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BUSINESS HOURS VS NON-BUSINESS HOURS IN BUSINESS ZONE : IMPACT ON SPEED AND ACCELERATION

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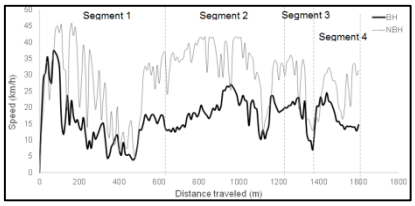
Graphical abstract



Abstract

The main purpose of this study is to assess the impact of business and non-business hours on speed and acceleration of car drivers. Driving profiles from 40 drivers were gathered on site using Global Positioning System (GPS) device during both business and non-business hours. Comparison tests conducted found that during business hours, drivers drove significantly slower than non-business hours. The descriptive analysis conducted also shows that drivers applied 30% higher acceleration during non-business hours. Results from this study confirm that business hours have an impact on the variation of speed and acceleration in business zone areas.

Keywords: Businesss zone, Business hour; non-business hour; speed; acceleration

1.0 INTRODUCTION

In city environments especially in business zones, the behaviour of the driver can be influenced by various factors. This includes the condition of traffic flow, the presence of intersection and pedestrian activities, and road geometric design [1, 2].

Rohani and Buhari [3] highlighted that, factors such as traffic control, number of stops along the road, and personal driver behaviour also can have an impact on driving strategy in an urban street environment that contribute to the variation in speed and acceleration.

In addition, in the areas where traffic calming is implemented, driving speed reduces up to 23% [4]. Ariën *et.al*, [5] conducted a simulator study to examine the impact of traffic calming measures (TCM) on major roads in rural and urban areas. In this study, the researchers investigated how gate construction located at the entrance of the urban area and horizontal curves can have an impact on driving behavior. At gate construction areas, the driver reduces speed shortly before and after the entrance. The speed behavior was also similar at the horizontal curves (road bends) [6]. Although, the gate construction and horizontal curves can improve traffic safety by reducing the speed, however, it can increase acceleration and deceleration that can influence fuel consumption and emission.

A similar impact on acceleration, fuel consumption and emission also can be the result of business zone activities. This is especially when pedestrian movement along the road is high. Drivers may reduce the speed or stop to give way to pedestrians to cross the road [7].

Improper on street parking, especially in city areas can reduce road capacity and cause delays from the stop-start situation in the traffic stream. Vehicle manoeuvres when entering or leaving the parking interrupt vehicular movement on the road. Furthermore, the available road width is reduced to accommodate the parking space [8].

Business zone-related traffic issues can create significant problems in communities, namely the safety of road users. The most obvious cause of traffic conflicts in business zones is the presence of vehicles and pedestrian, who make trips for commercial and economic activities. High volumes of vehicular and pedestrian traffic in these areas during business hours

causes vehicle conflicts and congestion as well as driving-related challenges [9].

In this paper, the differences of speed and acceleration rate control (during braking and accelerating) of the drivers in business zones during two different periods of driving, i.e. business and non-business hour, are presented. The objective of this study was to examine the variation of driving behaviour while interacting with city business activities. The results of this research can be used as an input for improvements to the safety and traffic performance especially in study area.

2.0 RESEARCH APPROACH

Data used in this study were speed profiles observed from four road segments in the business zone of Batu Pahat, Johor Malaysia. All of the road segments are located adjacent to each other (Figure 1). The road geometric characteristics for all segments can be considered similar (road with 3 lanes, one-way traffic flow, availability of on-street parking, 3.0m lane width). The road segments pass through intersections controlled by pre-timed traffic signals. All mentioned characteristics were set as control variable in this study.

Business activities were found to be highest in these study areas because there are business premises such as shoplots, bank and office spaces on both side of the road. From observations, the majority of business activities started at 9.30 a.m. every day and were busy between 10.30 a.m to 4.30 p.m.

