Effects of Road Hump's Profiles on Traffic Speed in Kuala Lumpur Residential Areas

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Abstract: The installation of road humps in residential areas has calmed the local roads by reducing the vehicle speeds along that particular roads. This paper aims to deliberate the impacts of road hump profiles in reducing vehicle speeds along the selected residential roads, which primarily compared two residential areas in Kuala Lumpur; Setiawangsa and Keramat. An observational field survey was aimed at the existing road geometrics and road hump profiles, whereas a spot speed survey was done to collect vehicles speed at the six selected points. The data were analyzed by using descriptive analysis which explained the changes in vehicle speeds along the chosen roads. Paired samples test has used to evaluate the significant difference in vehicle speeds. As predicted, the result of this study verifies that humps are effective in reducing speeds in residential areas concerning the hump's profiles.

Keywords – Road Hump, Residential Area, Speed Reduction, Speed Change, Kuala Lumpur

1. INTRODUCTION

Speeding vehicles can be a menace to other road users, particularly on residential streets. Low vehicular volumes along the residential roads have invited more drivers to use the local road as a way to bypass congested collector and arterial roads (Laplante and McCann, 2008). As a result, large volumes of traffic generated and speeding vehicles are increased in residential areas. Traffic calming is one of the measures that can be considered to control the speed of the vehicles on local roads and thus to improve the safety of the road users (McCann, 2005; City of Sunnydale, 2008). One of the traffic calming measures that are widely used on a local road is road hump, which causes discomfort to the vehicles when crossing over it. Road hump is placed to enforce speed limits, thereby preventing over-speeding of vehicles in residential areas and thereby promoting an orderly flow of traffic and improving the safety of the road users. According to Johnson and

Nedzesky (2004), road humps are three to four inches high and 12 feet in length with rounded, flat or parabolic shaped top.

Karim et. al. (2003) identified that vehicles acceleration caused the changes in speed at a certain distance after hump and at hump. Studies by Thompson (2002) and Rickert (2008) had noted that road humps could reduce vehicle speed and also decrease cut through traffic. Both have determined that there were about 10 mph reductions in speed in five different locations. Dixon and Jacko's (1998) study indicated that the speed of the vehicles reduces by 40 percent on the road provided with the road hump. Several studies conducted by Cottrell et. al. (2006) in California showed a reduction in mean speed along fourteen roads. However, only four roads have experienced an increase in mean speed.

This paper evaluates the effects of different road hump profiles on the vehicle speeds in various residential roads. Besides, the findings of field survey will signify the actual scenario of road humps installation in Malaysian residential areas.

2. SITE BACKGROUND

This study involved two residential areas in Kuala Lumpur, which are Setiawangsa and Keramat (*Refer Figure 1*). To evaluate the factors that influenced speed reductions along the residential road, two roads in each area were selected. The characteristics of the selected roads were identified and shown in Table 1. The selected roads in this study are located in residential areas serving local traffic.

Figure 1 Persiaran Setiawangsa

Figure 3 Jalan Keramat

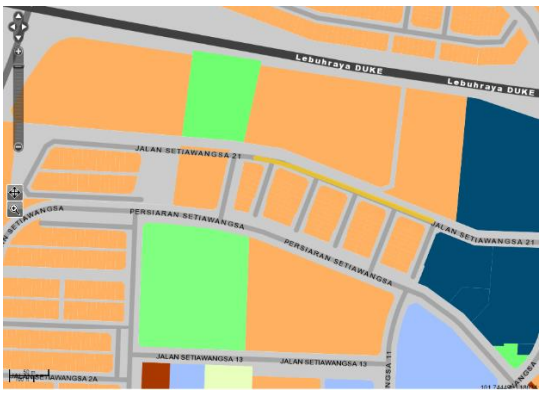

Figure 2 Jalan Setiawangsa 21

Figure 4 Jalan AU1C/1

Table 1 Characteristic of Selected Road

AREA	ROAD	CARRIAGEWAY		ROAD SHOULDER WIDTH (m)	SIDEWALK (m)	REMARKS
		LANE	WIDTH (m)			
SETIAWANGSA	Persiaran Setiawangsa	1	3.6	3	N/A	N/A
	Jalan Setiawangsa 21	1	3.6	N/A	1.9	Sloppy road with on-street parking
KERAMAT	Jalan AU1C/1	1	3.2	5	N/A	Sloppy road with intersection in between
	Jalan Keramat	1	3.5	N/A	2.5	Curved section in between

Based on the observation, there was a discrepancy in hump profiles for all study areas. Malaysia Ministry of Works has indicated the height of a hump should be 75mm to 100mm, besides the minimum and maximum length is 3.7m and 4.25m respectively (2002). Thus, the primary concern for this study was the humps installed along Jalan AU1C/1, which designated in round-shaped, height of 30mm, 5.6m width and 1.5 – 1.7m in length. Regarding hump type, all humps installed in round-shaped except for a hump along Jalan Keramat, which was sinusoidal. The profiles of the selected humps along these two roads can be referred in Table 2.

