EFFECT OF HUMP SPACING ON SPEED SELECTION OF ISOLATED VEHICLES: THE CASE OF EXCLUSIVE VILLAGES IN METRO MANILA

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Abstract: This research was conducted primarily to determine the relationships between hump spacing and the speed selection of isolated vehicles in residential street environments. The speed profile of each of the observed isolated vehicle was used to determine the speed selection patterns of drivers in selecting their speed within a given road hump interval. The effect of hump spacing and its relationship with average speed, 85^{th} and 95^{th} percentile speed and maximum speed were analyzed using regression. Approximately 80% or more of the vehicles traveling within a hump interval of 48m and 178m apparently reached their peak speed within the third quarter of the hump spacing. This study shows that hump spacing appears to be strongly related to maximum speed. Likewise, this study shows that cruising speeds seem to be attainable only for hump spacing about 118m and above.

Key Words: Speeds, Profile, Speed Selection, Humps Spacing, and Danger Zone

1. INTRODUCTION

Traffic calming is widely recognized as necessary, mainly because of the hazard that speeding vehicles bring if not controlled. This is true especially for streets in residential areas where pedestrian movement should be given preference over the fast passage of motor vehicles. Traffic calming is an effort to use various traffic management devices to address concerns about speed, cut through traffic, and safety on neighborhood roads (Patel, Sayer and Tiwari, 1994). Because of the potential problem caused by excessive vehicle speeds especially in residential areas, remedial measures have been implemented by introducing traffic calming devices to reduce the speed of vehicles effectively. An example of such device is known as road hump. Proper construction of road humps is very important. Improperly constructed humps can cause serious damage to vehicles and discomfort to passengers even at moderate running speeds. Local authorities in residential areas responsible for the construction of road humps should have adequate knowledge on the proper approach to construct them. Road humps should give less negative impact to vehicles and their occupants, while still achieving the reduction of vehicle speed.

In the Philippines, road humps vary in terms of dimensions and materials used for constructing them. The length of the humps can reach 12 ft but some may be shorter than 4 inches. Likewise, the height of humps can be as high as 6 inches and as low as 1 inch. As to the materials used for constructing /installing road humps, ***concrete*** and ***bituminous asphalt*** are the most common though there are many isolated cases where ***worn out tires***, and ***coco-lumber*** are used as road humps.

The Philippines has no local standards for the installation and construction of humps, some engineers and constructors construct humps in residential areas that are too close to one another or the interval is too short. As a result, vehicle riders become irritated due to the uncomfortable ride brought about by improperly constructed humps. This problem is very evident in residential areas where road humps are designed and placed in a manner that do not only restrict vehicle speed but also cause discomfort to passengers and even damage to vehicles.

This research focused on determining the relationship between driver's speed selection and different spacings and dimensions of humps. The results of this study may serve as a reference in formulating local guidelines and design standards on humps as a traffic calming measure in the Philippines. Specific objectives of this study include the following:

- To determine the relationship of the average and maximum speed selection of isolated vehicles with respect to spacing of humps.
- To be able to explain how these relationships can be used in the proper installation of humps.
- To be able to suggest guidelines, criteria, and design standards for the construction of road humps appropriate to the country's local conditions.

2. SCOPES AND LIMITATION

This study was limited on the analysis of speed selection of isolated vehicles in relation to hump spacing in some residential streets in Metro Manila. The effects of road geometry and intersection geometry were not included except hump spacing and design. Only road humps having a length greater than 1.22 m (4 feet) and spacing of not more than 200 meters were considered. A street section that is straight and flat and has a width above 8.5 meters was considered. Data collection was limited to exclusive villages only. The subject vehicles for data collection were only cars and vans that were isolated in nature (i.e., no vehicle was traveling at the same time with the observed vehicle, whether it was behind, in front or on the opposing lane). Past studies indicated that the presence of another traveling vehicle on the same street significantly influenced the speed selection behavior of the driver (Pitcher, 1989).

The following briefly describes the criteria adopted in selecting the study area.

- Driver must be familiar with the selected street environment – minimized the effect of psychological factor due to unfamiliarity of place. This can be done by selecting exclusive villages as a study area with the assumption that a majority of the driver if not all are from the villages and are familiar with the street environment.
- Road width must not be less than 8.5 meters – low interference or side friction (i.e., parked vehicles)
- Road humps must be well painted – for visibility
- Length of road humps must not be less than 1.22 m (4 feet) – fairly comfortable ride at moderate speed; shorter hump can be easily straddled by high speeding vehicles

