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HEAVY VEHICLES SPEED PROFILING ON URBAN EXPRESSWAY: THE CASE OF FEDERAL HIGHWAY

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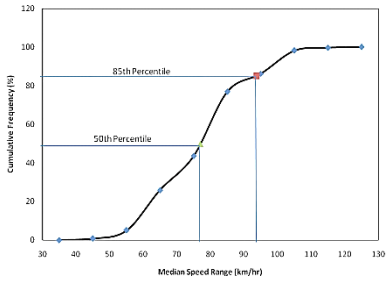
Graphical Abstract



Abstract

The presence of heavy vehicles on expressways will have an impact on the traffic performance. The geometrical design of expressways with the purpose of providing a better performance towards vehicles especially passenger cars, is also a prudent facility to the heavy vehicles, especially when it comes to speed. Though national allowable speed for heavy vehicles has been set, the actual situation may differ according to the general observation. This study attempts to explore the speed distribution of heavy vehicles typical urban expressways in Malaysia with Federal Highway Shah Alam-Kuala Lumpur being the case study. Extensive data was collected through video recording before being abstracted and processed by utilizing the TRAIS software. Then, statistical analysis showing the speed distribution and profiling are presented. The results showed that in average heavy vehicles drive at speed of more than the allowable limit for the determined expressway section. The 85th percentile also indicates that thespecial speed limit of heavy vehicle on expressway is violated and therefore speeding enforcement would be appropriate instead of adjust in posted speed limit.

Keywords: Heavy vehicle, speed, expressway

1.0 INTRODUCTION

Expressways in urban areas of Malaysia consist of a minimum 2 lanes each way to serve the increasing traffic demand. It is reported that 535,113 new passenger cars were registered in Malaysia by the end of 2011 [1]. Road transportation Department [2] reports on the total registered commercial vehicles of 997,649 at the end of 2011. The increase of heavy vehicles (HV) will have a significant impact on the expressway capacity and performance.

By simple definition, HV is known to be a commercial vehicle used for transporting goods and materials [3]. The authority in Australia has a deeper definition of HV which is known as a motor vehicle or trailer of gross vehicle weight (GVW) more than 4.5tonnes [4]. While in Malaysia, no exact definition of HGV have been learned so far yet the authority seems to rely on the term of commercial vehicle and goods vehicle [5].

With more demands due to the development progress, freight transport seems to grow rapidly around the world. The urban areas seem to contribute to the large portion of freight movements. Wright [6] reported that the freight task is predicted to increase by 50% between 2006 and 2020 in the capital cities of Australia. Malaysia is no exception as it is reported that the total volume handled at Port Klang will rise 7.7% to 197.70mil tonnes in 2012, while volume at the Port of Tanjung Pelepas will rise by 8.2% to 130.09mil tonnes. The scenario lead to high frequencies of HV on the road, influencing on the traffic flow. As HV is characterized by the loading, speed, movement behavior, and dimension, they could affect the traffic flow characteristic and

become a main rival to cars ingetting the service of limited road spaces in urban area.

Speed is one of the traffic parameter to influence the car-following pattern involving HV. In Malaysia, regulation has been enforced for HV to drive at the maximum speed of 90km/hr while as for the car, at maximum of 110km/hr on the expressway. However, 90km/hr speed could be achieved by un-laden compared to laden HV due to heavier loads. Though expressway in Malaysia provide the minimum of 2-lanes per direction which allow cars to maneuver and change lane at the presence of HV, the situation is only convenient during low traffic condition.

A certain understanding level of traffic behavior is important due to the growing presence of the HV affecting other road users especially passenger cars which contribute to the largest vehicle group on the expressway. The interactions between cars and HV will give a significant contribution in understanding the fundamental microscopic study of traffic characteristic for microscopic study. Studieson significant interactions between vehicles are essential and would contribute to the capability of microscopic simulations for freeway sections under certain traffic flows [7]. There was also a study on discomfort level for car drivers in the vicinity of HV was introduced to explain more on the interaction between HV and cars [8]. Therefore, this study presents the statistical analysis on the field data set of HVs which is expected to give a better overview on the Malaysian urban expressway traffic condition.