Table 2 Road Hump Profiles

AREA	ROAD	HUMP	HUMP TYPE	HEIGHT (mm)	LENGTH (m)	WIDTH (m)	SPACING (m)
Setiawangsa	Persiaran Setiawangsa	A	Round	80	3.2	11.9	92
		B	Round	60	3.4		
	Jalan Setiawangsa 21	A	Round	60	3.5	11.2	58
		B	Round	50	2.7		
Keramat	Jalan AU1C/1	A	Round	30	1.7	5.6	78
		B	Round	30	1.5		
	Jalan Keramat	A	Sinusoidal	50	3.5	8.5	70
		B	Round	50	3		

3. RESEARCH METHODOLOGY

3.1 Method of Data Collection

Systematic sampling technique has applied to select vehicles for the speed measurement. Radar guns (Stalker Lidar XS) were used to measure the speed of the moving vehicles at six points which were 25 meters before approaching road humps, 15 meters before and after road humps, between road humps and at the road hump 1 and 2 (*Refer Figure 1*). The 15m stretch was measured according to the recommendation by IRC (1981) (*Refer Table 3*) which accordance to the different speed of traffics. The speed of cars, motorcycles, vans, buses and lorries which passing the road provided with road humps for a total duration 12 hours from 7 a.m. to 7 p.m. were measured. Due

to the limitation in equipment, the speed survey could not be done in for all six points in a row. The study was conducted in three days per site which means two points per day, with the assumption that traffic moving along the residential road would be similar throughout the three days.

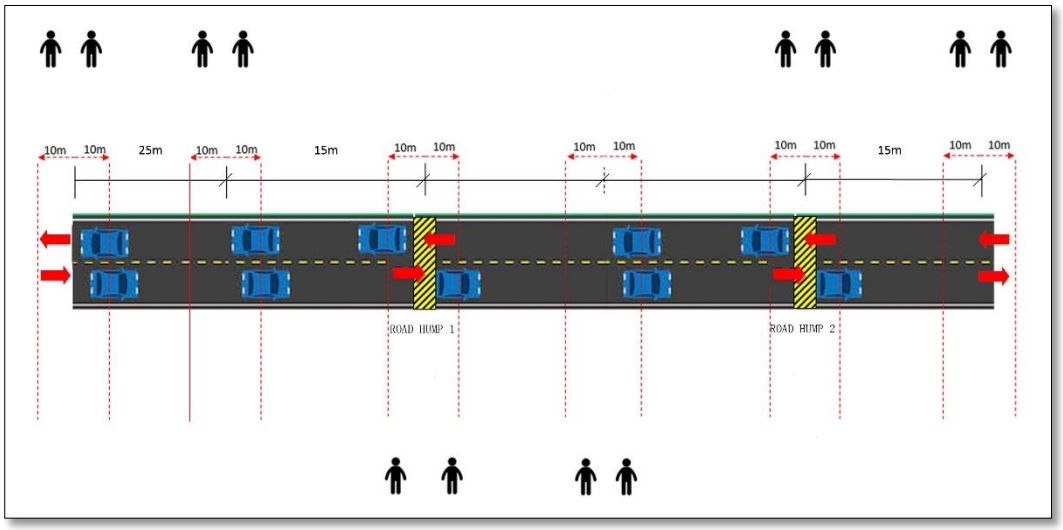

Figure 5 Illustration of Speed Survey

Table 3 Recommendation Study Length or Stretch by IRC

STREAM SPEED (km/h)	LENGTH (m)
Less than 40	27
40 – 65	54
Greater than 65	81

Source: IRC (1981)

3.2 Method of Analysis

The analysis of vehicle speeds involved statistical descriptive analysis including measures of central tendency and measures of variability which meant to evaluate the relationship of humps in speed reductions. Besides, paired samples T-test used to test the significant difference in vehicle speeds between humps.

