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ESTIMATING AVERAGE DAILY TRAFFIC USING ALTERNATIVE METHOD FOR SINGLE CARRIAGEWAY ROAD IN SOUTHERN REGION MALAYSIA

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ABSTRACT

Average Annual Daily Traffic (AADT) and Average Daily Traffic (ADT) are two parameters that are commonly required by traffic engineers and road designers to design and analyse the traffic operational performance of a road segment. In Malaysia, ADT is normally used to forecast the volume of traffic in the design year as well as to design the pavement thickness. Basically, ADT can be generated using expansion factor estimates from Peak Hour Volume (PHV). Current practice in Malaysia uses an expansion of 10% to estimate ADT from PHV. This paper discusses the results of a study carried out to establish a model for estimating ADT using PHV for single carriageway road. The 24-hours traffic data were collected at 9 sites in the districts of Johor, Malaysia for the period of 14 days. The 7-days data were used to establish the model and the other 7-days data were used to validate the model. For validation purposes, the absolute percent error (APE) for each estimate of ADT obtained from the model was calculated and compared with observed ADT. The statistical test at 95% confidence level was conducted to determine the significance difference between the ADT from actual data and the estimate ADT from model. The result shows that a power-formed trend line ($y=ax^b$) suits to the observed data with the coefficient of determination of about 0.90. Validation result shows that the ADT for the model has lesser APE compared with the ADT estimated using the factoring approach. A comparison of both estimated and actual ADT values using t-Test shows that there is no significant difference between the estimated ADT using models and the actual ADT. However, the ADT estimated using the expansion factor of 10% shows the vice versa. Such a finding implies that the model obtained from this study predicts ADT accurately than the current practice.

Keywords: average daily traffic, expansion factor, peak hour volume, single carriageway road, traffic volume.

INTRODUCTION

Technical evaluation and justification is one of the priority requirements in road project approval because such a project would involve a substantial amount of financial allocation. One of the important inputs in technical evaluation is traffic data. The higher demand of traffic volume the higher the viability of a road project. In practice, the future traffic demand is forecasted from past year traffic data. Therefore, an excellent record system and good trend of data will lead to the accuracy of estimating or forecasting task. There are various types of data, such as Average Annual Daily Traffic (AADT), Average Daily Traffic (ADT), Vehicle Classification (VC), Peak Hour Volume (PHV), travel time, speed, headway and gap, used in traffic analysis. All types of data would give a different interpretation and function. It depends on the traffic engineer or road designer on how to select the best type of data to achieve the objectives of the analysis. AASHTO Guidelines [1] for Traffic Data Programs listed several functions of the traffic data; ensuring safety and mobility to the traveling public, supports capital investment programs and budgets, as well as effective design and maintenance programs. AADT and ADT are two parameters that are commonly required by traffic engineers and road designers to design and analyse the traffic operational performance of a road segment. In Malaysia, the AADT based on annual traffic census exercises is not available due to expensive equipment required and high cost involved in data collection. Therefore, ADT is normally used to forecast the traffic volume as well as to design the pavement thickness. Such an approach relies on the accuracy of the ADT. In general, ADT is obtained from manual classified traffic count (MCC) which is usually carried out twice in a year. For each exercise, the counting is done for 7 consecutive days at the selected road segment. The second data collection exercise is carried out six month after the first exercise. In cases where ADT is not available, the factoring approach based on the PHV is used to estimate ADT.

In the factoring approach the current Malaysian practise uses an expansion factor of 10% to expand the PHV into ADT. The origin of the factor of 10% is not clear but it appears to be taken directly from the equation of maximum hourly capacity (pcu/h) expansion to daily capacity (pcu/day) [2]. The equation was established almost 30 years ago and never been checked for the accuracy. Since ADT is used for traffic volume forecasting and design pavement thickness, there is a necessity to review the approach. Therefore, this paper describes the results of a study carried out is to review and establish an approach to estimate the ADT for single carriageway roads.

METHODS TO ESTIMATE AADT AND ADT

The Federal Highway Administration Traffic Monitoring Guide (FHWA) [3, 4] conducted the survey to obtain traffic data using portable counters for a few days as Short Period Traffic Counts (SPTC) or at least one

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week as Seasonal Traffic Counts (STC) per year, and Automatic Traffic Recorders (ATR) which give Permanent Traffic Counts (PTC). The factoring approach then is use to estimate the AADT using the ADT from Short-Term Traffic Count (STTC) for the road segment in the same group of PTC or ATR.