2.0 METHODOLOGY

This study required the main parameter, speed to be collected on site. Speed is generally understood as rate of travel of an individual vehicle measured in km/h, in which is measured as in Eq. (1).

$$v = d/t \quad (1)$$

where,

v = speed
d = distance
t = time

2.1 Field Data Collection

Field study were carried out to collect and analyze all traffic data pertaining to the statistical analysis related to the HV speed profiling. In general, the observation sites selected should be representative of urban expressway road layout and traffic would provide a high proportion of HV.

This study used the video recording method and utilized the TRAIS software which required the video image angle to be as closed to 90^0 from top. Video recording is one of the best method in evaluating traffic movement as the video image could be played repeatedly for the purpose of analysis. Othman [9] explained on the advantages of using video camera recording method. One particular difficulty with the method is in finding a suitable vantage point with good visibility to acquire the data.

As for this study, data collection was conducted at Federal Highway of Shah Alam-Kuala Lumpur route. The former Kuala Lumpur-Klang Road with existing at-grade intersection was replaced by interchanges, then name as Federal Highway, making it as Malaysian first expressway. Federal Highway has been upgraded to from limited access 4-lane to 6-lane toll expressway,with exit number system. Due to its location in the Klang Valley, Federal Highway is considered as one of the urban expressways.

The study mainly focused at the free-flow-speed regime. However, for a systematic evaluation of traffic parameters under range of traffic flows, the data was recorded at 8.00-10.00am, 11.00am-1.00pm and 3.00-5.00pm, during workday. Typical urban expressway in Malaysia especially in Klang Valley, HVs are allowed onto road beginning at 9.30am to 6.30 am, to avoid impact on the traffic congestion. Survey location was of 6-lane expressway, with typical lane width of 3.5m and only one stream observation was considered as shown in Table 1.

Table 1 Location information

Expressway	Federal Highway
KM	14.5
Speed Limit	80km/hr
Stream/Bound	North-Bound
Number of Lanes	6
Lane Width	3.5m
Weather	Dry and Clear
Flow Condition	Non-Congested

Urban expressway data collection is considered hazardous due to high speed allowance to vehicles. The authority did not allow the data collection process to be in the expressway area. Therefore, location with overhead bridges of local road crossing the expressway or pedestrian bridge was chosen and a custom-designed tripod was fabricated to allow the 90^0 angle of video image recorded, as shown in Figure 1.

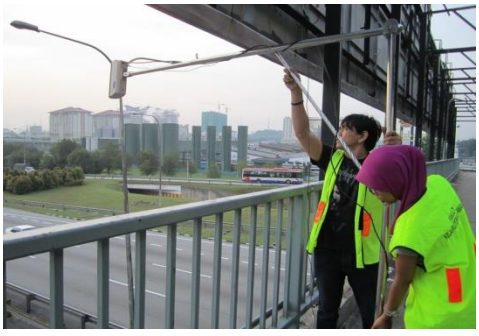


Figure 1 Specially fabricated tripod video camera

Table 3 Descriptive analysis for speed value

Count	Min	Max	Median	Mean	Standard Deviation	Skewness	Kurtosis
3738	43	126	86	82	14.3	0.003	-0.53

2.2 Data Abstraction and Processing

As mentioned earlier, TRAIS video based data analyzer was used to abstract video image and process the data acquired from the video recording. TRAIS is a software which provide an automated virtual line in the video image that is in accordance with real world line marked on the road. The virtual line represents the distance and act as the detection line which is vital to generate the parameters of vehicle length, speed, time headway and time gap.

As the video recording requires for the angle being as close to 90^0, the detection line is in parallel to the viewers eye and reduce the parallax error. Having been tested and complied to the ASTM for the standard error, TRAIS has been recognized by the Highway Planning Unit (HPU) of Malaysia. Figure 2 shows the TRAIS dashboard in the process of extracting the traffic parameter. The green line is the detection line.

