

A Review of Literature on the Effects of Road Hump on Traffic Speed and Traffic Noise in Institutional Area

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Abstract

Traffic speed and noise are the major transport-related determinants in affecting the quality of learning and research environment in a University. The calm and safe environmental set-up of a University is very crucial in creating a conducive learning and research atmosphere on-campus. The increasing number of private vehicles on-campus has resulted in the increase in speed and noise level and thus has attributing towards an increase in environmental pollution on-campus. Road humps are considered effective as a traffic calming measure in reducing speed and noise level of the moving vehicles. However, the imminent reduction in the speed of the vehicles depends very much on the profiles of a road hump in terms of its width, length and height. The difference in the profiles of the road hump will cause changing driving behavior of the users, especially when approaching a road hump. Thus, this paper is part of the ongoing study to analyse the effectiveness of road hump as a traffic calming measure in the campus area. The literature on traffic calming in Malaysia is highlighted in this paper.

Keywords: traffic calming measure; road hump; traffic speed; noise level; institutional area

1. INTRODUCTION

A healthy, conducive and safe learning and research environment are vital for active involvement in research and learning activities. But, the increase in private vehicle use on-campus has caused an increase in speed and noise level and thus caused deterioration on campus environment. Huang and Cynecki (2000) noted that traffic calming is a viable solution for the deterioration of living conditions caused by increased vehicle speed and noise by giving an impression that the road is not meant for high-speed traffic. Considering several possibilities of traffic calming measures, several researchers have suggested that road hump has the ability to effectively control the speed and noise of the moving vehicles. The analysis of fatal and injury accident data on the road sections with vertical traffic calming measures shows a significant decrease in fatal and injury accidents after the installation of this measure. Jateikienė *et al.* (2016) mentioned that the rate of fatal accidents declines 60% while, the number of people with injuries decreases by 63% after the application of road humps. On the other hand, Traffic Advisory (1994) highlighted that the presence of a speed cushion or road humps can result in a substantial drop in traffic noise levels. Meanwhile, Desarnaulds *et al.* (2004) mentioned that a report on the towns of Slough and York shows that the reduction of noise level and the difference in speeds between the cushions, from 2 to 12 km/h, is 0.45 dBA/km/h. However, the

effectiveness of road hump on the change in vehicle speed and noise level in an institutional area has yet to be investigated in depth. As mentioned by Hui Min and Che Ros in their study, road humps have been implemented in Malaysia especially in the residential area but the effect of road hump installation in reducing the speed of vehicles in campus area is not well explored. Besides, the study by Bachok *et al.* (2016) also focusing on the effect of road hump in a residential area.

From the literature study, the road humps with different design characteristics in terms of its width, length and height have resulted in changes in driving behavior of the users when approaching these road humps. As a result, it is observed that road humps at a certain locations has provided positive effects in reducing the speed and noise level but at the same time, it was also observed that other road humps have induced almost no effects on speed and noise level of the vehicles. Thus, it necessitates the importance of knowing the changes in driving behavior of the users especially in terms of speed when approaching road humps with different design characteristics.

2. METHODOLOGY

The method used is a desk study identifying the relevant literature on the road hump effects on speed and noise level in the institutional area. In this study, the design profile of road hump was selected as the variable explaining the effects of road hump on traffic speed and traffic noise.

3. LITERATURE REVIEW

3.1 Traffic Calming

Lockwood (1997) stated that traffic calming is the combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver behaviour and improve conditions for non-motorized street users. Additionally, Pharoah & Russell (1991) also agreed that traffic calming is the attempt to achieve calm, safe and environmentally improved conditions on streets. Moreover, Gulden & De La Garza (2016) added that traffic calming is a kind of measure that helped to increase the quality of life in urban, suburban, and rural areas by reducing automobile speeds and traffic volumes. Overall, researchers agree to several similarities in between their description of traffic calming which are physical measures that are implemented on the desired road as to reduce the speed, improve road safety, positively alter the user behaviour and significantly enhance the environmental conditions on the streets.

Briefly, Rahman *et al.* (2005) stated that the main purpose of traffic calming is to reduce traffic speed and volume concurred with Huang & Cynecki (2000) that the purpose is to reduce traffic volume and speed to levels permissible for a street's functional class and nature of surrounding activities.

3.1.1 Traffic Calming in Malaysia

In Malaysia, the Highway Planning Unit (HPU) under the Ministry of Works has published the traffic calming guidelines in 2002; however, Muhammad Marizwan and Alvin Poi (2010) stated that the traffic calming measures implemented in Malaysia were found to be installed primarily on an ad-hoc basis with no referral to standard and guidelines. The speed limit on-campus of a University is normally 30 km/h or less; however, the lack of standardization may not allow for the speed limit to be achieved due to unanticipated effects and a lack of effectiveness (Parkhill

et al. 2007). Also, Rosli & Kadar Hamsa (2013) mentioned that 12 speed-controlling measures highlighted in the guidelines published by HPU, are categorized under two groups as seen in Table 1.