4. CHANGE IN VEHICLE SPEEDS BEFORE APPROACHING ROAD HUMP

Table 3 summarizes the average speed variation of different types of vehicles; car, motorcycle and heavy vehicles before approaching road hump (*Refer Figure 2; Point 1*).

Table 4 Change in Vehicle speeds before Approaching Road Hump (km/h)

LOCATION	CAR	M/CYCLE	VAN	BUS	LORRY
Persiaran Setiawangsa	-1.04	-0.57	-0.63	-0.65	-0.84
Jalan Setiawangsa 21	-4.63	-1.16	-3.29	4.75	-3.63
Jalan AU1C/1	-10.22	-8.32	-9.13	-1.00	-8.00
Jalan Keramat	-8.66	-1.13	-8.29	-3.05	-3.11

There was a wide variation in the speed reductions for all types of vehicles in every area. In general, the vehicle speeds reduce ranged from 0.57 km/h (Persiaran Setiawangsa, motorcycle) to 10.22 km/h (Jalan AU1C/1, car). The disparity can be related to the road dimensions and its surroundings. For example, vehicles that were moving along Jalan Setiawangsa 21 experienced a larger reduction compared to Persiaran Setiawangsa, as it is a sloppy road and the existence of on-street parking along the road. However, the speed increased to 4.75 km/h was due to the bus accelerating while moving uphill. Another example is Jalan AU1C/1. Its 3.2m width affects the traffic flow which resulting in speed reductions ranging from 8.32 km/h to 10.22 km/h. In contrast, the reductions at Jalan Keramat is affected by the vehicles exiting the junctions and bus stopping along the road.

5. PERCENTAGE OF VEHICLE SPEEDS CHANGE

a. Persiaran Setiawangsa

Table 5 Percentage of Vehicle Speeds Change (Persiaran Setiawangsa)

Dir.	Veh.	P2-P3	P3-P4	P4-P5	P5-P6	Dir.	Veh.	P3-P2	P4-P3	P5-P4	P6-P5
IN	Car	-76.89	38.77	-79.22	9.38	OUT	Car	-51.19	47.47	-58.47	26.13
	M/cycle	-51.60	32.68	-54.49	5.22		M/cycle	-25.92	36.28	-35.57	21.33
	Van	-73.26	38.96	-81.35	11.04		Van	-41.02	38.12	-59.23	29.27
	Bus	-69.25	45.64	-96.29	15.07		Bus	-61.11	30.77	-30.00	16.67
	Lorry	-74.90	40.05	-77.80	16.15		Lorry	-44.05	40.84	-65.26	36.74

Table 4 shows the percentage of vehicle speeds change at Persiaran Setiawangsa. Buses that entering Persiaran Setiawangsa recorded the highest rate of speed change from P4 to P5. Similarly, lorries recorded the highest speed change at the same point while exiting the road. This deceleration caused by the junction between the points which affects the traffic flow. However, the wide spacing between humps influenced most of the vehicles to accelerate.

b. Jalan Setiawangsa 21

Table 6 Percentage of Vehicle speeds Change (Jalan Setiawangsa 21)

Dir.	Veh.	P2-P3	P3-P4	P4-P5	P5-P6	Dir.	Veh.	P3-P2	P4-P3	P5-P4	P6-P5
IN	Car	-62.20	19.84	-23.49	14.18	OUT	Car	-29.72	34.78	-47.80	18.06
	M/cycle	-43.20	11.73	-8.82	10.74		M/cycle	-15.36	15.90	-17.46	11.09
	Van	-45.44	27.76	-21.66	15.89		Van	-39.08	41.08	-53.29	20.39
	Bus	-62.50	17.91	-3.41	11.46		Bus	-27.59	-16.67	20.00	16.67
	Lorry	-38.28	16.88	-14.93	8.22		Lorry	-46.67	22.32	-33.72	11.00

There is about 62% of a speed change by the lorries and cars which moving from P2 to P3. This change is due to the effect of sloppy road and cars parked on the roadside that forced the vehicles to slow down. Conversely, vans which moving from the opposite direction also experienced the highest speed change since the van's braking while driving downhill and intersections located between P5 and P4. The speed increased from P3 to P4 and also from P4 to P3 at both directions due to the sudden braking while approaching hump expected as shown in Table 5. Hence, most of the vehicles accelerated after leaving the hump.

