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Foreword

Welcome to ESTEEM Volume 2. In this issue, we address a gamut of topics from the engineering disciplines to language education. We hope that ESTEEM, by publishing articles from a diverse range of disciplines, will encourage debate and exchange among researchers from assorted academic backgrounds.

I would like to thank our advisor, Prof. Madya Mohd Zaki Abdullah for his distinctive imprint on this edition. His leadership of the journal in its 2nd year of growing impact and reputation has been outstanding. His vision, commitment to excellence, and attention to detail are widely recognized by the Penang academic community as determining factors in the journal's success so far. We will do our best to continue and expand on this tradition of excellence.

Since its launch in 2003, ESTEEM is indeed fortunate to have a dynamic Editorial Team. These people have provided the journal with an outstanding service of reviewing submissions for publications. The journal follows the established policy of a blind review process consisting of at least two peer reviewers per submission. We depend upon their knowledge and judgement in advancing the scope and utility of this journal. Without their support and enthusiasm none of this would have been possible. Also, my thanks to all the contributors, both the successful and not so successful.

Our vision of the ***ESTEEM*** journal is that it should be the journal that belongs to you, the academic and research community. This includes all engineers and academicians working to unravel the mysteries of research, teaching and learning, in all its facets. We wish the journal to be responsive to your needs and your interests. Please feel free to contact any of us in the editorial board to give us your ideas and suggestions for the development of the journal. We look forward to working with you all in expanding this emerging venue for communicating high quality research on the many aspects of academia.

Finally, I would like to take this opportunity to invite all authors and readers to contact me at **esteem@ppinang.uitm.edu.my** to share their comments and advice on how to further enhance the journal's value to the wider research community in knowledge and how to move ESTEEM to the next level of excellence.

The Chief Editor
May, 2005

Design of Road Humps in Residential Area

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ABSTRACT

Speed hump is one of the traffic calming devices that has been installed in residential area in Malaysia. This study was to find a better design of speed hump in reducing speed of vehicles. Data were collected using Speed Radar Meter Detector. Two sets of data were collected. They were speed before reaching the hump (at 30m before the device, this is due to safe stopping sight distance) and speed over the hump for both motorcycles and cars. Data were collected in one hour or at least 50 vehicles at three locations. The effectiveness of the humps is measured by comparing the reduction in speed at the hump. The effectiveness of the speed hump also influenced by other parameters such as height and width of it.

Introduction

Speed hump is one of the traffic calming devices. Other traffic calming measures are roundabout, threshold, median island, road closure, T-deviation, curb blister, rumble strip, driveway entry, wombat crossing, centre blister, narrowed blister, speed signs, road markings, bus adaptation and bicycle adaptation. Traffic calming comprises a set of modifications to a road layout and associated traffic information signs in order to improve road safety and environmental quality. Traffic calming can improve safety for pedestrians by reducing vehicles speed, volume and reduce noise and pollution levels.

Speed humps are the most effective forms of reducing traffic speed and use vertical deflection to ensure that vehicles slow down when crossing them. They were rated best for their relatively low cost and their effectiveness in reducing vehicle operating speed (typically by 8 to

16 km/h, if properly spaced) [G.D Garrod *et al*]. Federal Office of Road Safety in Western Sydney of Australia (1993) stated that speed hump slows vehicles to 20-25 km/h at the device.

A study has been made by Chua, C and Fisher (1991) to rank the residents' and professionals' viewpoint on effectiveness of devices. This result showed that speed hump is on the first and second rank selected by residents and professionals.

Table 2.1: Ranking of Effectiveness of Devices

	Ranking of Effectiveness of Devices					
Viewpoint	Entry Threshold	Speed Hump	Offset C'way	Roundabout	Raised Threshold	Curvilinear Alignment
Residents	3	1	5	2	4	6
Professionals	4	2	6	1	3	5

The design of the speed hump and their effects to speeding is interconnected. A proper application of speed hump is important to achieve the effectiveness of the device. Parameters involved in designing speed humps are:-

- Height of the hump
- Width of the hump (in direction of travel)
- Profile i.e. sinusoidal, parabolic, circular or flat-topped
- Design speed

Many studies had been conducted to measure the effectiveness of speed hump on vehicles speed. All of the studies showed that vehicles will slow down when approaching a hump. Carleton, M.G (1989) conducted a study on speed hump and other devices and found that the hump is strongly depends on spacing and design of the devices. His study indicated that the speed reduction over the hump is 19% - 41%. Carleton concluded that the spacing of the devices was seen as critical to the effectiveness of the result. He conduct a study where most of the devices were spacing at 100 meters to 150 meters and concluded that at spacing greater than 200 meters practically all were ineffective for speed control.