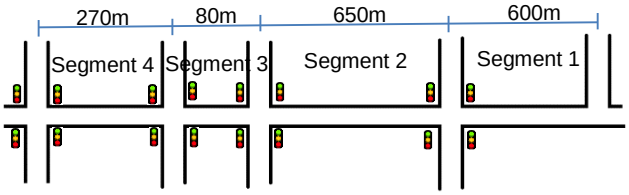


Figure 1 Study road layout

To obtain research speed profiles, 40 drivers were hired and instructed to drive a research car (Perodua Kancil model) for two trips along the study road during both period of business (10.00 a.m – 11.30 a.m) and non-business hours (7.00 a.m. – 8.30 a.m). Drivers' control of speed and acceleration were then recorded using a Global Positioning System (GPS) device for every second. Data was collected during the earlier mentioned period of time and conducted on Tuesday only to control the consistency and quality of data for analysis purposes. Therefore data collection took two months to be completed. Furthermore, to assess the impact of business hours on traffic flow, a preliminary study on Level of Services (LOS) was conducted before driving behaviour data was collected. It was found that LOS observed during 7.00 – 8.30 a.m. and 10.00 – 11.30 a.m. were A and D respectively. From observations, it was found that majority of people comes to this study area for shopping, banking and etc.

All driving profiles were processed and filtered to remove any error that can influence the process of data analysis. This includes a data smoothing process to remove the outliers. After these processes, a final data set consisting of 70 non-business trips and 76 business hour trips was used for analysis. Six trips were removed from the research data due to error of lost GPS signals.

3.0 RESULT AND DISCUSSION

3.1 Comparison of Speed

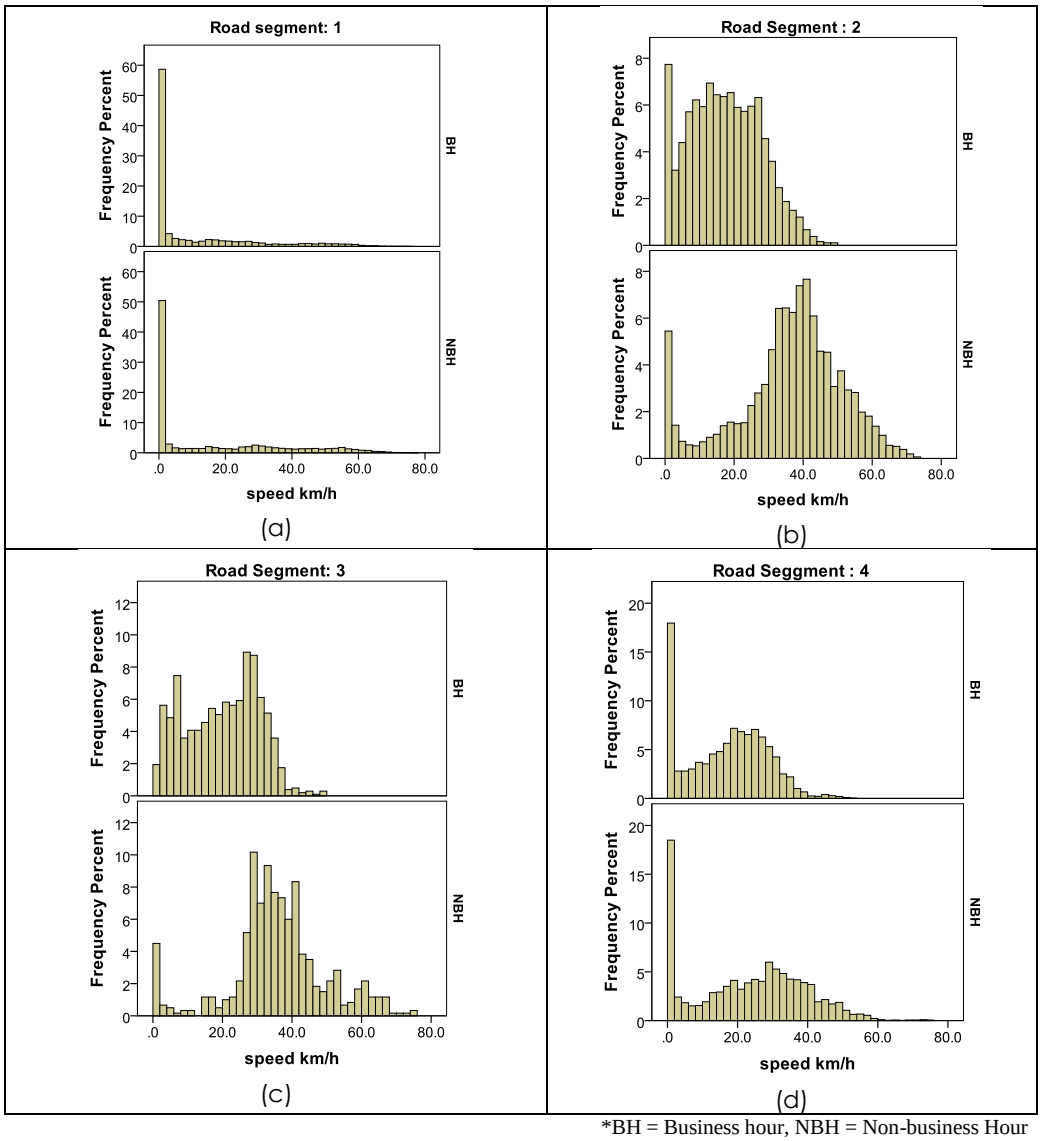
There were differences in the speed distribution between non-business hours and business hours observed from the research data. Speed during both travel periods did not have a good distribution of data that showed a distinct peak for all road segments (Figure 2). Graphical comparison also indicates that the speed distributions during non-business hours were more likely to skew to the right compared to speed during business hours, which indicated speed were higher within this period.