Figure 2 TRAIS video based data analyzer dashboard

Vehicle length will allow for vehicle classification to be made and according to TRAIS, there are four classifications of vehicle as shown in Table 2.

Table 2 Vehicle classification according to TRAIS

Class	Classification
1	Cars/Small Vans/Utilities
2	Lorries/Large Van
3	Trucks/Buses
4	Motorcycles

All the data extracted is saved in the Excel spreadsheet and was filtered and sampled accordingly before being analyzed using Minitab 16.0. The parameters generated from TRAIS is mainly time-based.

The speed of each vehicle was computed using the time taken to travel between the two consecutive detection lines and considered as spot speed due to short distance detection line.

3.0 RESULTS AND DISCUSSION

3.1 Descriptive Analysis

A total of 6 hours data collection were done resulting to total counts of HV being at 3738. Class 1 and 4 type of vehicle have been eliminated from further analysis. Determination of HV has included the buses.

Result in Table 3 shows the descriptive statistic of the HV speed. From the result, the minimum speed of HV is 43km/hr and the maximum is 125km/hr. The mean speed is 82km/hr, which indicates generally that the speed limit of the particular determined section of the expressway at 80km/hr is violated.

However, this is quite insignificant to generalize the violation as the speed limit of expressways in Malaysia range from 80km/hr-110km/hr. Furthermore, the maximum speed limit for HV being on the expressway is 90km/hr. Somehow, this might indicate the pattern of driving among HV drivers, as supported by Ossen and Hoogendoorn [10] who reported that HV drivers tend to be more robust in handling their machine as compared to cars' drivers.

Histogram of the speed profile was plotted in Figure 3 which shows that majority of HVs from the data drive at speed of 85km/hr relatively. The graph also indicates that HVs on urban expressways tend to speed more that the allowable national speed limit at 90km/hr.This is likely due to HV comprises of buses as well in which the capability of buses to speed more is higher than trucks and lorries. Driving at more than the allowable speed for HV is kind of hazardous to other road users especially passenger cars and motorcycles.

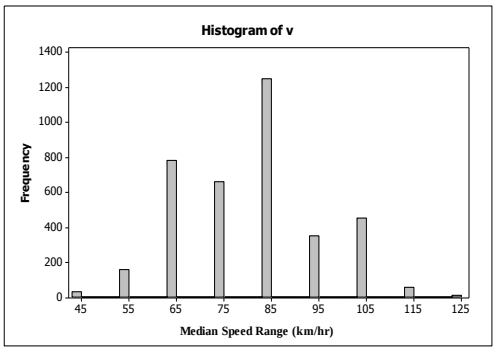


Figure 3 Histogram of median speed range over cumulative frequency

The 85th percentile and 50th percentile analysis was done to evaluate more the speed profile of HVs in compliance with the posted speed limit. 85th percentile is the speed which 85% of the observed vehicles are driving at or below. Figure 4 illustrates the cumulative frequency versus median speed range of the observed HVs which indicates the 85th percentile speed at 94km/hr, 14km/hr more than the actual posted limit of 80km/hr.

According to the 5-mph rules, this 85th percentile result might indicate for speeding enforcement rather than adjustment of posted speed limit. And this is supported by the 50th percentile speed of 77km/hr shown in Figure 4.