Canadian Highway Agencies [5, 6] used a regression-based approach to convert ADT into AADT. This method requires short term data traffic on the particular road segment to compare with all existing PTCs at the same periods. Then, the regression analysis was used to derive the coefficient of determination, R2 values. The traffic data from PTC with highest R2 value was selected to estimate the AADT in the next step. The regression-based approach was reported to have less accurate AADT compared with factoring approach due to data collected in different seasons. The accuracy can be improved by using the data collected for every season as an average.

In Malaysia, the Highway Planning Unit, Ministry of Works (HPU) conducted Manual Classified Count (MCC) for seven consecutive days at selected census points twice in a year. The time gap between the first and second data collection exercises is normally six month. There are 554 survey stations all over located on Federal and State Roads, Single and Dual Carriageway Roads [5]. The data obtained from each of the survey station is use to determine the PHV, ADT and Vehicles Composition (VC). The traffic composition is divided into six types of class, namely Class 1: Motorcars and Taxis, Class 2: Small Vans and Utilities (light 2-axles), Class 3: Lorries and Larges Van (heavy 2-axles), Lorries with 3-axles and above, Class 5: Buses and Class 6: Motorcycles and Scooters [5]. There are two types of traffic counting conducted, i.e. 24-hours and 16-hours traffic counts. The 24-hours traffic count only available at 60 survey locations out of 554 sites. The remaining is the 16-hours count. Therefore, modification was done by practitioners to estimate ADT based on Equation. (1) [2]:

$$C = 10c \tag{1}$$

Where C refers to daily traffic capacity (pcu/day) and c is maximum hourly capacity (pcu/hour). The initial use of Equation. (1) focuses on the calculation of daily traffic capacity. The modification, however, replaced daily traffic capacity, C with ADT; and maximum hourly capacity, c as PHV, resulting in ADT equals to 10PHV.

METHODOLOGY

A similar pattern of traffic flow and function of road segment will give the most accurate estimate ADT [4]. The traffic data used in this study were obtained for the year 2012. The 7 days data collected in April and the other 7 days data which was collected in September was used in the analysis. Data collected in April was used to develop the model while data collected in September was used to validate the model. This study also uses PHV data as the main input to generate the ADT.

Two approaches were considered in the model development process, i.e. (1) expansion factor approach, and (2) trend line curve fitting approach. For the trend line approach, three possible forms of the trend line were adopted, i.e. linear regression, parabolic curve, and power-formed trend line. The coefficient of determination, R^2, and the absolute percent error (APE), as suggested by Ming Zhong [4], were used to evaluate the significant and accuracy of each model developed. APE was computed using Equation. (2).

$$APE(\%) = (|EstADT - ActADT| x100)/ActADT \tag{2}$$

where,
EstADT = Estimated ADT
ActADT = Actual ADT

The estimates of ADT were then compared with corresponding actual ADT using the data observed in September 2012. The t-test was used to determine the significant difference between the estimated and actual ADT data.

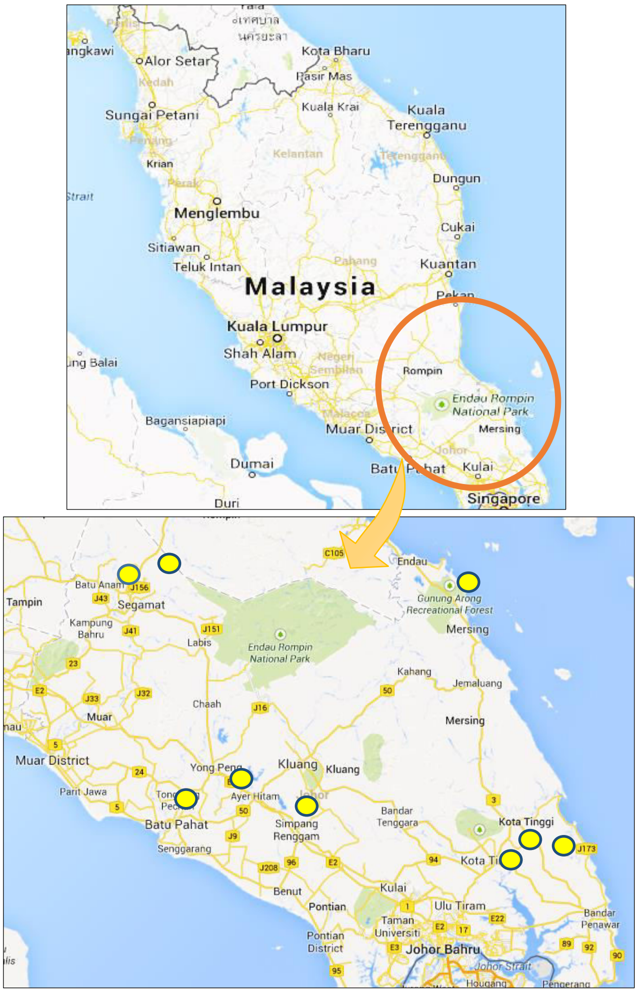

Figure-1. Study area and selected survey stations location in Southern Region Malaysia.