In addition, the descriptive analysis result as presented in Table 1 specified that, the speed observed in this study fell into a range of 0 to 76.1 km/h. Specifically, the maximum speed captured from the data showed that drivers reached their highest top speed during non-business hours. Furthermore, it was noticeable that along the study road, the mean speeds were significantly different between driving hours (these differences were significant at $p \leq 0.05$). Overall, drivers were found to drive 32% to 42% slower during business hours compared to non-business hours. This can be clearly seen from Figure 3 which shows a graphical comparison of mean speeds during business hours and non-business hours along the study road.

The result from speed comparison analysis significantly showed that, the behaviour of drivers can be influenced by business hour activities. This is because, during this hour drivers are more constrained in their driving than they are during non-business hours due to factors such as higher density of traffic, frequency of junctions, interactions with pedestrian and on-street parking activity. This can impact the control of speed as presented in speed distribution. Additional percentage of zero speed observed during business hours was mainly due to the interaction between drivers and other vehicles on the road and pedestrian activities. In contrast, these factors have relatively lower impacts during non-business hours, where drivers have more freedom of control in their driving behaviour except when the driver has to deal with fixed conditions such as stopping at traffic lights.

Table 1 Speed observed on study road segments

Road Segment	Business Hour			Non-Business Hour		
	Max.	Min.	Mean	Max.	Min.	Mean
1	74.9	.0	10.2	76.1	.0	15.8
2	49.5	.0	17.4	73.7	.0	36.2
3	49.5	.0	19.9	75.3	.0	35.8
4	52.0	.0	17.0	75.7	.0	23.2



*BH = Business hour, NBH = Non-business Hour

Figure 2 Speed Distribution for (a) Road Segment 1, (b) Road Segment 2, (c) Road Segment 3 and (d) Road Segment 4