Mc Donald, PE & Jarvis, JR (1981) conducted a study at two different locations with different characteristic as shown below:-

Location	Width (m)	Height (mm)	Profile	Spacing (m)	Design speed (Km/h)
Peacock Avenue	3.7	100	Watts profile	110 to	40
Armytage Street	3.0	85	Watts profile	150	40

McDonald made an analysis based on the result and stated that before the humps were installed, 77% of drivers were exceeding the 40 km/h speed limit in force in Armytage Street. He described that over 69% of drivers were exceeding the same limit in Peacock Avenue and after 5 months of hump use only 19% of Armytage Street drivers and 13% of Peacock Avenue drivers reached speeds of 40 km/h or more. The length of road over which the limit was exceeded was also reduced to very short sections. The results are concluded as below:-

Table 2.5: Before and After Studies

Peacock Avenue	Before	Imm. After	After
Mean speed (km/h)	45.5	28.0	32.1
Armytage St	Before	Imm. Afer	After
Mean speed (km/h)	45.4	28.8	27.8

McDonald made an analysis on public reaction and found a little difficulty was experienced by drivers crossing the larger profile hump in Peacock Avenue, and 35% of drivers registered at least some difficulty crossing the 3 m long by 85 mm high humps constructed in Armytage Streeet. One third of drivers using Armytage Streeet were not satisfied with the shape and size of the humps used. McDonald made an examination of the humps in Armytage Street and found the damages to the hump indicates that few of the impacts has been severe. Driver reaction and the evidences of hump damages would thus suggest that the profile of 3 m width and 85 mm height was less suitable for on road use than the larger profile.

In fact, there are variety heights of humps as we study the practice in other country. Humps that are built along a stretch of Grey Rock Road in Agoura Hills, California were 70mm (2.75 in) high. The 85th percentile traffic speeds fell by 10 km/hr to 15 km/h after the installation of humps. Humps placed in Westlake Village, California, were 67 mm

(2.625 in) high. The humps reduced the 85th percentile speeds by 15 km/hr to 23 km/hr and from 39 km/hr to 47 km/hr.

From the above literatures, we can conclude that speed over the humps regardless of their profile and spacing is in the range of 25 km/hr – 47 km/hr.

The objective of this study was to investigate the impact of speed humps on the vehicle speeds. More specific objectives are:

1. To determine whether speed humps can be used effectively to reduce vehicle speeds,
2. To evaluate the use of speed humps in reducing average vehicle speeds.

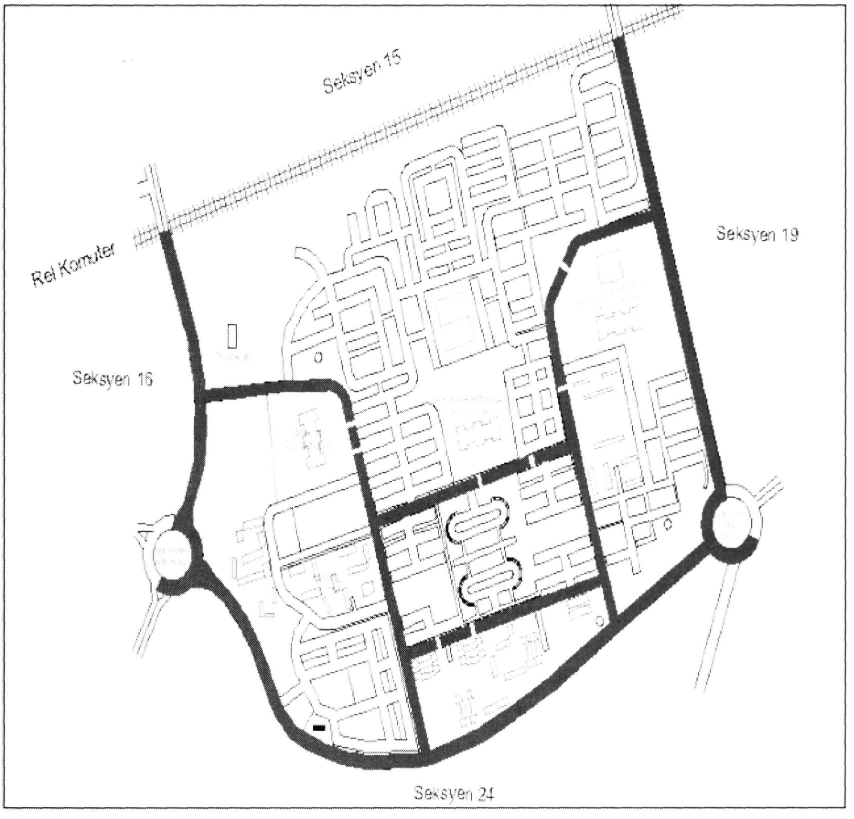

Figure 1: A Map for Area Study Seksyen 18 in Shah Alam

Research Questions

In this study, the design and testing of the humps were based on the following questions:

1. Is there any difference of mean speed at different points which are before the hump and when crossing the hump?
2. Is there any difference of speed between motorcycle and car?