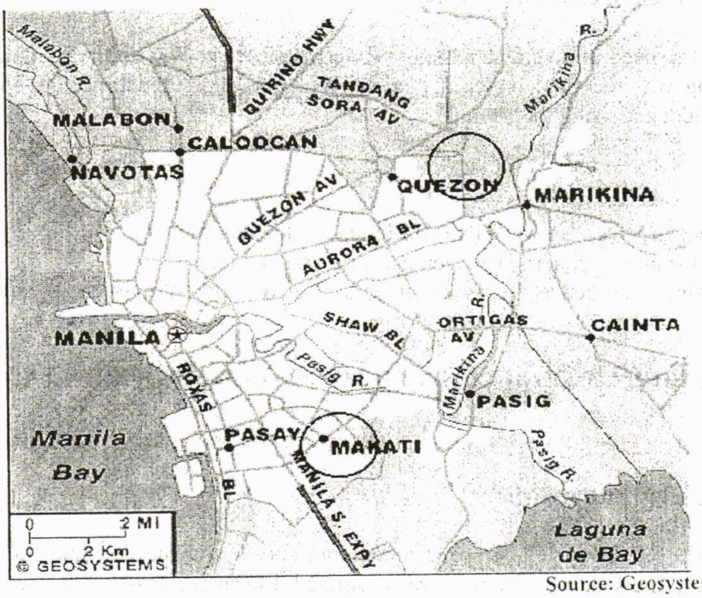
Other physical aspects such as road surface condition, straight and level road section were also included in the site selection. Trucks, buses, jeepneys, and motorcycles were not considered. Due to some constraints, (i.e. limited time and resources for the study and the unavailability of records or database of villages in Metro Manila who are presently using humps as a speed control measures, the author find it very difficult to select or identify villages whose environment meet the criteria mentioned in Section 2), there were only six (6) hump spacings covered from five different street sections. Two of the six spacings were taken from a single street since a third hump was placed at the mid block section of the street.

3. DATA GATHERING

3.1 Study Area

The study area comprises of two exclusive villages in Metro Manila particularly in Quezon City and Makati City (See Fig. 3.1). These are the La Vista Village in Quezon City and Dasmariñas Village in Makati City. The two villages are considered to be among the most modern residential villages in Metro Manila which shelters affluent families, foreign capitalists, business tycoons and industrial titans.

Dasmariñas Village is located within the CBD of the new town of Makati City. It is bounded on the northeast by the barangay of Forbes Park, on the northwest by the EDSA avenue, a major thoroughfare in Metro Manila and by the Barangay of San Lorenzo, on the southwest by the barangay of Magallanes and on the southeast by the barangay of Post Proper South. It has 1,090 lots with a total land area of 1,300,000 m^2.



Source: Geosystems

Figure 3.1: Location of Selected Villages with Humps in Metro Manila As Study Area

La Vista Village on the other hand is located at barangay Pansol, Quezon City. It is bounded on the north by the MWSS Balara Homesite, on the south by the Miriam High School Campus, on the east by Barangay Malanday of Marikina City, and on the Marikina City, and on the west by Katipunan Avenue and UP campus. It has a total land area of 123,260 m^2 that comprises a total of 303 lots.

Due to lack of standards in the installation of humps in residential streets in Metro Manila, the preliminary survey was aimed to provide the basic requirements needed for the formal survey.

This study covered six (6) different hump spacings from five different streets in two Metro Manila residential villages namely: Kamias Street, Mahogany Street, Dasmariñas Street, Lumbang Street in Dasmariñas Village, Makati City and Bagobo Street in La Vista Village, Quezon City. These streets were classified as minor roads as stipulated in Presidential Decree 957.

3.2 Speed Data Collection

To obtain sufficient information on the derivation of relationship between vehicle speed and distance traveled along a street having humps at both ends, a series of observation markers of predetermined spacing was installed. The predetermined spacing between markers usually starts with 5m from the first hump then gradually increased to 7, 10, 12, 15 etc up to the first half of the total hump spacing. The same manner will be done on the other half forming a symmetry with respect to the mid-block section so that vehicle coming from both directions can be treated similarly. The largest spacing between markers used is 22.5m near the middle for the longest hump spacing of 178 m, since at this spacing, the vehicle is assumed to travel at relatively high speed. A series of stopwatch operators was assigned to record the time each vehicle crosses a pair of consecutive markers.

To determine the speed of a vehicle passing between a single pair of observation markers, the time of passing was recorded for each marker. With this measured time, the speed of the vehicle was calculated using the formula:

$$V = 3.6*L/T \qquad (1)$$

Where: V = Mean Speed Between Pair of Markers, kilometer per hour
L = Distance or spacing between pair of markers, meter
T = Time recorded as the vehicle traverses between pair of markers, second.

4. RELATIONSHIP OF VEHICLE SPEED TO ROAD HUMP DESIGN AND SPACING

4.1 General Analysis Approach

The relationship between average speed, maximum speed, and the 85^{th} and 95^{th} percentile vehicle speeds to the spacing of humps was examined. Linear regression was used to develop a mathematical model describing the relation between different speeds with respect to hump spacing. The 85^{th} and 95^{th} percentile speed were primarily used in the analysis aside from the average speed due to the following reasons: the 85th percentile speed is the speed at or below which 85 percent of free flowing vehicles are traveling. This is usually the basis for the posted speed limits especially in residential streets where pedestrian safety is a concern. Similarly, the 95th percentile speed is also an important parameter in the design of roads, since design speed of road is usually based on this parameter. Also, this study analyzed the critical area in which most vehicles attained their peak speed including the length of acceleration, cruising and deceleration. The effects of geometric configuration of road humps on speed selection of isolated vehicles were also analyzed.

4.2 Analysis of Speed Selection Pattern

Though this study had a limited number of observed vehicles (378) and hump intervals six (6) the data gathered were able to show some significant results in the way drivers of isolated vehicles select their speed. Figure 4.2 shows the speed profile of each vehicle for each direction of travel in between two humps. Each graph of the speed profile is oriented such that vehicles are entering from the left side of the plot. The graphs show that each plot of the speed profiles of a majority of the vehicles is skewed to the right. This shows that the driver normally accelerates gradually as he leaves the entrance hump up to a point where maximum speed is reached, then decelerates relatively faster while approaching the exit hump.