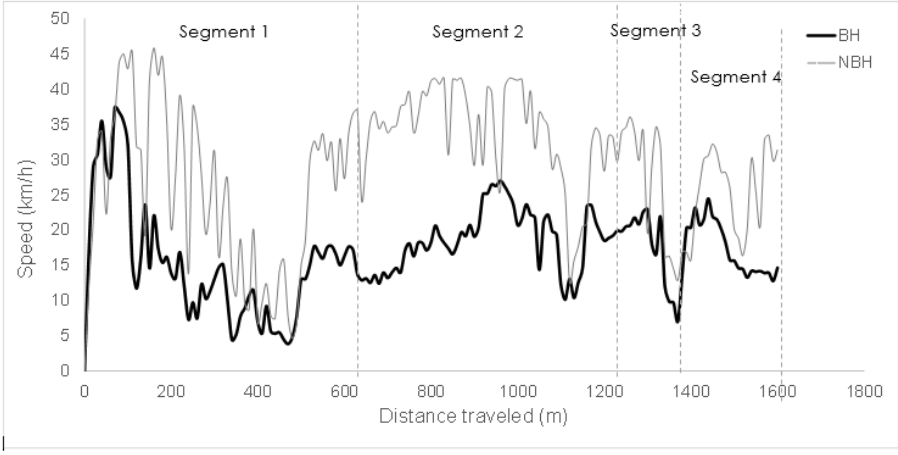


Figure 3 Comparison of mean speed between business hours and non-business hours

3.2 Comparison of Acceleration

Figure 4 exhibits the distribution of acceleration during business hours and non-business hours at study road. It can be seen in the figure that, the acceleration distribution for all road segments exhibits normal for both periods of business and non-business hours. In addition, acceleration at all segments for both periods peaked at zero ms^{-2}. This is consistent with the speed dispersion as presented in Figure 2. It can be seen from the figure that the proportion of zero acceleration during business hours are likely to be higher than during non-business hours. Further investigations found that, zero acceleration observed from the research data were mainly from stopping activity, due to the interactions of the driver with signalised intersections and interactions with other vehicles in traffic stream that require the driver to stop frequently. The stopping phase was found to be more recurrent during business hours that influence overall acceleration data distribution.

As presented in Table 2, the descriptive analysis conducted shows that the overall acceleration data were between -3.64 ms^{-2} and 3.56 ms^{-2}. Drivers were found to significantly apply 30% higher acceleration during non-business hours compared to business hours. This can be seen graphically from Figure 5.

In this paper, the analysis of accelerations focuses on 2 main driving phases; accelerating and braking. Table 3 shows descriptive analysis results of the acceleration along the study road with the percentage of mean acceleration differences between business hours and non-business hours. In addition, the results for the analysis of variance conducted are presented in Table 4. The results captured from both tables, show that drivers applied significantly higher acceleration rate while accelerating and braking during non-business hours on all road segments. The percentage difference of the acceleration rate between both periods of travel for accelerating and braking ranged from 7.73% to 23.53% and 7.73% to 22.37% respectively.

The effect of business hours on accelerating and braking were assessed in this study. As indicated earlier, in the city environment especially in a business zone, driver behavior can be influenced by factors such as traffic control, interactions between pedestrian and vehicle, etc. During business hours, low acceleration applied by drivers can be associated with the desire to drive with caution to avoid conflict with pedestrians and other vehicles.