Methodology

Method used in collecting data from the identified locations was discussed. Data collection was divided into two categories;

1. Data collection for vehicles speed – a radar speed meter was used to obtain the speed of vehicles at three places of three different humps, namely, hump A, hump B and hump C. The radar speed meter is placed and directed at a point over the hump and also placed at 30 m before vehicle approaches speed hump or at a point where there is no effect of hump to the vehicles speed.
2. Data collection for humps profile. The specification of hunp A, B and C are as follows:

Table 2: Specification of Speed Hump

Material Use	Dimension	Signage/Road Marking
Asphaltic Premix Wearing Course	**Flat-top Hump (Hump A)** Width : 2.5 m – 4 m Height : 75 mm to 100 mm	
	Round-top Hump (Hump B) Width : 3.7 – 4 m Height : 50 mm to 100 mm	WD 1 – Road Hump Road Marking : Yellow color
	Sinusoidal Hump (Hump C) Width : 3.8 m – 4 m Height : 75 mm to 100 mm	
	30 m from closet intersecting curb or pavement edge line	

Resource: Malaysian Traffic Calming Study Fig. 3.8

Results

The samples were taken from 149 vehicles. The speed at approaching the hump ('point a') was compared to the speed while crossing the hump ('point b') to determine if any short term speed impacts were present following the application of the speed humps. The speed and noise data were evaluated and tested statistically to determine the impacts.

There were three categories of speed reduction in this study, the lowest speed reduction referred to the speed of 1-12 km/hour, the medium speed reduction referred to 13-24 km/hour, and the highest speed reduction referred to 25-36 km/ hour.

85 percentile of speed was considered as a safety speed on a normal highway or road, where it refers to the speed at which 85 percent of the motorists are driving at or below. This is because 15% of drivers on a road are considered driving with a dangerous speed. 85 percentile of seed is an index of traffic speeds for a road segment used by transportation professionals for traffic analysis purposes. Thus the safety speed was calculated for humps A, B and C in this study. Table 3 showed the 85 percentile of speed for the speed at different sides (with hump A, B and C) and different points ('point a' and 'point b').

Table 3 showed that the 85 percentile speeds of vehicle at 'point a' for humps B and C were more than 40 km/h, where the legal speed in most of residential areas is 30 to 40 km/h. Table 3 also showed that the speed at humps A, B and C has deterred speeding of vehicles on the road, where all the vehicles reduced their speed at 'point b'. The 85 percentile of speed reduction at humps A, B, C were 11 km/h, 23 km/h and 33 km/h respectively. The highest percentage of 85 percentile of speed reduction was recorded at hump C. The lowest percentage of 85 percentile of speed reduction was recorded at hump A, where most of the vehicles in this area did not speed before the hump and after the hump as depicted in Table 3.

Table 3: 85 Percentile Speed at Humps A, B and C

Humps	A	B	C
Speed at point a (speed before the hump)	31	53	53
Speed at point b (speed while crossing the hump)	22	31.05	26.5
Speed at point b – Speed at point a	11	23	33
Percentage of 85 percentile of speed reduction	35.5%	43.4%	62.3%

Mean speed reduction according to three different categories of mean speed reduction, namely the lowest mean speed reduction, the medium mean speed reduction and the highest mean speed reduction were shown in Table 4. It showed that generally number of car (99) was more than motorcycle (50) which passed over the humps. Table 4 also showed that most of the vehicles (94%) which passed over hump A with the lowest mean speed reduction. Most of the vehicles (82%) which passed over hump B with the middle mean speed reduction. The distribution of vehicles for the mean speed reduction were quite balance at hump C, where the means speed reduction were 16%, 49% and 35% of vehicles reduced the speed with the lowest, medium and highest mean speed reduction respectively.

Table.4: Categories of Mean Speed Reduction for Three Different Humps

		Categories of Mean Speed Reduction			
Hump	Vehicle	Lowest 1-12 km/h	Medium 13-24 km/h	Highest 25-36 km/h	Total
	Car	28	3		31
A	Motorcycle	19			19
	Total	47	3		50
		94%	6%		100%
	Car	6	28		34
B	Motorcycle	3	13		16
	Total	9	41		50
		18%	82%		100%
	Car	6	14	14	34
C	Motorcycle	2	10	3	15
	Total	8	24	17	49
		16%	49%	35%	100%

Mean speed at point ‘a’, point ‘b’ and mean speed reduction for humps A, B and C were recorded in Table 5. Table 5 showed that there were statistically significant decreases in mean vehicle speed occurred between point ‘a’ and point ‘b’ for humps A, B and C. Through paired samples t-test, the significant differences of data point ‘a’ and point ‘b’ for hump A, B and C were shown. The values of t for hump A, B and C were 16.919, 25.068 and 18.523 respectively. Paired samples correlations also showed that the mean speed at point ‘a’ was highly significant correlated with the speed at ‘point ‘b’. The coefficient correlation between 'point a' and mean speed 'point b' were 0.656, 0.758 and 0.168 respectively.