To know the proportion of vehicles attaining a certain maximum speed, the maximum speed each vehicle attained was categorized and analyzed (Table 1). From this, the maximum speed likely to be attained by a majority of the passing vehicles relative to the spacing between two humps can be analyzed. An important observation that can be drawn from the given Figure is that, a significant proportion of vehicles reached a maximum speed above 50 km/h for all streets with hump spacing above 100m, but no vehicle reached a maximum speed above 40km/h in a street with hump spacing of 48m and 54m. The European Transport Safety Council (1995) report that only 5 percent of pedestrians died when struck by vehicle traveling at 20 mi/h (32 km/h); however, the proportion of fatalities increased to 45 percent at 30 mi/h (48km/h) and to 85 percent at 40 mi/h (64 km/h).

Table 1: Proportion of Vehicles Attaining Maximum Speed in Between Hump Spacing.

NAME OF STREET	Direction	Spacing of Humps	Percentage of Vehicles According to Classification of Maximum speed Attained						
			<20kph	21-30kph	31-40kph	41-50kph	51-60kph	61-70kph	>71kph
Mahogany Street	Southbound	48	0	45	55	0	0	0	0
Mahogany Street	Northbound	48	0	22	78	0	0	0	0
Kamias Street	Southbound	54	4	61	35	0	0	0	0
Kamias Street	Northbound	54	0	75	25	0	0	0	0
Lumbang Street	Southbound	118	0	0	28	50	22	0	0
Lumbang Street	Northbound	118	0	0	20	53	27	0	0
Bagobo Street	Southbound	120	0	0	21	53	26	0	0
Bagobo Street	Northbound	120	0	7	49	36	7	0	0
N-Dasma Street	Southbound	163	0	0	53	41	6	0	0
N-Dasma Street	Northbound	163	0	0	7	56	37	0	0
S-Dasma Street	Southbound	178	0	0	28	47	25	0	0
S-Dasma Street	Northbound	178	0	0	10	56	29	5	0

