular’. Traffic data taken at the same location, but in different years were available and the data taken at the latest year were used for analysis and validation. So among the 243 number of raw data files only 185 were useable for the research.

3.3. Analyzing the Data

Traffic count data from 148 count stations (80% of the total) were analyzed. 15 minutes traffic volumes for one day (24 hour period) were available for all stations. The expansion factors relevant to each time duration and time interval for every count station were calculated. When considering one count station, for each time duration there are 96 time intervals, hence 96 expansion factors.

The following shows an example for the short duration volume counts calculation,

Consider the AA026 road location at 98km post in Ampara district. The short duration volume counts for the time interval of 00.00 – 03.00 for the above count station are given in Table 1

Table 1 Short duration volume counts calculation for location 98km post at AA026 road

<table>
<thead>
<tr>
<th>Time</th>
<th>Traffic Volume</th>
<th>Short Duration Volume Counts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1hr</td>
</tr>
<tr>
<td>00.00 - 00.15</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>00.15 - 00.30</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>00.30 - 00.45</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>00.45 - 01.00</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>01.00 - 01.15</td>
<td>4</td>
<td>17</td>
</tr>
<tr>
<td>01.15 - 01.30</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>01.30 - 01.45</td>
<td>7</td>
<td>16</td>
</tr>
<tr>
<td>01.45 - 02.00</td>
<td>8</td>
<td>21</td>
</tr>
<tr>
<td>02.00 - 02.15</td>
<td>5</td>
<td>22</td>
</tr>
<tr>
<td>02.15 - 02.30</td>
<td>2</td>
<td>22</td>
</tr>
<tr>
<td>02.30 - 02.45</td>
<td>6</td>
<td>21</td>
</tr>
<tr>
<td>02.45 - 03.00</td>
<td>1</td>
<td>14</td>
</tr>
</tbody>
</table>

The total volume count from 00.00 to 01.00 = (2+8+2+3) =15
The total volume count from 01.00 to 03.00 = (4+2+7+8+5+2+6+1) =35

The same traffic flow is assumed to be repeated in the following day too. So a circular calculation was done using excel equations for the completeness of the calculation of the expansion factors. As an
example the first value in the 1h short duration volume counts column which is 13, is the short duration count from 23.15 to 24.00 of the previous day plus the short duration count from 00.00 to 00.15 in that particular day. But as we have assumed that the daily flow variation repeats in the next day, flow from 23.15 to 24.00 of the previous day can be taken as that of the particular day which we consider.

The following shows an example for the expansion factors calculation,

Consider the AA026 road location at 98km post in Ampara district. Consider 2h time duration and the time interval of 01.00 – 03.00,

\[
\begin{align*}
\text{Average Daily Traffic of the count station} & = 1382 \\
\text{Short Duration Traffic volume} & = 35 \\
\text{Expansion Factor} & = \frac{\text{Short Duration Count} \times 100\%}{\text{Average Daily Traffic}} \\
& = \frac{35 \times 100}{1382} \\
& = 2.532562
\end{align*}
\]

Traffic volume within the time intervals for one day (24 hour period) and the expansion factors relevant to each time duration for every count station were calculated separately. After categorizing the count stations, average expansion factors were needed to be calculated for 1 hour, 2 hour, 3 hour, 4 hour, 5 hour and 6 hour intervals within each category.

### 3.4. Categorizing the Count Stations

The flow profile within a day changes according to the location of the count station. The count stations should be categorized according to the flow variation. For the flow variation to be taken into account quantitatively, the methods/parameters tried were peakiness of the flow profile, time difference between morning and evening peaks, standard deviation of the flow and highest peak (whether the highest peak occurs at morning, evening or mid day). Each method had to be tried to decide whether it gives any relationship between the flow profile and the land use patterns. Among them, the Highest Peak method seemed to have more correlations with the land use patterns. (See Figure 2)

If the highest 1 hour flow occurs between 00.00-10.00 time interval within a day, those count stations were categorized as type 1. If it occurs between 10.00-15.00 time interval, those were categorized as type 2 and if the highest 1 hour flow occurs between 15.00-24.00 time interval, those stations were selected to category 3.

The following graphs show the normalized flow variation of three categories.

![Figure 1](image)

**Figure 1** The normalized flow variation of (a) category 1 (AA033 road 5km post at Gampaha) (b) category 2 (AA010 road 6km post at Kandy) (c) category 3 (AA011 road 90km post at Polonnaruwa)

By looking at Figure 2 below, it can be seen that category 1 (blue colour) stations have more proximity to highly urban cities like Colombo, Gampaha and Kandy. Red colour ones which are in 2nd category,
have near proximity to semi urban towns like Polonnaruwa, Matale, Dambulla etc. The third type can be seen in rural areas.

Figure 2 Count Station Categorization

3.5. Selecting the Optimum Time Interval

The time interval within the day where each time duration should lie to get minimum errors in the expansion factors should be selected. For that the expansion factors of the same category under same time duration were used to find the standard deviation within each time interval. Using the standard deviation values found and by finding the mean of those expansion factor values too, the error was found according to the equation below. The time interval giving the minimum error was selected as the optimum time interval.

\[ \text{Error} = \frac{(\text{Standard deviation of expansion factors})}{(\text{Average of expansion factors})} \times 100 \] (3)

The following table shows the average of expansion factors, standard deviation of expansion factors and the errors for the category 3 and 6 hour time interval.