Table 5: Paired Samples Test for 'point a' and 'point b'

Hump	Mean Speed & StdD at point 'a'	Mean Speed & StdD at point 'b'	Mean Speed Reduction	N	Paired samples test t	Sig	Correlation Coefficient	Sig
A	26.84 4.24	19.12 3.20	7.72 3.23	50	16.919	0.000	0.656	0.000
B	44.50 7.75	26.26 6.84	18.24 5.15	50	25.068	0.000	0.758	0.000
C	44.20 6.15	22.20 4.65	22.00 8.31	49	18.523	0.000	0.168	0.000
Total	38.48 10.34	22.53 5.88	15.95 8.45	149	23.035	0.000	0.577	0.000

The study showed that there were differences in the mean speed reduction among the three humps. The results showed that the observed significance level is 0.000 for the mean speed at point 'a', point 'b' and the mean speed reduction at humps A, B and C, where F ratios are 131.937 ($p < 0.05$) at point 'a', 24.434 ($p < 0.05$) at point 'b' and 77.518 ($p < 0.05$) respectively for the speed reduction. From analysis of correlation, means speed reduction were highly correlate with the design of speed humps, with the level $r = 0.692$, $p = 0.000$. Therefore, hypothesis 1.1, 1.2 and 1.3 were rejected.

1.1 H_0: There is no significant difference of means speed among the humps at point 'a'.
1.2 H_0: There is no significant difference of means speed among the humps at point 'b'.
1.3 H_0: There is no significant difference of means speed among the humps for the speed reduction.

Results showed that there was statistically significant difference in mean speed between car and motorcycle at point 'a', where $F = 6.283$ and $p < 0.05$. Thus hypothesis 2.1 was rejected. Data also showed that there was statistically significant difference in mean speed reduction between car and motorcycle, where $F = 4.890$ and $p < 0.05$. Hence, hypothesis 2.3 was rejected. But there was no significant difference between car and motorcycle for mean speed at point 'b'. Hypothesis 2.2 was not rejected.

2.1 H_0: There is no significant difference of means speed between car and motorcycle at 'point a'.
2.2 H_0: There is no significant difference of means speed between car and motorcycle at 'point b'.
2.3 H_0: There is no significant difference of speed reduction between car and motorcycle.

The multiple comparison test had shown that pairs of differences were significant for the main result that there was significant difference of mean speed reduction at humps A, B and C. Therefore, from the descriptive statistics (in Table 4) it can be concluded that the speed reduction of side C was the highest, and followed by side B and A.

Hypotheses 1 and 2 were about the main effect of hump and about types of vehicle. All these hypotheses were rejected, except hypothesis 2.2. However, hypothesis 2.2 was not about speed reduction, it was speed at 'point b'

Discussion and Conclusion

Vehicles which traveled with the speed more than 40km/hr in a residential area were considered speeding in the area. In this study, vehicles at site B and site C were speeding. Vehicles at site A traveled with a low speed. The 85^{th} percentile speed on hump A indicating that a speeding problem did not exist on site A. From the measurement of mean speed at approaching the humps, site B and site C need a speed hump because most of the vehicles in the area were speeding.

An evaluation of the 85th percentile speeds indicated that the speed hump effectively reduce 85th percentile speeds at all humps. Also, from Table 4, it showed that mean speed at the hump was below 40 km/hr for all the humps. The mean speed at the hump was under the speed limit in a residential area. But, the mean speed did not achieve mean speed of the speed limit while crossing the hump. This is because the mean speed at hump B was 26.24 km/hr comparing to hump A was 19.12 km/hr and hump C was 22.20 km/hr.

The two-sample t-test or the approximate two-sample t-test was used to compare differences in mean speeds between the speed approaching the humps and speed while crossing the humps. The speed data collected at Hump C indicated that the highest speed reduction occur at this site. Hump C gave a better design in terms of speed reduction. Shortly, the result showed that Hump C successfully reduced the mean speed to the speed under the speed limit of 25km/hr and it also achieved the highest speed reduction among the three humps.

Nevertheless, the amount of speed reduction also depends on the speed approaching the hump. In terms of types of vehicles, speed of car will reduce more if compare to motorcycle. This is because of the impact of sudden jerk or uplift force is more on car than motorcycle.

Coclusion

From analysis of speed reduction for different types of vehicle at speed approaching the humps and speed while crossing the humps, it resulted that the mean speed reduction may cause by the speed at approaching the humps. The speed reduction was highly and positively correlated at speed approaching the humps.

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