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Table-1. The survey location description.

No	District	Survey station ID	Road ID	Description of location	April 2012		September 2012	
					ADT [veh/day]	PHV [veh/hr]	ADT [veh/day]	PHV [veh/hr]
1	Batu Pahat	JR101	FT05	Johor Bahru-Batu Pahat-Muar	18,352	1,202	19,005	1,353
2		JR104	FT24	Johor Bahru-Batu Pahat-Muar	20,754	1,484	31,376	2,373
3	Kluang	JR305	FT01	Johor Bahru-Ayer Hitam	17,126	1,258	17,169	1,339
4	Kota Tinggi	JR403	FT92	Johor Bahru-Pengerang	18,153	1,231	16,498	1,376
5		JR404	FT03	Johor Bahru-Kota Tinggi	26,939	1,922	24,881	1,839
6		JR409	FT03	Johor Bahru-Kota Tinggi	14,720	1,037	15,297	1,166
7	Mersing	JR501	FT03	Johor Bahru-Endau	17,264	1,175	15,863	965
8	Segamat	JR801	FT01	Johor Bahru-Segamat-Batu Enam	17,534	1,370	19,709	1,363
9		JR802	FT12	Lebuhraya Tun Abdul Razak	16,993	1,299	16,540	1,294

As far as the sites are concerned, this study focused on road segments in the southern region of Malaysia including all the districts in Johor as one group. The road segments considered were the two-lane single carriageway rural roads. In this case, the traffic pattern and function are almost similar. Out of 60 sites, only 9 sites have similar pattern of traffic flow in this region. Figure-1 shows the study area and the locations of the selected survey stations in the southern region of Malaysia. Table-1 summarises the description of the site location and data extracted from the RTVM 2012 [7].

ANALYSIS AND RESULTS

Nine sets of data on April 2012 tabulated in Table-1 were analysed using both approach as mentioned earlier. For factoring approach, the percentage of PHV over ADT were averaged and found that the average is 7.14%. On the other hand ADT equals to 14PHV.

For the second part of the analysis which is the evaluation of best fitted line to represent the relationships between ADT and PHV. Three possible types of relationship were attempted in the curve fitting exercises, i.e. the linear regression model, parabolic model and power-formed model. Figure-2 illustrates the variations of ADT and PHV based on three possible forms of relationships. Table-2 summarises these relationships and the corresponding R^2–values.

As can be seen from Table-2, all three forms of relationship between ADT and PHV have a R^2–value of greater than 0.85 which indicates a very good relationship between the two variables.

Each of these relationships was then validated using the new data set observed at respective sites in September 2012. Table-3 summarises the APE and P-values as a result of the comparisons between each of the estimation models and the actual data. It can be seen that, in general, the power–formed model yields high accuracy of ADT estimates when compared with the other forms of models because the model has the smallest APE value.