c. Jalan AU1C/1

Table 7 Percentage of Vehicle speeds Change (Jalan AU1C/1)

Dir.	Veh.	P2-P3	P3-P4	P4-P5	P5-P6	Dir.	Veh.	P3-P2	P4-P3	P5-P4	P6-P5
IN	Car	-27.54	40.42	-40.43	21.40	OUT	Car	-24.79	27.08	-43.81	2.03
	M/cycle	-14.37	31.92	-32.78	11.87		M/cycle	-8.60	21.42	-19.43	0.83
	Van	-34.20	46.15	-54.32	27.60		Van	-34.25	29.58	-57.87	3.43
	Bus	-5.26	-18.75	-60.00	23.08		Bus	-57.14	39.13	8.00	0.00
	Lorry	-15.87	36.68	-71.55	18.88		Lorry	-34.11	1.53	-16.96	10.40

According to Table 6, most of the vehicle speeds at P3 and P5 decreased ranging from 5.26% to 71.55%. It can be attributed to the effect of road hump dimensions which was perceived to change the driving behaviors. Like other roads, acceleration also happened at P4 and P6 which were between the humps and after the hump. With the hump spacing being 78m, the increase in speed at P4 due to the acceleration of the vehicle. As expected, most of the vehicles were likely to accelerate after leaving the road hump.

d. Jalan Keramat

Table 8 Percentage of Vehicle speeds Change (Jalan Keramat)

Dir.	Veh.	P2-P3	P3-P4	P4-P5	P5-P6	Dir.	Veh.	P3-P2	P4-P3	P5-P4	P6-P5
IN	Car	1.29	-7.71	-12.86	8.06	OUT	Car	3.91	18.95	-28.24	22.59
	M/cycle	-5.35	-5.43	-2.01	4.45		M/cycle	-0.52	16.74	-19.55	10.37
	Van	-18.82	16.04	-25.82	15.33		Van	0.81	22.67	-29.21	22.26
	Bus	-15.84	19.10	-20.52	18.10		Bus	-1.36	17.18	-25.44	13.19
	Lorry	-31.79	14.87	-23.55	15.74		Lorry	-2.75	14.29	-12.90	24.15

The highest speed change took place at P3 and P5 respectively, which ranged from 5.35% to 31.79%. Instead of the humps effect, the reductions in moving vehicle speeds was due to the disruption of traffic flow which affected by the vehicles parked or stopped on the roadside. Initially, vehicles from P6 to P5 accelerated from a straight section then forced to reduce speed from P5 to P4 due to the curve section before approaching hump. Similarly, the speed at P5-P6 increased after leaving the hump and curve section.

6. SIGNIFICANCE OF SPEED REDUCTION OVER ROAD HUMPS

a. Persiaran Setiawangsa

A paired T-test was conducted to compare the difference in speed at Hump A and B in both directions. Table 8 represents the result of the paired T-test carried out for the speed measured along Persiaran Setiawangsa.

Table 9 Paired Sample Test for Persiaran Setiawangsa

Hump			Paired Differences					t	df	Sig. (2-tailed)
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
						Lower	Upper			
CAR										
A	Pair 1	Point_2 - Point_3	15.025	6.346	.412	14.213	15.837	36.451	236	.000
	Pair 2	Point_4 - Point_3	15.032	5.797	.393	14.258	15.806	38.285	217	.000
B	Pair 3	Point_4 - Point_5	14.105	6.236	.405	13.307	14.904	34.821	236	.000
	Pair 4	Point_6 - Point_5	7.069	5.926	.401	6.278	7.860	17.613	217	.000
MOTORCYCLE										
A	Pair 1	Point_2 - Point_3	9.026	7.278	.829	7.374	10.678	10.882	76	.000
	Pair 2	Point_4 - Point_3	6.958	7.578	.777	5.414	8.502	8.949	94	.000
B	Pair 3	Point_4 - Point_5	10.169	7.055	.804	8.568	11.770	12.648	76	.000
	Pair 4	Point_6 - Point_5	6.263	5.282	.542	5.187	7.339	11.558	94	.000
VAN										
A	Pair 1	Point_2 - Point_3	12.271	5.771	.833	10.595	13.947	14.731	47	.000
	Pair 2	Point_4 - Point_3	13.380	6.302	.891	11.589	15.171	15.014	49	.000
B	Pair 3	Point_4 - Point_5	13.250	4.545	.656	11.930	14.570	20.196	47	.000
	Pair 4	Point_6 - Point_5	11.920	5.945	.841	10.231	13.609	14.178	49	.000
LORRY										
A	Pair 1	Point_2 - Point_3	10.000	6.325	2.828	2.147	17.853	3.536	4	.024
	Pair 2	Point_4 - Point_3	12.250	5.497	1.943	7.655	16.845	6.303	7	.000
B	Pair 3	Point_4 - Point_5	11.400	5.983	2.676	3.971	18.829	4.260	4	.013
	Pair 4	Point_6 - Point_5	8.375	3.998	1.413	5.033	11.717	5.925	7	.001