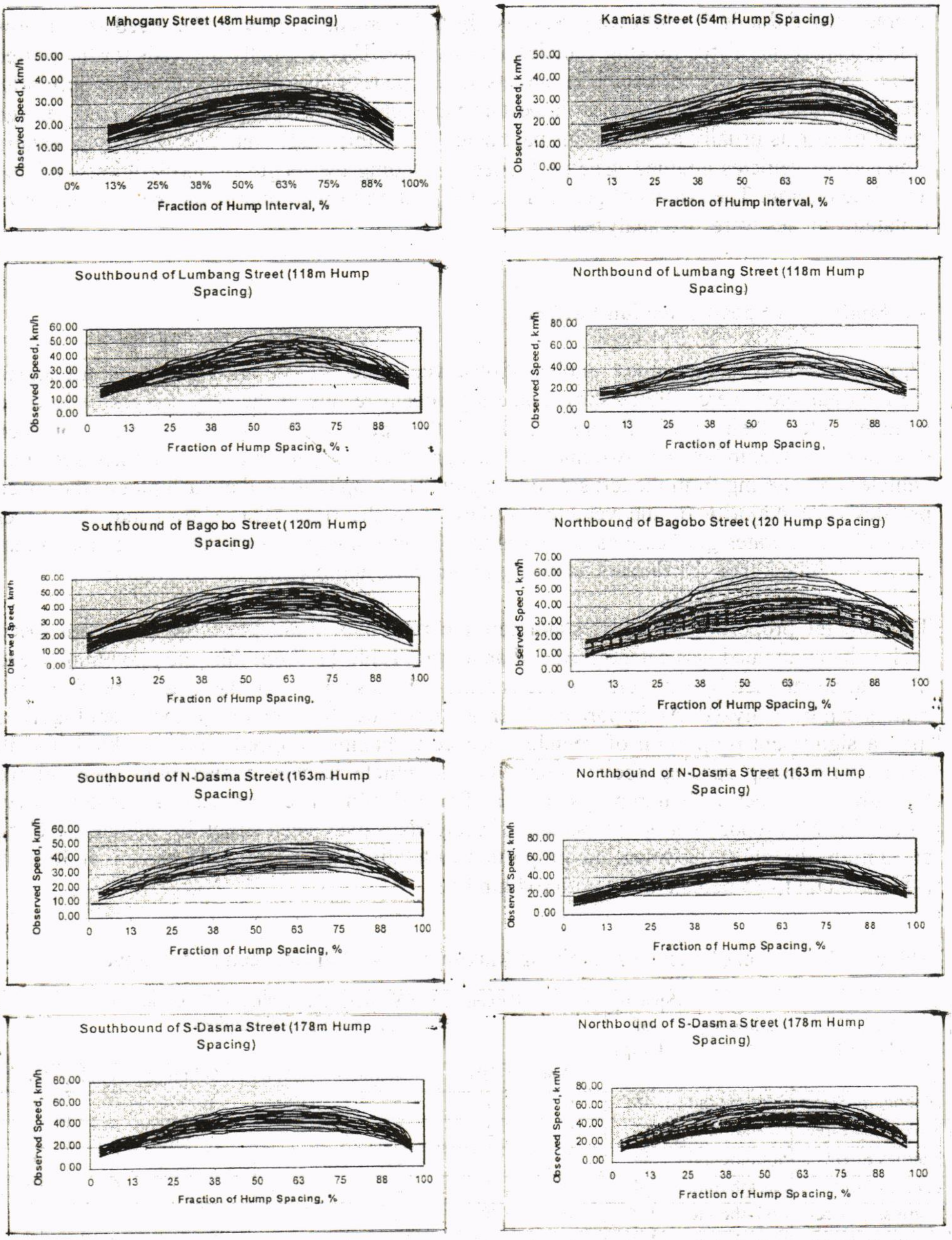


Figure 4.2 Speed Profile Diagram

4.3 Identification of Danger Zone Relative to Maximum Speed Attainment

For the purpose of this study, the term critical area or "Danger Zone" refers to the segment or quarter of hump spacing in which majority of the passing vehicles reach their peak speed. To determine the critical area or section in which individual vehicle attained its maximum speed, the distance between two humps was divided into four quarters. Table 2 below shows the proportion of individual vehicles attaining maximum speed within the specified quarter. The percentages show that most of the observed isolated vehicles attained maximum speed in the middle two quarters of the street. The majority of which reached its peak speed in the third quarter of hump spacing. Considering that a vehicle is traveling in the direction from first quarter to fourth quarter, the critical area in between hump spacing was found to be in the third quarter. In addition, the second quarter is also considered a danger zone or critical area considering that the vehicle is traveling or coming from the opposite direction. Table 2 also shows that there were instances when the maximum speed was attained at the fourth quarter of hump spacing. Furthermore, 80% or more of the observed vehicles reached their maximum speed within the third quarter of the six different hump spacings. The critical section in which majority of the passing vehicles attained their peak speed is depicted in Figure 4.3.

Table 2: Proportion of Vehicles Attaining Maximum Speed at Specified Quarter

Name of Street	Street Length (M)	Quarter in which Individual Vehicle Attained Maximum Speed				Total number Of Observations
		1st	2nd	3rd	4th	
Mahogany Street	48	0%	17.69%	82.31%	0%	45
Kamias Street	54	0%	20.29%	79.71%	0%	35
Lumbang Street	118	0%	2.13%	95.74%	2.13%	47
Bagobo Street	120	0%	3.57%	94.64%	1.79%	112
N-Dasma Street	163	0%	4.30%	95.70%	0%	47
S-Dasma Street	178	0%	9.89%	90.11%	0%	91

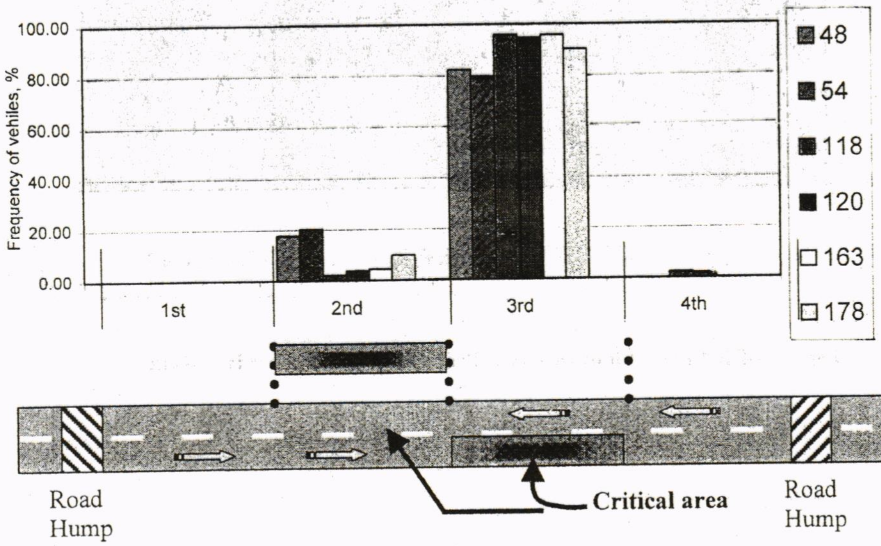


Figure 4.3: Location of Critical Area in Relations to Hump Spacing

4.4 Relationship of Post Entry Speed to Hump Design Using Height and Length of Humps

An attempt was made to investigate the relationship between entry speed and height and length of humps, but this was not successful. When considering the relationship between the ratio of the height and length of humps (*H/L ratio*) and the different entry speeds, only the average entry speed was explained to a limited degree as shown in Fig. 4.4.1. A 2-tailed t-test was also performed to verify for the average post entry speed. By considering the level of significance of 10%, the slope of the line for the average post entry speed is significance but not at 5% level of significance. This implies that at 10% level of significance, higher H/L ratio generated lower average post entry speed. It should be noted that the H/L ratio is an indicator for the gentleness of hump at which the smaller the ratio the more comfortable is the ride while crossing the humps. The result of the model of the 85th and 95th percentile speed suggests that the H/L ratio is not a good explanatory variable to describe initial speed or post entry speed. Effort was also made to relate entry speed with height and length separately but again showed only a slight association. Average post entry speed was not associated with the height or the lengths of hump (Fig 4.4.2 and Fig 4.4.3). This lack of association may be due to the differing attitudes or preference of the driver in selecting his post entry speed.