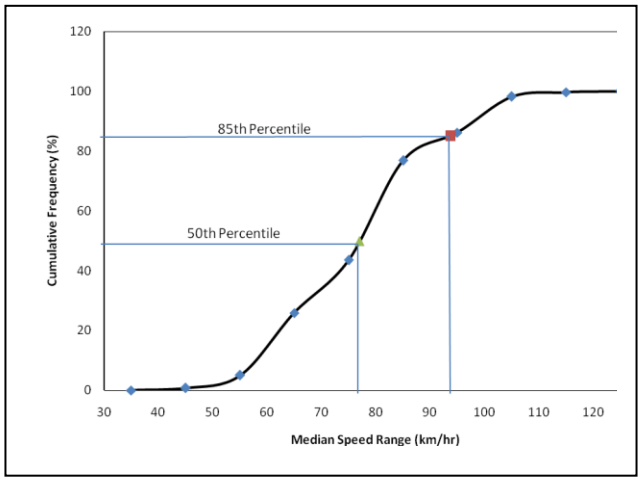


Figure 4 50th and 85th speed percentile

HV is also learned to achieve a very high speed during the period between 9.00am to 1.00pm as shown in Table 1. This is likely due to the period in which, traffic flow is not considered peak anymore, and thus making HV drivers tend to speed easily. Although by regulation, HVs are only allowed onto the expressway starting at 9.30am, the result in Table 4 indicates there are HVs being on the road before 9.30am, driving at the average speed of 73km/hr. However, the regulation does not involve buses which therefore contribute to the number.

Table 4 Descriptive analysis according to time interval

Time Period	Count	Min	Max	Median	Mean
8.00-9.00	111	55	101	77	73
9.00-10.00	913	43	115	88	82
11.00-12.00	820	58	126	90	86
12.00-1.00	579	55	105	85	81
3.00-4.00	610	50	95	81	76
4.00-5.00	705	45	97	79	70

3.2 Statistical Analysis

For further statistical analysis, it is important for the skewness and kurtosis to be checked for the purpose of ascertaining the normality distribution. Skewness is a statistical number that indicates if the distribution is symmetric or not while kurtosis indicates a statistical number that tells us if a distribution is taller or shorter than a normal distribution.

Based on Table 3, the data is assumed to be normally distributed as value of skewness and kurtosis is close to zero. The normal distribution is also supported by the histogram curve fit in Figure 5.

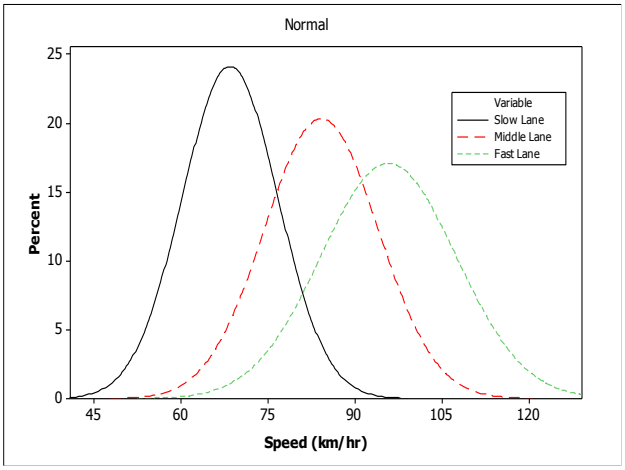


Figure 5 Histogram curve fit for normality distribution

As Federal highway comprises of 3-lanes per way, distribution of HVs on the road is best to be looked at for the significance of comparison of speed. Generally, HVs use the middle lane more than slow lane and fast lane according to Table 5, with the mean speed of 84km/hr. Although the number of HVs being on the fast lane is lower compared to the slow and middle lane, yet it still indicates that HVs have no issue in using the outer lane, though has been banned from doing so. Furthermore, HVs could travel up to the average speed of 96km/hr on the fast lane which is relatively higher than the allowable speed limit at the particular location, and violating the speed limit of HVs.

Table 5 Speed distribution according to lane

Location	HVs Volume	Min (km/hr)	Max (km/hr)	Mean (km/hr)
Slow Lane	1224	43	100	68
Middle Lane	1614	47	116	84
Fast Lane	900	59	126	96

To compare characteristics of HVs mean speed among different lanes, the two sample t-test is often the most appropriate test. However, it is important to ensure that the correct version of the test is being

used (equal variances or non-equal variance). Therefore, F-test was firstly conducted to see the equality of variance. If the variances are not significantly different, the t-test with equal variances assumed can be used. Otherwise, the t-test with equal variances not assumed need to be used. Firstly, the F hypothesis tests with 95% confidence level were utilized to examine whether speed variance of two locations were equal or not. Hypothesis was made as below:

$H_0: \sigma_1^2 = \sigma_2^2$
$H_1: \sigma_1^2 \neq \sigma_2^2$.