The findings show that there was a significant difference in the speed of all types of vehicles for both pairs (*Refer Table 8*). Thus, Hump B has significantly reduced the speed of vehicles in Persiaran Setiawangsa residential area. While Hump B was less statistically significant since there were a significant increase in speed at Hump A for the car from P2 to P3, $t(236)=36.451$, $p=0.000$ and from P4 to P3, $t(217)=38.285$, $p=0.000$. Similarly, van's speed also increased from P2-P3, $t(47)=14.731$, $p=0.000$ and from P4 to P3, $t(49)=15.014$, $p=0.000$. Besides, the speed of lorry increased at the same point, $t(4)=3.536$, $p=0.024$ (P2-P3) and $t(7)=6.303$, $p=0.000$ (P4-P3). This increasing speed can be due to the higher hump height of Hump A causing greater speed reductions.

b. Jalan Setiawangsa 21

The difference in speed along Jalan Setiawangsa 21 which at Hump A and B has tested for statistical significance by using t-test. The result in Table 9 shows that the test was statistically significant at 95% confidence interval.

Table 10 Paired Sample Test for Jalan Setiawangsa 21

Hump			Paired Differences					t	df	Sig. (2-tailed)
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
						Lower	Upper			
CAR										
A	Pair 1	Point_2 - Point_3	10.846	7.012	.435	9.990	11.702	24.942	259	.000
	Pair 2	Point_4 - Point_3	9.272	6.717	.511	8.264	10.280	18.155	172	.000
B	Pair 3	Point_4 - Point_5	4.138	6.377	.395	3.360	4.917	10.465	259	.000
	Pair 4	Point_6 - Point_5	3.925	4.100	.312	3.309	4.540	12.590	172	.000
MOTORCYCLE										
A	Pair 1	Point_2 - Point_3	9.302	7.311	1.115	7.052	11.552	8.343	42	.000
	Pair 2	Point_4 - Point_3	4.164	7.343	.990	2.179	6.149	4.205	54	.000
B	Pair 3	Point_4 - Point_5	1.977	7.100	1.083	-.208	4.162	1.826	42	.075
	Pair 4	Point_6 - Point_5	2.782	5.583	.753	1.272	4.291	3.695	54	.001
VAN										
A	Pair 1	Point_2 - Point_3	7.956	6.908	1.030	5.880	10.031	7.725	44	.000
	Pair 2	Point_4 - Point_3	9.765	7.718	1.872	5.797	13.733	5.217	16	.000
B	Pair 3	Point_4 - Point_5	3.689	5.744	.856	1.963	5.415	4.308	44	.000
	Pair 4	Point_6 - Point_5	3.941	5.771	1.400	.974	6.909	2.816	16	.012
LORRY										
A	Pair 1	Point_2 - Point_3	6.125	8.391	2.967	-.890	13.140	2.065	7	.078
	Pair 2	Point_4 - Point_3	10.500	9.192	6.500	-72.090	93.090	1.615	1	.353
B	Pair 3	Point_4 - Point_5	2.500	7.171	2.535	-3.495	8.495	.986	7	.357
	Pair 4	Point_6 - Point_5	2.000	2.828	2.000	-23.412	27.412	1.000	1	.500

The change in speed of all vehicles at Hump A was statistically significant from P2 to P3 and P4 to P3. Alike for Hump B, the change in vehicle speeds was statistically significant from P4 to P5 and P6 to P5 except for lorry which was insignificant from P6 to P5, $t(1)=1.000$, $p=0.500$. Based on observation, there were light-weight lorries which used for delivery of goods. Thus they

tend to accelerate to beat the time. Nevertheless, only the speed of car decreased at Hump B. Thus, the different height and width of hump would affect the vehicle speeds.

c. Jalan AU1C/1

A paired T-test was conducted to compare the difference in speed at Hump A and B in both directions. Table 10 represents the result of the paired T-test performed for the speed measured along Jalan AU1C/1.