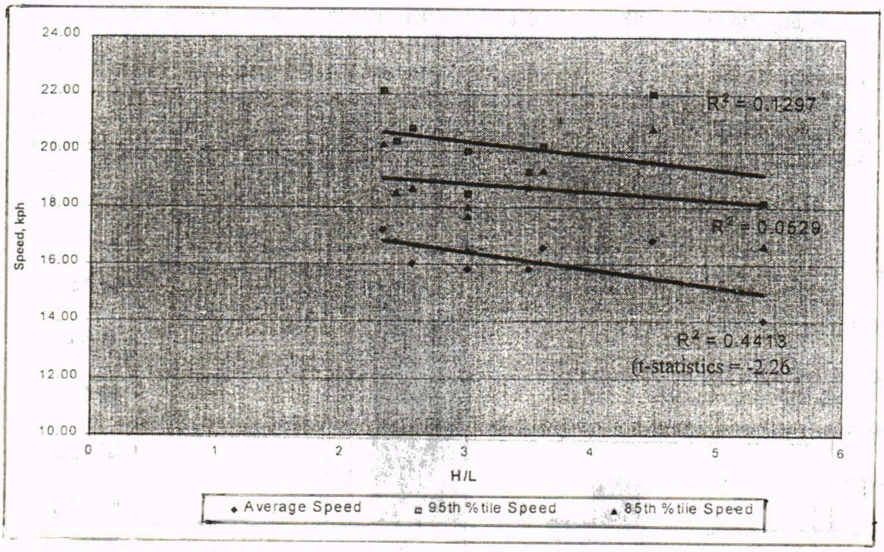


Figure 4.4.1: Linear Fit of Different Post Entry Speed using H/L Ratio

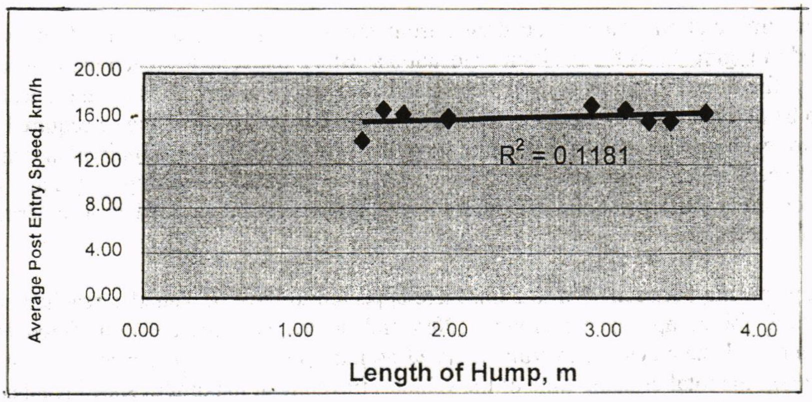


Figure 4.4.2: Post Entry Speed vs. Length of Hump

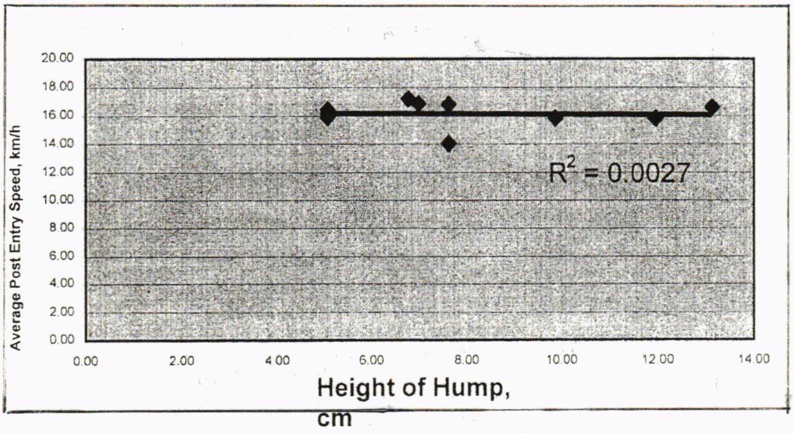


Figure 4.4.3: Post Entry Speed vs. Height of Hump

Nevertheless, the linear fitting in Fig 4.4.1 shows an indication that as the H/L ratio increases the post entry speed also decreases. There are also indications that some drivers used to start accelerating while the rear wheels of the vehicle they are driving are still at the off-ramp of the speed hump. Likewise, others start accelerating after the rear wheel already clears the road hump or some drivers accelerates at either severe or moderate rate. These behavioral differences can be observed from a large variation and inconsistent post entry speed being recorded in the site. Likewise, the mean of post entry speed for majority of humps fall within 15-17.5 km/h ranged.

4.5 Relationship of Maximum Speed to Length of Acceleration and Deceleration

Important information that can be drawn from the speed profile diagram of the vehicles presented in Figure 4.5 is the position or location at which the vehicles reach their peak speed. Similarly, the three components of vehicle speeds, i.e., acceleration, cruising and deceleration can also be derived from the speed profile diagram. In this study, the distance required for the vehicle to reach its maximum speed while traveling between two humps interval is termed the length of acceleration. Similarly, the distance measured from the exit hump at which a vehicle start to decelerate after gaining maximum speed and or cruising speed is also termed the length of deceleration.

For hump spacing between 48m to 54m, there appeared to have no vehicles reached cruising speed while for hump spacing around 120m and above, vehicles are considered to have already attained their desired maximum speed as indicated by the presence of the cruising speed. When the total cruising time of the vehicles traveling at maximum speed reached more than 3 seconds, the said vehicle was assumed to have not affected by the spacing of the hump. Furthermore, Figure 4.5 seem to indicates that drivers were not directly affected by hump spacing above 163m although this needs further research and thorough investigation. For hump spacing above 120m, a considerable portion of vehicles traveled at constant speed greater than this value.