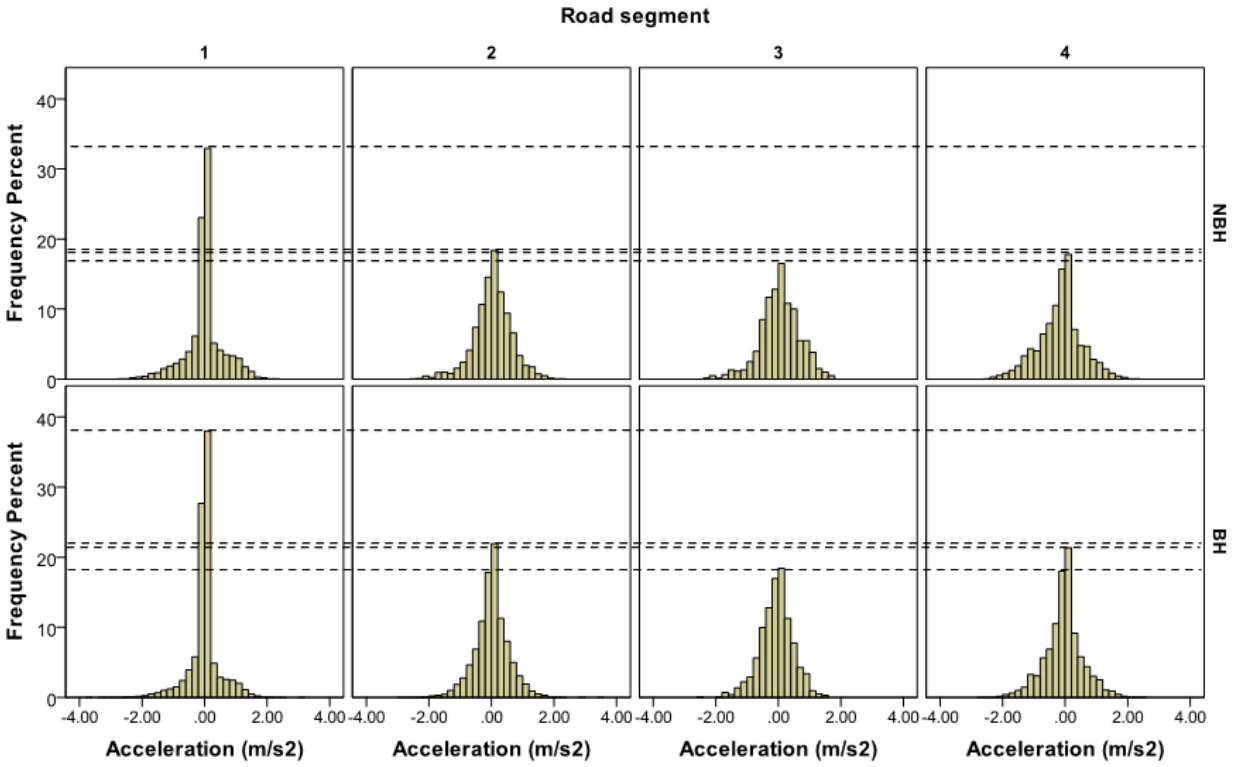


Figure 4 Acceleration distribution for road segments 1, 2, 3 and 4

Table 2 Descriptive analysis for acceleration

Journey period		N	Minimum	Maximum	Mean	Std. Deviation
NBH	Acceleration m/s²	16318	-3.44	3.56	-.0154	.63364
BH	Acceleration m/s²	28761	-3.64	3.53	-.0107	.53113

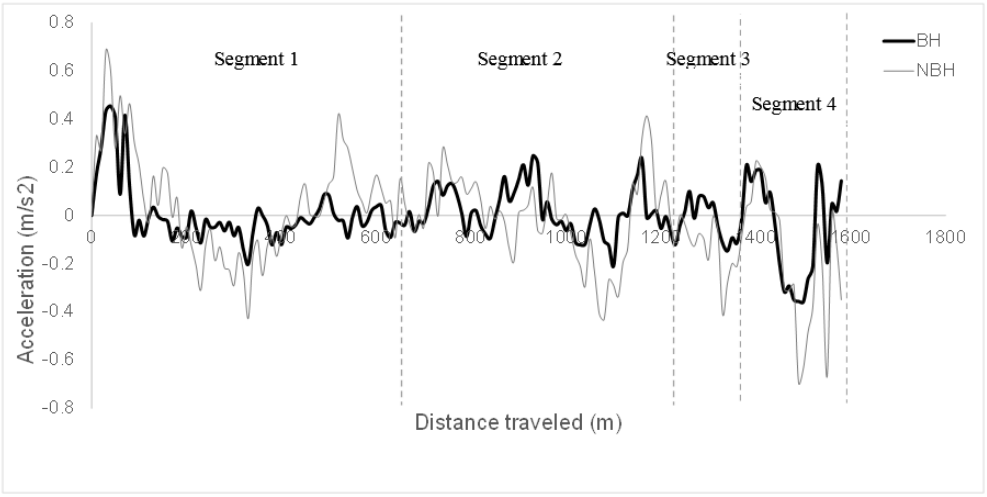


Figure 5 Mean of acceleration versus distance travel along study road during business and non-business hours

Table 3 Descriptive analysis of acceleration during accelerating and braking phase and percentage of difference in mean between business and non-business hours