Table 11 Paired Sample Test for Jalan AU1C/1

Hump			Paired Differences					t	df	Sig. (2-tailed)
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
						Lower	Upper			
CAR										
A	Pair 1	Point_2 - Point_3	4.642	4.353	.339	3.973	5.312	13.699	164	.000
	Pair 2	Point_4 - Point_3	8.013	6.531	.525	6.977	9.049	15.276	154	.000
B	Pair 3	Point_4 - Point_5	8.145	8.048	.627	6.908	9.383	13.001	164	.000
	Pair 4	Point_6 - Point_5	.426	4.681	.376	-.317	1.169	1.133	154	.259
MOTORCYCLE										
A	Pair 1	Point_2 - Point_3	3.096	4.009	.375	2.353	3.840	8.247	113	.000
	Pair 2	Point_4 - Point_3	6.655	9.320	.889	4.893	8.416	7.488	109	.000
B	Pair 3	Point_4 - Point_5	7.816	7.751	.726	6.378	9.254	10.766	113	.000
	Pair 4	Point_6 - Point_5	.218	3.536	.337	-.450	.886	.647	109	.519
VAN										
A	Pair 1	Point_2 - Point_3	4.938	2.568	.642	3.569	6.306	7.690	15	.000
	Pair 2	Point_4 - Point_3	7.667	6.401	1.848	3.600	11.734	4.149	11	.002
B	Pair 3	Point_4 - Point_5	9.438	8.571	2.143	4.870	14.005	4.404	15	.001
	Pair 4	Point_6 - Point_5	.583	3.088	.892	-1.379	2.546	.654	11	.526
LORRY										
A	Pair 1	Point_2 - Point_3	2.500	2.268	.802	.604	4.396	3.118	7	.017
	Pair 2	Point_4 - Point_3	.286	6.824	2.579	-6.026	6.597	.111	6	.915
B	Pair 3	Point_4 - Point_5	10.375	5.951	2.104	5.400	15.350	4.931	7	.002
	Pair 4	Point_6 - Point_5	1.857	3.338	1.262	-1.230	4.944	1.472	6	.191

The increase in motorcycle's speed at Hump B was statistically insignificant from P6 to P5, $t(109)=0.647$, $p=0.519$ but statistically significant from P4 to P5, $t(113)=10.766$, $p=0.000$. Also, there was statistically insignificant in van's speed from P6 to P5, $t(11)=0.654$, $p=0.526$ while significant from P4 to P5, $t(15)=4.404$, $p=0.001$. However, the speed of lorry was insignificant at Hump A from P4 to P3, $t(6)=0.111$, $p=0.915$, but significant from P2 to P3, $t(7)=3.118$, $p=0.017$. This insignificant can be related to the effect of intersection between the humps which would interrupt the traffic flow. Besides, the additional acceleration and deceleration of vehicle speeds, due to the gradient of the road.

d. Jalan Keramat

A t-test has used to check the difference in speed along Jalan Keramat which at Hump A and B. The result in Table 11 shows that the effect was statistically significant at 95% confidence interval.