Each pair is assumed to have equal variance if $F_{statistical} < F_{critical}$. Table 6 shows the $F_{statistical}$ data after tested. The symbol "*" is to indicate that the $F_{statistical} > F_{critical}$, thus H_0 is rejected and therefore the speed variance between the lanes is not equal.

Table 6 F-test for variance of speed at different lanes

	Slow Lane	Middle Lane	Fast Lane
Slow Lane	-	1.4083*	1.9962*
Middle Lane	1.4083*	-	1.4038*
Fast Lane	1.9962*	1.4038*	-

The t-test was then conducted to look at any significance difference between the average speedof HVs according to lane category. As the F-test shows that the speed variance is not equal between the different lane category, t-test; two sample assuming unequal variance was chosen for further analysis. Hypothesis was made as below:

$H_0: \mu_1 - \mu_2 = 0$
$H_1: \mu_1 - \mu_2 \neq 0$

Null hypothesis is accepted if the $t_{statistical} < t_{critical}$. Table 7 shows the t-test data after tested. The "*" is to indicate that the $t_{statistical} > t_{critical}$, thus H_0 is rejected and therefore the speed mean between the lanes is considered significantly different.

Table 7 t-test result mean speed

	Slow Lane	Middle Lane	Fast Lane
Slow Lane	-	18.9	24.5
Middle Lane	18.9*	-	10.3
Fast Lane	24.5*	10.3	-

4.0 CONCLUSION

Through image processing technique by utilizing the traffic video analyzer software called TRAIS, 3738 samples comprising of HVs were analyzed to provide an understanding of HV speed profiling. Results showed that in average, HV travels at speed of 82km/hr on the Federal Highway which generally violating the particular expressway section speed limit of 80km/hr, but not thespecial HVs speed limitof 90km/hr, for expressway. However, those HVs are able to speed up to more than the allowable HVs speed limit 90km/hr, as shown by the 85th percentile result, at 94km/hr. This situation might indicate a scenario of speeding among HV drivers, which might require a higher enforcement rather than adjustment on the posted speed limit.

From the result, it also shows that HVs tend to speed more during non-peak hour given the situation that HV is only allowed to be on the expressway starting from 9.30am and above. The mean speed between HV occupying different lane categories is also significantly different which indicates that the speeding based on lane category is a common practice among HV drivers.

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References

[1] Malaysia Association of Malay Car Importers and Sellers. 2011. www.pekema.org.my.
[2] Road Transportation Department. 2012. *Statistik Pendaftaran Kenderaan Perdagangan.* http://portal.jpj.gov.my.
[3] Huang W., Li Xu-hong, Ju Peng, He Jie. 2005. Site Survey And Analysis Of Highway Trucks Overloading Status Quo In Anhui. *Journal of Eastern Asia Society for Transportation Studies*. 1-15.
[4] Commonwealth of Australia. 2009. *Road Transport Reform (Heavy Vehicles Registration) Act 1997; Section 2.* Attorneys General Department, Canberra.
[5] Government of Malaysia. 1987. *Road Transport Act 2006.* Malaysia.
[6] Wright, S. J. 2006. *Review Of Urban Congestion Trends, Impacts And Solution.* Traffic Management Systems for Australian Urban Freeways, Prepared by ARRB Consulting for Council of Australian Governments: Canberra.
[7] Toledo, T. and David, Z. 2007. *Modeling The Duration Of Lane Changes.* Transportation Research Board 86th Annual Meeting.
[8] Peeta, S., Zhang, P. and Zhou, W. 2005. Behaviour-Based Analysis Of Freeway Car–Truck Interactions And Related Mitigation Strategies. *Transportation Research Part* B39: 417– 451.
[9] Othman, C. P. 1999. *A Simulation Study Of Speed And Capacity Of Rural Single Carriageway Roads.* PhD Thesis. University of Wales Cardiff, Wales, U.K.
[10] Ossen, S. and Hoogendoorn, S. P. 2009. *Heterogeneity In Car-Following Behavior: Theory And Empirics*. Transportation and Traffic Theory.