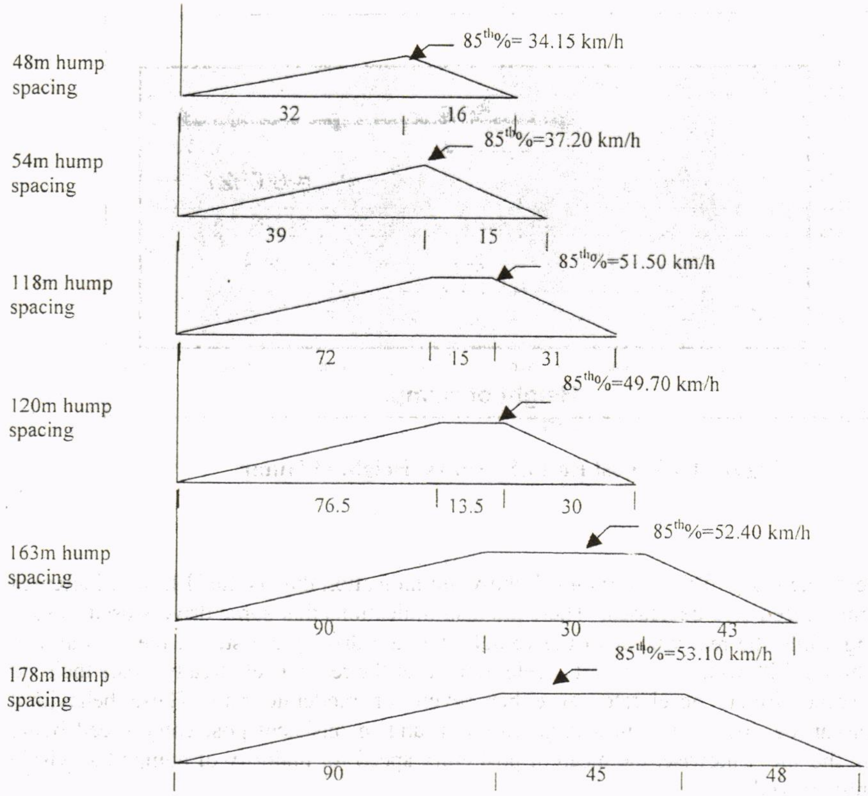


Figure 4.5: Plot of the 85th percentile speed versus hump spacing comprising three behavioral components (Acceleration, Cruising, and Deceleration)

4.6 Relationship of Vehicle Speed to Hump Spacing

The maximum speed attained by the individual vehicle was computed and the average of the maximum speed including the 85th and 95th percentile speed was then determined. A model relating vehicle speed to hump spacing from the six different streets observed was derived using linear regression analysis. The average speed of each vehicle observed per street or hump spacing was also computed. As explained in the earlier part of this chapter, the logic of primarily using 85th and 95th percentile speed in this study was mainly for the following reasons: traffic engineers generally use the 85th percentile speed to represent traffic speeds on a particular street. Ideally, the 85th percentile speed on street is equal to the posted speed limit or is usually the basis for the posted speed limits, with only 15 percent of the vehicles traveling above the posted limit (ITE's Transportation Planning Handbook, 2nd Edition, 1998). Similarly, the 95th percentile speed is also an important parameter in the design of road, since design speed of road is usually based on the 95th percentile representative speed. The generated result of linear fit of the average of the maximum speed, 85th, 95th percentile representative vehicles speed is shown in Fig 4.6. The model shows that as the hump spacing increased from 48 m to 178 m, the average of the maximum speed of the vehicles would also increased from 31 km/h to as high as 48 km/h. The 85th percentile speed ranges from 36 km/h to as high as 55 km/h. Likewise, the 95th percentile speed ranges from 37 km/h to as high as 61 km/h for the same range of hump spacing. R-square is highest for model using hump spacing to explain the 95th percentile representative speed. For all models, hump spacing appears to be a very useful explanatory variable to explain the inter-hump speed, although more data are needed to produce a more statistically supported conclusion.

