

A THEORETICAL REVIEW ON THE EFFECTS OF ROAD HUMP ON TRAFFIC VOLUME, SPEED AND NOISE IN RESIDENTIAL AREAS

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ABSTRACT

Living environment in residential areas can be disturbed by the over-speeding of vehicles resulting in increased noise level. Extreme speed and noise create aggravation such as sleep disturbance and health problems among the residents, as well as causing physical impacts. Therefore, as a corrective measure, it becomes a trend in the new development of residential areas to install road humps on these residential roads. The proper installation of road humps on the residential roads is an alternative method to enforce speed limits, thereby preventing high traffic volume and noise in residential areas. Various literature had depicted that road humps increase the noise level due to the sudden braking of vehicles when approaching humps albeit the speed reduces. This paper deliberated the effectiveness of road humps on traffic volume, speed and noise in residential areas from the literature. This paper also discussed the effects of the design profiles of road hump on the change in speed of vehicles, traffic volume and noise level.

Keywords: Traffic Calming, Road Hump, Traffic Volume, Traffic Speed, Traffic Noise, Residential Area

INTRODUCTION

The exposure to high speed and noise produced by the vehicles has led to the deterioration of the living environment in many residential neighbourhoods. Most of the residents in the urban areas felt that their surroundings were affected by the physical disturbance, especially noise, speed and high traffic volume (Hamsa et al., 2010; Turkoglu et al., 2005; Ouis, 2001). On the other hand, people living in the suburbs were subjected to reduced speed, noise and traffic volume due to less traffic congestion (Puncioiu and Nedelea, 2011). Several physical and regulatory traffic calming measures applied to specific areas along the residential streets in cities to reduce the adverse effects of speed, noise and traffic volume in that areas. These measures help to reduce speed and traffic volume in residential areas (Zein et al., 1997; Orlob, 1977; Guide to Traffic Engineering Practice, 1988). Therefore, it reduces traffic noise and conflicts between road users (Du et al., 2001; Cloke et al., 1999; Ernish et al., 1998; Abbott, 1997). As traffic calming measures aid to increase the safety of the road users, most of the countries are applying these measures along the residential roads. As stated in Traffic Calming Guidelines, traffic calming can be defined as an approach which permits behavioural changes of drivers, pedestrians and others, who interact on roads and sidewalks (HPU, 2002). This paper intends to review the literature on the effects of road hump, as a traffic calming measure, on traffic volume, speed and noise in residential areas.

TRAFFIC CALMING

Traffic calming can be defined as “works that are affecting the movement of vehicular and other traffic to promote safety in preserving or improving the environment through which the highway runs” (Traffic Calming Act 1992). In other words, traffic calming can be interpreted as the use of self-enforcing speed reduction measures (Surrey County Council, 2008). Similarly, traffic calming is translated directly from the German word *Verkehrsberuhigung* and *Hass-Klau*, and it was first used in English in 1985 (Hass-Klau,

1985). During that time, it involved physical design to slow down or reducing motor-vehicle traffic other than improving the safety of pedestrians and cyclists.

In European countries, traffic calming is practised as an effective way to reduce casualty collisions, consequently improving the road safety (Traffic Advisory Unit Leaflet, 1997; Herrstedt, 1994). Back in the 1970s to early 1980s, Australian and North American authorities have begun to use traffic calming schemes in reducing speed and traffic volume in residential areas (Blanke and Brilon, 1993; Local Area Traffic Management, 1988, Orlob; 1977). Instead of impeding speeding in residential areas, traffic calming is a scheme where streets are designed in a way, which may change the psychological feel of the street by the drivers as well as influence the drivers' manners to avoid undesirable driving practices (Ernish et al., 1998; City of Calgary Traffic Calming Policy, 2010). Besides, it helps to enhance the livability of a resident by reducing noise and other traffic impacts such as accident severity and accident occurrence (Roess et al., 2004; Kloeden et al., 1997; Taylor and Tight, 1996).

According to Auckland Transport Code of Practice (ATCOP), the implementation of traffic calming is in line with the potential road users and function and it can be horizontal deflection, vertical deflection and road marking or signage (ATCOP, 2013). Horizontal deflections or horizontal shifts denotes to changing the road in the horizontal direction in which refers to the vehicles travelling on the road with a horizontal shift will have to move left and right (Pennsylvania Department of Transport, 2001). Whereas vertical deflections refer to the vertical realignment of a localised section of the carriageway which controls speeding by causing an uncomfortable jolt to the drivers where the vehicles have to move up and down (ATCOP, 2013; Litman, 2011; Institute of Transportation Engineers, 1999). ITE (1999) has listed chicanes, throttles, standard roundabouts, mini-roundabouts and false roundabouts as horizontal deflections whereas road hump, road bump, rumble strips, speed cushion and speed table as vertical deflections. One of the vertical deflections, as listed by ITE which performs as the most efficient and reliable technique for reducing speed and creating driver's awareness, is road hump or speed hump (HPU, 2002).

DESIGN CHARACTERISTICS OF ROAD HUMP

In the 1970s, North American and international jurisdictions accept road humps since its implementation in Britain by the Transport and Road Research Laboratory (TRRL). Hence, the design and application of the road humps during that time varied and became controversial due to objection by the residents and other road users (Parkhill et al., 2007). In 1997, ITE published a "Recommended Practice" guidelines for the design and application of road humps.