Road segment	Driving phase		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min.	Max.	percentage of mean acceleration differrent
							Lower Bound	Upper Bound			
1	Accelerating	NBH	3513	.4311	.45420	.00766	.4160	.4461	.03	2.86	23.53
		BH	5580	.3296	.39960	.00535	.3191	.3401	.03	3.06	
		Total	9093	.3688	.42439	.00445	.3601	.3775	.03	3.06	
	Braking	NBH	3542	-.4182	.50043	.00841	-.4346	-.4017	-3.28	-.03	22.37
		BH	6047	-.3246	.43352	.00557	-.3355	-.3137	-3.64	-.03	
		Total	9589	-.3592	.46156	.00471	-.3684	-.3499	-3.64	-.03	
2	Accelerating	NBH	2455	.4712	.38911	.00785	.4558	.4866	.03	3.56	12.30
		BH	4880	.4133	.35682	.00511	.4033	.4233	.03	3.53	
		Total	7335	.4327	.36893	.00431	.4242	.4411	.03	3.56	
	Braking	NBH	2063	-.4775	.45960	.01012	-.4974	-.4577	-3.44	-.03	13.35
		BH	4707	-.4138	.37976	.00554	-.4246	-.4029	-2.92	-.03	
		Total	6770	-.4332	.40678	.00494	-.4429	-.4235	-3.44	-.03	
3	Accelerating	NBH	319	.5040	.38005	.02128	.4621	.5459	.03	1.64	23.20
		BH	454	.3871	.30008	.01408	.3594	.4147	.03	1.47	
		Total	773	.4353	.34008	.01223	.4113	.4593	.03	1.64	
	Braking	NBH	269	-.4814	.43493	.02652	-.5336	-.4292	-2.22	-.03	7.73
		BH	548	-.4442	.37033	.01582	-.4753	-.4131	-2.56	-.03	
		Total	817	-.4565	.39290	.01375	-.4834	-.4295	-2.56	-.03	
4	Accelerating	NBH	1198	.4864	.43455	.01255	.4618	.5111	.03	2.25	7.73
		BH	1915	.4489	.41408	.00946	.4303	.4674	.03	2.50	
		Total	3113	.4633	.42240	.00757	.4485	.4782	.03	2.50	
	Braking	NBH	1778	-.6020	.50612	.01200	-.6255	-.5785	-2.50	-.03	21.92
		BH	2225	-.4700	.42889	.00909	-.4879	-.4522	-2.67	-.03	
		Total	4003	-.5287	.46932	.00742	-.5432	-.5141	-2.67	-.03	

Table 4 ANOVA results of acceleration

Road segment	Driving phase		Sum of Squares	df	Mean Square	F	Sig.
1	Accelerating	Between Groups	22.185	1	22.185	124.850	.000
		Within Groups	1615.378	9091	.178		
		Total	1637.562	9092			
	Braking	Between Groups	19.552	1	19.552	92.654	.000
		Within Groups	2023.056	9587	.211		
		Total	2042.608	9588			
2	Accelerating	Between Groups	5.485	1	5.485	40.514	.000
		Within Groups	992.747	7333	.135		
		Total	998.232	7334			
	Braking	Between Groups	5.828	1	5.828	35.401	.000
		Within Groups	1114.262	6768	.165		
		Total	1120.090	6769			
3	Accelerating	Between Groups	2.563	1	2.563	22.783	.000
		Within Groups	86.723	771	.112		
		Total	89.286	772			
	Braking	Between Groups	.250	1	.250	1.620	.003
		Within Groups	125.715	815	.154		
		Total	125.965	816			
4	Accelerating	Between Groups	1.041	1	1.041	5.843	.016
		Within Groups	554.215	3111	.178		
		Total	555.256	3112			
	Braking	Between Groups	17.207	1	17.207	79.655	.000
		Within Groups	864.296	4001	.216		
		Total	881.503	4002			

4.0 CONCLUSION

Research findings suggested that in general, speed and acceleration of the drivers in the business zone areas can be influenced by activities during business hours. Drivers were found to drive up to 42% significantly faster during non-business hours.

Acceleration rates were also found to significantly differ between business and non-business hours when the driver accelerates and brakes. During business hours, drivers apply considerably lower acceleration rates compared to those during non-business hours.

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