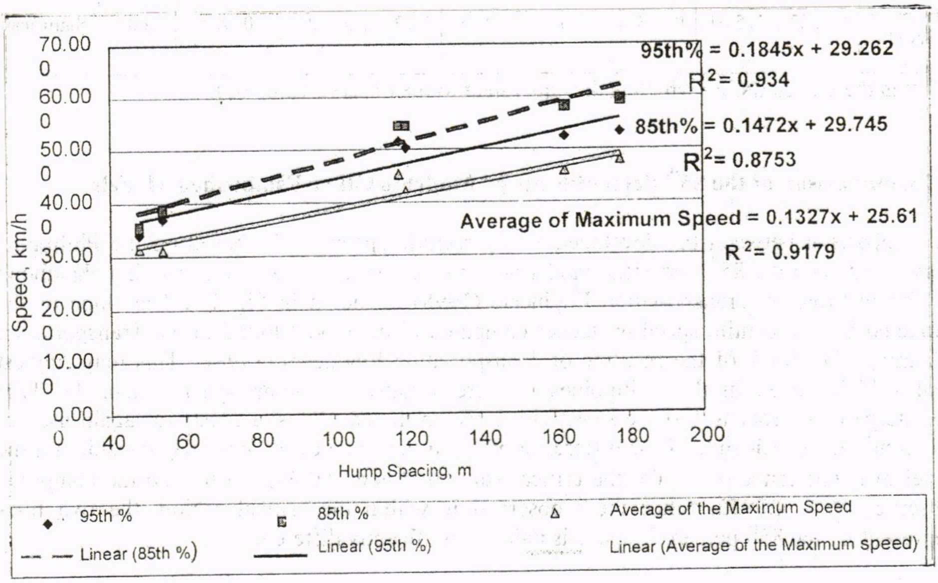


Figure 4.6: Linear fit of Different Speeds vs. Hump Spacing

The graph further indicates that drivers are less sensitive to the residential street environment specifically to pedestrian's safety as shown by the slope of the line of the 85th and the 95th percentile speed. These results might be partly attributed to the driver's familiarity to a given residential street environment, since a large portion of the drivers were assumed to be regular users of the roads. A t-test of significance was then performed to validate the usefulness of the derived equation of lines (see Table 3).

Table 3: Summary for t-Test Analysis of the Generated Line of Best Fit

Speed	Equation Line of best fit	R^2	Degree of Freedom, df	α	$t_{critical}$	b_1	S_{b1}	t^*	Conclusion
85th %tile	0.1472x+29.745	0.875	4	0.05	2.13	0.1472	0.027778	5.299	Significant
95th %tile	0.1845x+29.262	0.934	4	0.05	2.13	0.1845	0.024521	7.523	Significant
Average of the Average speed	0.0907x+19.007	0.973	4	0.05	2.13	0.0907	0.007516	12.07	Significant
Average Speed	0.0905x+19.028	0.467	375	0.05	1.65	0.0905	0.004996	18.11	Significant
Average of the Maximum Speed	0.1327x + 25.61	0.918	4	0.05	2.13	0.1327	0.01985	7.003	Significant

t^* = is the test statistic t which is the equivalent to the observe value of t.

4.7 Comparison of the 85th Percentile Speed Model to Other Established Models

A comparison between the developed 85th percentile speed model based on the Philippine survey data and the 85th percentile model presented in the Transportation Planning Handbook of the Institute of Transportation Engineers (1998) is shown in Fig 4.7. The slope of the modeled 85th percentile speed is steeper compared to the model found in the Transportation Planning Handbook of the Institute of Transportation Engineers (1998). This may suggest that vehicle speed in the Philippines is more sensitive to hump spacing than the TPH counterpart. In order to test the sensitivity between the two lines, a t-test was again used to examine the significance of the difference between the slope of the lines. By considering the level of significance $\alpha = 0.05$, the critical value of t is $t(10,0.05) = 1.81$ and the computed observed $t^* = 4.0975$. Since the t observed is within the critical region, the two lines representing the 85th percentile speed is indeed significantly different.

It should be noted that, it is very difficult to determine the exact amount and position as to where the maximum speed was really reached within a given hump interval. The derived models were only assumed to predict the approximate maximum speed given a specified hump interval.

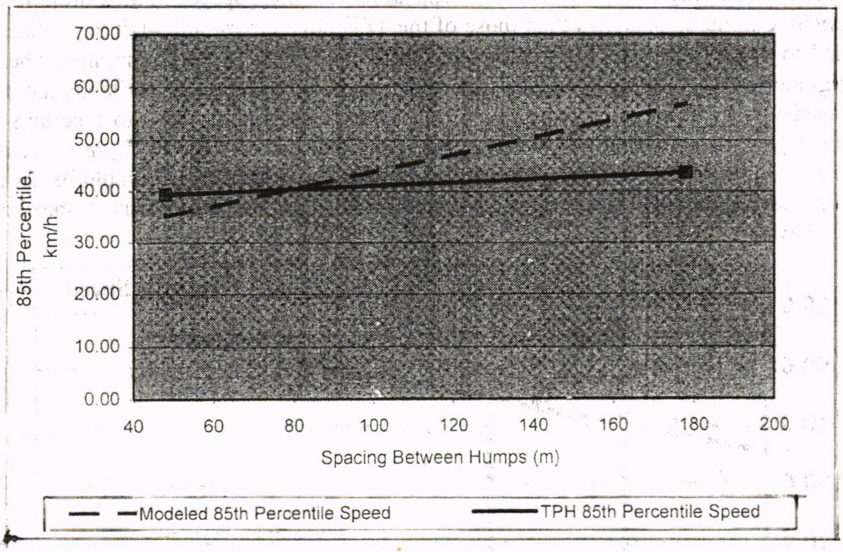


Figure 4.7: Comparison between the modeled 85th Percentile and the TPH 85th Percentile Speed

5.0 IMPLICATIONS TO HUMP DESIGN

Figure 4.2of page 6 shows that a driver normally accelerates gradually as he leaves the entrance hump, up to a point where maximum speed is reached, then decelerates relatively faster while approaching the exit hump. This is shown by the speed profile for all vehicles being skewed to the right when traveling through hump interval.

The percentage of vehicles attaining maximum speed also indicates a significant portion of vehicles reaching the peak speed above 50 km/h for all humps spacings above 100m. This result may be a cause for concern to local authorities since the fatality rate of pedestrians against impact speed is very high. In a recent review, the European Transport Safety Council (1995) reported that approximately 5% of pedestrians died when struck by a vehicle traveling at 32 km/h (20 mi/h). However, the proportion of fatal injuries increased to 45% as the speed increased to 48 km/h (30mi/h) and the figure of fatal injury becomes even higher when the speed is above 60 km/h.