Table 1. Categories of Traffic Calming Measures by HPU (2002)

Vertical Measures	Horizontal Measures
1. Speed bump	1. Traffic circles
2. Speed hump	2. Roundabout
3. Transverse bar or alert bar	3. Chicane
4. Speed table	4. Choker
5. Texture pavement	5. Centre island
6. Raised crosswalk	
7. Raised intersection	

Source: Highway Planning Unit, 2002

3.2 Road Hump

Residential streets with speed limits do not exceed 25 miles per hour are where road hump or speed humps typically lies (Fazzalaro, 2006). Several researchers agreed that road humps are significantly effective in reducing speed and noise. Webster (1993) claimed that the most effective traffic calming device that capable to reduce speed usually involve some form of vertical deflection, normally in the form of a road hump or raised table. In addition, the original work on the development of speed reducing road humps carried out at TRL resulted in a circular (round-top) hump profile which has been successfully used on roads in many countries (Sayer *et al.* 1999). Also, Smith & Giese (1997) believes that speed humps are a geometric roadway design feature with the purpose of slowing traffic in residential neighborhoods.

3.2.1 Road hump design

The Transport and Road Research Board of Great Britain determined that the ideal design shape for a speed hump was parabolic, 12 feet wide in the direction of travel and four inches high as recorded in 1975 (Clement, 1983; Hallmark *et al.*, 2002). Hallmark *et al.* (2002) also mentioned that at or below the design speed of this type of hump, a driver would experience no discomfort, but above the design speed drivers would experience increasing levels of discomfort as speed increases and has been agreed by Clement (1983). Smith & Giese (1997) asserts that speed humps are designed for public residential roadways that have two lanes or less at a posted speed limit of 30 mph or less, and 85th percentile speeds of 31-34 mph. Moreover, speed humps should be placed in series at 200-600 foot intervals to be more efficient. On the other hand, road humps are not to be implemented on curves, transit routes, or major emergency response routes. Also, Cline (1993) believes that even a quarter of an inch in height over 12 feet will create significant change in prevailing speed. Webster (1993) also highlights that road humps and raised tables are now permitted to be 50 - 100 mm in height and can have flat-tops. Ewing (1999) illustrated several road hump profiles that are commonly implemented on road as per Figure 1.

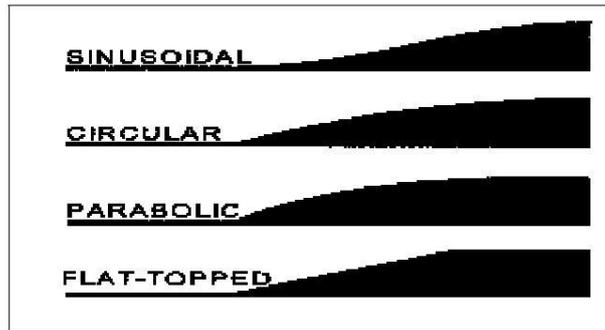


Figure 1. Road Hump Profiles Illustrated by Ewing (1999)

3.2.2 Road Hump Design in Malaysia

Muhammad Marizwan & Alvin Poi (2010) quoted that Highway Planning Unit, Ministry of Works, (2002) has listed non-standard design of road hump as one of the problems in traffic calming implementation in Malaysia (p. 4). Additionally, Highway Planning Unit, Ministry of Works (2002) also mentioned that road hump are raised areas of a pavement typically with a rounded or flat-top, usually 3.5 m to 4.0 m wide and 3.65 m, 6.71 m and 9.14 m long. Road humps also have profiles that are sinusoidal, circular, parabolic or flat-topped.

Malaysian Ministry of Road Works (2012) during the seminar in Kuala Lumpur suggests several road hump designs and specifications as follows:

Table 2. Road Hump Specification by Malaysian Ministry of Road Works (2012)

Material Used	Dimension
Asphaltic Premix Wearing Course	a) flat-top hump height: 75mm-100mm length: 2.5m-4m
	b) round-top hump height: 50mm-100mm length: 3.7m-4m
	c) sinusoidal hump height: 75mm-100mm length: 3.8m-4m

Source: Malaysian Ministry of Road Works (2012)

Positively, theoretical findings by Bachok *et al.* (2016) recommended hump heights of 50 mm -100 mm and lengths of approximately 3 m - 4 m to achieve vehicle speeds within the 35 km/h speed limit in Malaysian urban residential area. Further research by Bachok *et al.* (2017) also indicated the guidelines of road humps by Malaysian Ministry of Road Works (2012) and SIRIM, (2009) which is given in Table 3.