Table 12 Paired Sample Test for Jalan Keramat

Hump			Paired Differences					t	df	Sig. (2-tailed)
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
						Lower	Upper			
CAR										
A	Pair 1	Point_2 - Point_3	-.314	8.930	.681	-1.658	1.030	-.461	171	.645
	Pair 2	Point_4 - Point_3	5.250	8.154	.582	4.101	6.399	9.014	195	.000
B	Pair 3	Point_4 - Point_5	2.576	6.641	.506	1.576	3.575	5.086	171	.000
	Pair 4	Point_6 - Point_5	6.306	6.725	.480	5.359	7.254	13.128	195	.000
MOTORCYCLE										
A	Pair 1	Point_2 - Point_3	1.513	6.621	.484	.558	2.468	3.126	186	.002
	Pair 2	Point_4 - Point_3	5.380	9.024	.700	3.997	6.762	7.680	165	.000
B	Pair 3	Point_4 - Point_5	.513	9.169	.670	-.809	1.836	.766	186	.445
	Pair 4	Point_6 - Point_5	3.108	5.791	.449	2.221	3.996	6.915	165	.000
VAN										
A	Pair 1	Point_2 - Point_3	4.833	7.733	1.116	2.588	7.079	4.330	47	.000
	Pair 2	Point_4 - Point_3	6.207	6.928	.910	4.385	8.028	6.823	57	.000
B	Pair 3	Point_4 - Point_5	3.688	7.206	1.040	1.595	5.780	3.546	47	.001
	Pair 4	Point_6 - Point_5	6.069	7.987	1.049	3.969	8.169	5.787	57	.000
LORRY										
A	Pair 1	Point_2 - Point_3	5.917	7.020	1.170	3.541	8.292	5.057	35	.000
	Pair 2	Point_4 - Point_3	3.108	6.955	1.143	.789	5.427	2.718	36	.010
B	Pair 3	Point_4 - Point_5	4.167	7.651	1.275	1.578	6.756	3.267	35	.002
	Pair 4	Point_6 - Point_5	6.135	5.089	.837	4.438	7.832	7.333	36	.000
BUS										
A	Pair 1	Point_2 - Point_3	3.350	6.310	1.411	.397	6.303	2.374	19	.028
	Pair 2	Point_4 - Point_3	4.067	5.970	1.541	.761	7.373	2.638	14	.019
B	Pair 3	Point_4 - Point_5	4.350	7.206	1.611	.978	7.722	2.700	19	.014
	Pair 4	Point_6 - Point_5	2.867	4.357	1.125	.454	5.279	2.548	14	.023

The change in speed of all vehicles at Hump A was statistically significant from P2 to P3 and P4 to P3, except for car which was insignificant from P2 to P3, $t(171)=-0.461$, $p=0.645$. The effect of cars which accelerating to beat the traffic light attributed to this insignificant. Alike for

Hump B, the change in vehicle speeds was statistically significant from P4 to P5 and P6 to P5. However, the speed of all vehicles increased at both humps, except for lorry and bus. The increasing speed signified the effect of road dimension that affects the traffic flow, especially heavy vehicles.

7. CONCLUSION

The findings in this paper briefly deliberated the changes in vehicle speeds along residential roads which mostly affected by the road hump profiles, which also impacted by another factor such as road characteristics that influenced the traffic movement. Overall, the findings show that the long distance between humps and wider road width affect the vehicle speeds which resulting in vehicle accelerations.

As seen in this study, it is evident that humps would appear to be useful in controlling vehicle speeds along residential roads. However, improper installation of road humps give less impact in speed reductions, even encourage the drivers to accelerate. Furthermore, improper installation of humps also creates noise pollutions which could disrupt the neighborhoods. It is important that there are effective humps, so the drivers approach speeds are appropriate.

Though, these findings should be useful to plan or implement the road humps in future. To some extent, further studies are encouraged to prove that road humps can be effective deterrents in reducing speed, particularly in residential areas.

8. REFERENCES

Laplante, J., and McCann, B. (2008). Complete Streets: We Can Get There From Here, *ITE Journal*, 78(5), 24-28.

McCann, B. (2005). Complete the Streets! *American Planning Association.*

City of Sunnyvale. (2008). City of Sunnyvale Neighborhood Traffic Calming.

Johnson, L., & Nedzesky, a J. (2004). A Comparative Study of Speed Humps, Speed Slots and Speed Cushions. *ITE Annual Meeting and Exhibit*, 14.

Karim. M. R., Ibrahim, N. I. & Arif, W. R. (2003), Road Humps as Traffic Calming Devices, *Eastern Asia Society for Transportation Studies*.

Thompson, E. (2002). The Ups and Downs of Humps. Telegram & Gazette.

Rickert, C. (2008). Those Traffic Humps and Bumps: Calming or Annoying? *McClatchy - Tribune Business News.*

Dixon, M., and Jacko, J. (1998). An Investigation of Tactile and Visual Stimuli in the Roadway Environment. *Perceptual and Motor Skills*, 1998(87), 387-394

Cottrell, W., Kim, N., Martin, P., and Perrin, H. (2006). Effectiveness of Traffic Management in Salt Lake City, Utah. *Journal of Safety Research*, 37(1), 27-41, 0022-4375.

Highway Planning Unit (HPU) (2002), *Traffic Calming Guidelines*, Ministry of Works, Kuala Lumpur.

Indian Road Congress (1981), Recommendations regarding Alignment, Survey and Geometric Designs.