The critical section in which majority of isolated vehicles reach their peak speed was identified by dividing the distance or spacing between two humps into four equal distances. The drivers apparently reached their peak speed within the third quarter of the hump's interval although this maximum speed varied greatly among the drivers. Nevertheless, efforts have to be made to address this initial finding such that new safety measures (e.g., road sign) are developed to make pedestrians alert when crossing the street in the prescribed quarter known to be a critical area (Fig. 4.3, p7).

By comparing the 85th percentile speed model and that of the model found in the ITE's Transportation Planning Handbook (TPH), it appears that vehicle speeds in the Philippines are more sensitive to hump spacings than those of the TPH counterpart, although more data may be needed to produce a more statistically supported conclusion. In the Philippines where no definite guidelines on the proper construction and placement of humps is available, the model is very useful when it comes to controlling the vehicle's maximum speed to a certain level especially when local condition is a factor. For example, by referring to Figure 5.1, if the maximum speed were restricted to within 40 km/h, then the hump spacing should be about 65 meters. Increasing the spacing to 100 meters would also mean that the maximum speed could reach at 45 km/h.

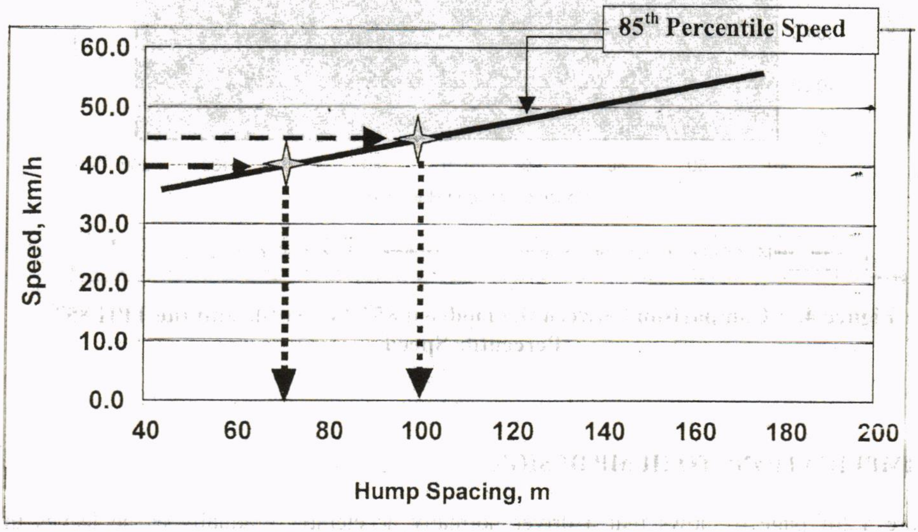


Figure 5.1: Model of the 85th Percentile Maximum Speed

With the assumption that a higher initial speed or post entry speed would result in higher maximum speed attain, the plot of the post entry speed against maximum speed attained for all six spacings was investigated and analyzed. Although this study did not capture the speed of the vehicles while crossing different humps, past study indicated that the hump crossing speed had relatively little effect on the maximum speed attained if the crossing speed was 24 km/h (15mi/h) or less. In this study it was assumed that the post entry speed was greater than the crossing speed. Out of the 378 total samples, 99.74 % of the observed isolated vehicles did not exceed a post entry speed above 24 km/h, which may be the cause for a low correlation to maximum speed attained.

Relationship between the post entry speed was investigated in order to know whether this post entry speed can be explained using height and length of humps as the explanatory variable. However, only the average initial speed was explained to a limited degree. Likewise, the height(H), length(L) and H/L ratio were not found to be a good explanatory variables to describe initial speed. Given such circumstance, the above graphs suggest that initial speed itself may only be controlled to a limited degree when it comes to the design aspect of humps.

This study shows that in all the models generated, hump spacing appears to be a very useful explanatory variable for maximum speed. The models show that if road hump spacing is increased from 48m to 178m, the average of maximum speeds, the 85th and the 95th percentile speeds would also increase from 32 km/h, 37 km/h, and 38 km/h to as high as 49 km/h, 56 km/h, and 62 km/h respectively. In addition, the said model presented in Fig. 4.20 can predict the desired hump spacing for target 85th percentile maximum speed of not less than 33 km/h. This is due to the fact that there were not enough humps with shorter spacings, say, less than 40m, that were observed, and that would probably provide lower possible speeds.

The use of the speed profile as a tool to provide different information on the driver's behavior is very effective especially if it involves the determination of the amount and location at which the maximum speed is attained. However, the validity of the information generated is largely dependent on the instrument used and the input data. If a similar study will have to be done in the future, efforts should be made to improve data collection by using modern sophisticated instruments to collect vehicle speed such as the electro-mechanical treadle sensor and the optical detector. Due to limited time and resources, this study was only able to observe six different hump spacings. It is strongly recommended that further study should be done considering more hump spacings with varying lengths especially between the gaps from 54m to 118m and between 120m to 163m hump intervals.

Traffic calming measures such as road humps have been shown to be valuable in modifying the speeds at which drivers choose to travel. However, there has been some concern that the benefits might have been at the expense of the increased traffic noise and other environmental impacts, thus, the impact caused by noise and vibration of vehicles at different hump designs and intervals should have to be addressed for future research.

Finally, efforts should also be made to incorporate the residents' perception on the impact of different design aspects of road humps in residential areas in the country.

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