Table 3. Guidelines for Road Hump in Malaysia

Source	Dimension	Spacing	Others
Malaysian Ministry of Works, 2012	a) Flat-Top Hump; Height: 75mm-100mm, Length: 2.5m-4m	100m	1) Vehicle speed between 30km/h to 60km/h
	b) Round-Top Hump; Height: 50mm-100mm, Length: 3.7m-4m		2) Allowed on district road, residential road, access road, rural road
	c) Sinusoidal Hump; Height: 75mm-100mm, Length: 3.8m-4m		3) Road Geometry: 2-way and 2-lane roads with no kerbs 4) Should not be located near road intersections
SIRIM, 2009	a) Parabolic Hump; Height: 75mm-100mm, Length: 3.7m-4.25m	Mentions that a spacing of 90m to 180m reduces 85th percentile speeds by 12km/h to 15km/h	1) Construction tolerance of +3mm
	b) Circular Hump; Height: 75mm-100mm, Length: 3.7m-4.25m		
	c) Sinusoidal Hump; Height: 75mm-100mm, Length: 3.7m-4.25m		

Source: Malaysian Ministry of Road Works, 2012; SIRIM, 2009

Table 3 indicates the differences between the suggested road hump dimensions by Malaysian Ministry of Road Works (2012) and SIRIM, (2009). This indicates that, there are no standardized guidelines for the implementation of road humps in Malaysia.

3.3 Effects of Road Hump on Traffic Speeds

Not much literature has discussed the effects of road hump design, namely the profile and spacing, on traffic speed, noise and traffic volume in one study; the previous study done by Salau, *et al.* (2004) and Sundo & Diaz, (2001) focused only on the effects on traffic speed.

In the inhabited zones where a large number of pedestrians and other vulnerable road users are expected, like school zones, it is necessary to decrease the speed to such a level that the risk of vulnerability is the lowest possible (Antić *et al.*, 2013). Thus, increased vehicle speed in residential and other traffic calming areas have adverse effects on social street activities, particularly impacting the safety of pedestrians in the case of any pedestrian-vehicle conflicts (Appleyard *et al.*, 1981; Muhammad Marizwan & Alvin Poi, 2010). In addressing the problem of increased vehicle speed, previous researches agree that road humps are effective at significantly reducing the 85th percentile of vehicle speed (Ewing, 2001; Huang & Cynecki, 2000).

A study also showed that with a spacing of 70m between road humps, the 85th percentile speed recorded 30m before and after the second hump was 31.88 km/h and 33.20 km/h (Yaacob & Hamsa, 2012). Parkhill *et al.*, 2007 has listed the hump profile as another factor affecting the effectiveness of a road hump; further elaborating that an incorrect hump profile would potentially cause discomfort to the users and reduces the effectiveness of a hump in encouraging drivers to slow down.

In addition, Antić *et al.* (2013) have evaluated the effectiveness of humps 30mm, 50mm and 70mm height in an inverse proportional to the traffic volume and found that all three heights

were capable of significant speed reductions; nevertheless, they noted that the speed recorded reduced with an increase in height. Besides, it was further supported by Bachok *et al.* (2016); the height and length of the road hump should be between 50mm-100mm and 3m-4m respectively in order to achieve the vehicles speeds within 35 km/h in a residential area.

3.4 Effects of Road Hump on Traffic Noise

Research by Harris *et al.* (1999) indicates that humps with a sinusoidal profile have been reported as being more comfortable for cyclists, and possibly also for car drivers, but there has been little information as to the relative difference between the profiles regarding their impact on noise and ground-borne vibration levels. This is agreed by Kojima *et al.* (2011) and Sayer *et al.* (1999). Whereby from 1990 several researchers to reduce noise and vibration of road humps were conducted to find "sinusoidal" shape is the best from the viewpoint of noise and vibration as well as passenger's comfort. Additionally, sinusoidal humps cause little noise and vibration when cars pass over. It rather reduces noise as a result of the effect of speed reduction. Cause of the noise was not the shock of traffic passing through humps but the re-acceleration of cars after passing humps (Kojima *et al.*, 2011).

From the previous studies done by Layfield and Webster (1997), the installation of traffic calming measures such as road hump resulted in reducing the traffic accidents, speeds as well as the traffic noise. As an example, lowering the speed of vehicles may mean that vehicle noise emission levels are lowered. In addition, after the measures are installed, traffic flows may be reduced which leads to the reduction in noise levels.

According to Hidas (1997), even though some studies indicated that residents are often concerned that the installation of traffic calming devices will raise noise levels in the community but it was proved by Clark (2000), study conducted in the United States which indicated that the lower speeds resulting from the proper design and application of traffic calming measures tend to lower noise levels. Furthermore, this statement was supported by the European studies, cited by Cline and Dabkowski (2005) that, alongside the speed reduction, there was a reduction in noise of around 10%.

4. CONCLUSIONS

This paper discussed the literature review on the effectiveness of road hump in controlling the speed and noise of vehicles along the selected road which focuses on the design profiles of the road hump. Based on the literature, it can be concluded that road hump installation is effective in reducing the traffic speed and traffic noise. Eventhough many studies have investigated the effectiveness of road hump installation in a residential area, but the effectiveness of road hump in the institutional area are not adequately investigated. Therefore, the effect of road hump installation in the institutional area should be explored in future studies.

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