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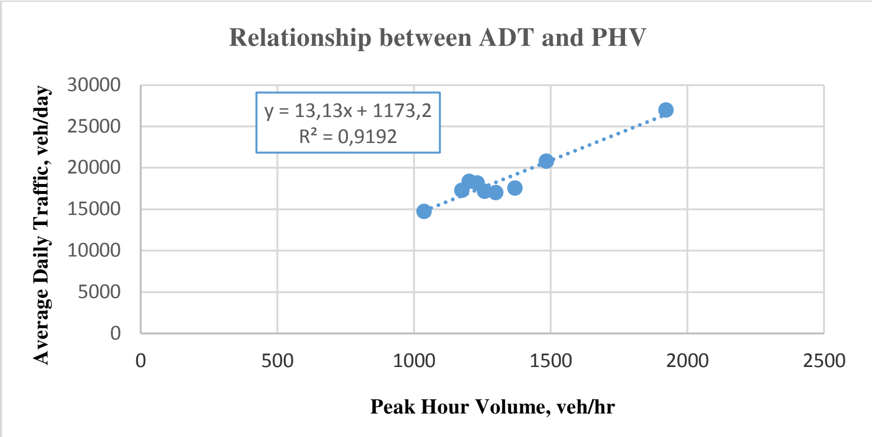
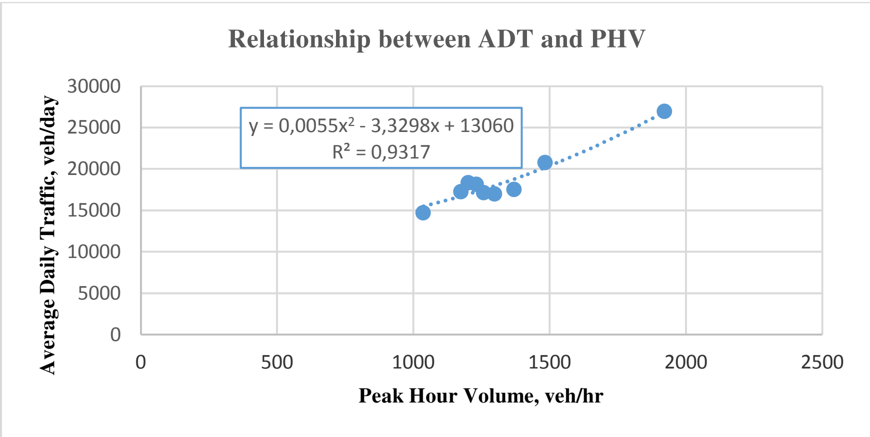
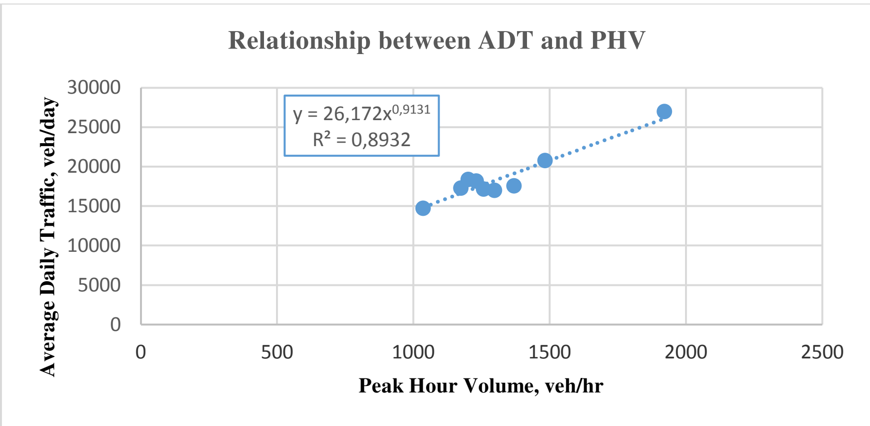


Linear regression trend line



Parabolic trend line



Power–formed trend line

Figure-2(a)-(c). Best-fitted lines of ADT and PHV.

Table-2. Possible relationships between ADT and PHV.

Type	Equation	R^2
Linear Regression	ADT = 13.13PHV + 1173.2	0.9192
Parabolic curve	ADT = $0.0055PHV^2$ - 3.3298PHV + 13,060	0.9137
Power-formed curve	ADT = $26.172PHV^{0.9131}$	0.8932

Table-3. APE and P-value for the comparisons of actual ADT and estimated value.

Approach	**APE [%]**	**Sig.** (P-value)
Previous Expansion Factor (ADT = 10PHV)	25.94	0.000
New Expansion Factor (ADT = 14PHV)	7.77	0.1937
Linear Regression	7.17	0.2121
Parabolic curve	7.76	0.1143
Power-formed curve	6.78	0.2891

The ADT estimated using the new approaches show no significant difference with the actual ADT at 95% confident level with a P-value >0.05. On the other hand, the ADT estimated using the previous expansion factor of 10% is significantly different from the actual ADT data with a P-value <0.05. It appears that the current practice of using an expansion factor of 10% has resulted inaccurate estimates of ADT. This result reinforces the argument put forward earlier that there is a need for the current estimating approach to be reviewed thoroughly. From the analysis, the best mathematical relationship between PHV and ADT for Southern Region Malaysia Two-Lane Single Carriageway Road is in the form of Equation. (3).

$$\text{ADT} = 26.172 PHV^{0.9131} \quad (3)$$

CONCLUSION AND RECOMMENDATION

The proposed alternative approach have better accuracy without imposing any additional cost or change to the current data collection program. However, it should be noted that the model is only applicable for the similar type of road function and similar traffic pattern.

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