Table 3 Average expansion factors, standard deviation of expansion factors and errors for 6 hour time interval for category 3

<table>
<thead>
<tr>
<th>Time interval (For 6h duration)</th>
<th>Average of expansion factors</th>
<th>Standard Deviation</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.00 - 17.00</td>
<td>40.577</td>
<td>4.067</td>
<td>10.021</td>
</tr>
<tr>
<td>11.15 - 17.15</td>
<td>40.208</td>
<td>3.710</td>
<td>9.227</td>
</tr>
<tr>
<td>11.30 - 17.30</td>
<td>40.060</td>
<td>3.293</td>
<td>8.219</td>
</tr>
<tr>
<td>11.45 - 17.45</td>
<td>39.991</td>
<td>3.269</td>
<td>8.173</td>
</tr>
<tr>
<td>12.00 - 18.00</td>
<td>39.698</td>
<td>2.689</td>
<td>6.774</td>
</tr>
<tr>
<td>12.15 - 18.15</td>
<td>39.517</td>
<td>2.317</td>
<td>5.863</td>
</tr>
<tr>
<td>12.30 - 18.30</td>
<td>38.972</td>
<td>2.054</td>
<td>5.270</td>
</tr>
<tr>
<td>12.45 - 18.45</td>
<td>38.494</td>
<td>1.968</td>
<td>5.111</td>
</tr>
<tr>
<td>13.00 - 19.00</td>
<td>38.071</td>
<td>2.022</td>
<td>5.311</td>
</tr>
</tbody>
</table>
Table 3 is an extraction of the data from 6h duration, category 3 table and it contains the minimum error value of 5.111 which gives the optimum time interval for 6h duration in category 3 as 12.45 – 18.45. The relevant expansion factor to extrapolate short duration volume count taken from 12.45 – 18.45 to ADT is 38.494.

4. RESULTS AND DISCUSSION

4.1. Results of Categorization

Table 4 Results of Categorization

<table>
<thead>
<tr>
<th>Category</th>
<th>Results</th>
</tr>
</thead>
</table>
| 1        | 67 count stations were found  
Can be identified as locations 20km distance away from highly urban cities like Colombo, Gampaha, and Kandy. Also the cities Kalutara, Matara and Anuradhapura include in this list. |
| 2        | 64 count stations were found  
Can be identified as locations 15km distance away from the towns which were not mentioned in category 1 |
| 3        | 17 count stations were found  
Locations in rural areas which does not fall into either the category 1 or the category 2 |

4.2. Expansion Factors and Optimum Time Intervals

Table 5 Average expansion factors for optimum time intervals

<table>
<thead>
<tr>
<th>Category</th>
<th>Expansion factors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1h</td>
</tr>
<tr>
<td>1</td>
<td>6.031558</td>
</tr>
<tr>
<td>2</td>
<td>5.938514</td>
</tr>
<tr>
<td>3</td>
<td>6.747337</td>
</tr>
</tbody>
</table>

Table 6 Optimum time intervals

<table>
<thead>
<tr>
<th>Category</th>
<th>Optimum Time Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1h</td>
</tr>
<tr>
<td>1</td>
<td>11.00 - 12.00</td>
</tr>
<tr>
<td>2</td>
<td>09.45 - 10.45</td>
</tr>
<tr>
<td>3</td>
<td>13.15 - 14.15</td>
</tr>
</tbody>
</table>

4.3. Validation

Among the total 185 count stations, 20% (37 stations) were used for validation. These stations were categorized according to the location. ADT was estimated using the relevant expansion factors (Table 5) corresponding to the optimum time interval (Table 6). The calculated ADT values were compared with the actual ADT to find out the error.

The error percentages obtained for each time duration in all 3 categories were averaged and plotted in Figure 3.
4.4. Discussion

Figure 3 shows the variation of the error percentage with the increase of short time duration for the three categories. For the 2nd category, the minimum error would be given by 2h duration counts so 2h may be the optimum short time duration for that category. It can clearly be seen that for the 3rd category, the error percentage drastically reduces for 2h duration. So for the 3rd category, doing a survey for 2 hours may be the optimum. For the 1st category, 3h or 4h durations may be the optimum because their error percentage has dropped down in a higher value when the short time duration is increased by 1h.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

It is very tough task to get solid relationships between the actual vehicular patterns and the statistically calculated values because the trip making characteristics are decided by human behaviors. Although the categorization of the locations was based on the highest peak which was the most suitable option, it also seems to have some issues with it as some locations categorized as urban have rural land use characteristics and vice versa. As the categorization of the locations was one of the four objectives of this research, the intention was to not to go deeper in this single objective. But a further study can be carried out to find these relationships more deeply, so the objective of classifying the count stations can be achieved without much of complications. Except for this objective, the other objectives of the research that are,

- To decide the suitable time durations for the short count
- To select the optimum time interval of the day for each time duration
- To calculate the relevant expansion factors for each time duration
were successfully achieved.

5.2. Recommendations

The categorization of the count stations can be fine tuned with more input data. Collecting more land use data near the count stations and formulating a list of parameters for identifying similarities between the categories may lead to give good results in the categorization procedure. This needs complex and deeper data collection and analysis and can be done as a separate research.
6. ACKNOWLEDGEMENT

We take this opportunity to express our sincere gratitude to all the people who gave their supportive hands in carrying out this research. We would like to thank our supervisor Dr.I.M.S.Sathyaprasad and our panel members, Prof. Ranjith Dissanayaka, Dr.Hemalie Nandalal and Dr. J.A.S.C. Jayasinghe for the guidance given throughout the time showing us the correct path to go. We would like to acknowledge the institution RDA, Mrs. Namalie Siyambalapitiya (Director- Planning - RDA) and other officials from RDA who helped in providing us with the traffic data, Mr. Dave Brewer and Mr. John Holder from MetroCount technical support unit for the assistance given, Mr. S.D.T. Guruge and Mr. Y.M.P.N.Lankathilaka for preparing the java software for exporting traffic volume data to excel.

7. REFERENCES