Road hump is an upstretched portion in the road pavement surface extending transversely across the vehicle direction. Ewing and Kooshian, 1999, stated that road humps are typically installed on a residential road and not on a major road, bus routes or primary emergency response routes. Effectively, road humps must be three to four inches high and 12 to 22 feet long and placed in series at 200 to 600-foot intervals with round, flat or parabolic shaped top (Johnson and Nedzesky, 2004, Clement, 1983) (*Refer Figure 1 - 4*). At first, Europe, Australia and New Zealand agreed to use the 12 feet long and three to four inches high parabolic-shaped road hump developed by TRRL. Later Australian Road Research Board has suggested 22 feet long flat-topped road hump as a new alternative to the original road hump (Smith and Giese, 1997).

A summary of road hump profiles in different countries is in Table 1 below.

Table 1: Road Hump Profiles

AUTHORS	COUNTRY	DIMENSION		
		LENGTH (m)	HEIGHT (mm)	SPACING (m)
Cline (1993)	California	3.7	70 – 76	-
Emslie (1997)	South Africa	3.6 – 4	80 – 120	50 – 200
The Highways (Road Humps) Regulations (1999)	England and Wales	min. 0.9	25– 100	-
Partington (1999)	UK and US	3.7	76	106 – 167
Malaysia Ministry of Works (2012)	Malaysia	2.5 – 4	50 – 100	100
ATCOP (2013)	New Zealand	3.7 – 5	100	80 – 120

Table 1 shows the differences in the recommended hump dimensions from several countries, specifically in length and height of humps. The differences in hump profiles might affect the speed of moving vehicles which can also raise specific issues regarding the installation of road humps. The corresponding profiles are for the desired maximum speed where vehicles can comfortably cross the humps. The length and height of humps should be precise to avoid difficulties for the drivers. Besides, the road hump profiles mainly, height and spacing should be consistent which influencing the drivers' comforts. Though, the road humps should be placed accordingly, the location of road humps is determined by the current physical characteristics of the site.

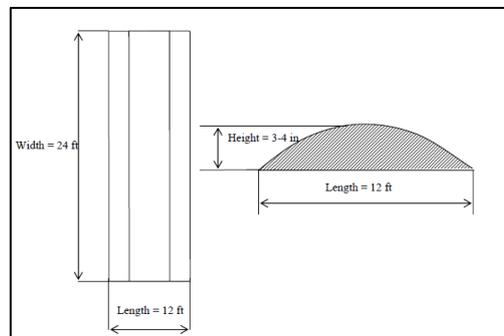


Fig.1: Schematic of Typical Circular Road Hump
(Source: Johnson and Nedzesky, 2004)

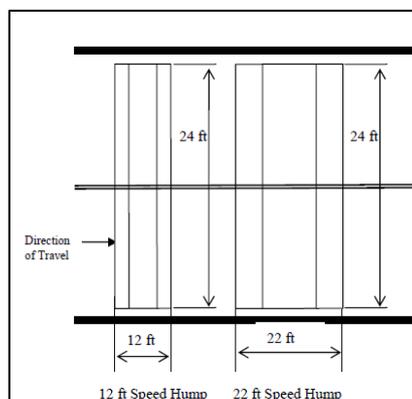


Fig.2: Schematic Drawing of Road Hump
(Source: Johnson and Nedzesky, 2004)

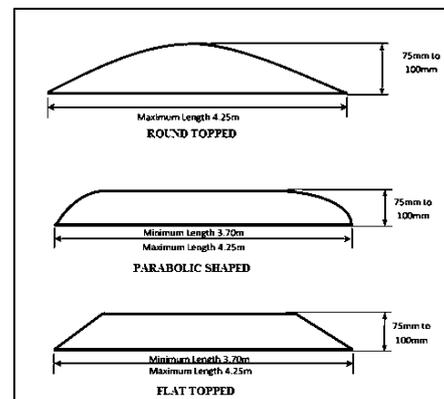


Fig.3: Typical Design of Road Hump
(Source: Malaysia Ministry of Work, 2011)

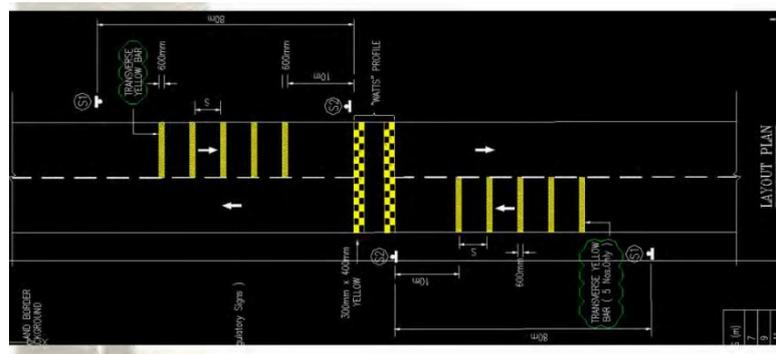


Fig.4: Road Hump Layout Plan
(Source: Malaysia Ministry of Work, 2011)

ROAD HUMP'S EFFECTS ON TRAFFIC VOLUME, SPEED AND NOISE IN RESIDENTIAL AREAS

The impacts of traffic calming measures mainly road humps on traffic volume, speed and noise vary significantly by type, geometry, location, spacing and other factors. Several studies have shown the effectiveness of the road humps in reducing traffic volume, speed and noise level.

Traffic Volume

According to National Collaborating Centre for Healthy Public (NCCHP), there is a relationship between traffic volume, noise and speed. Reduction in the number of vehicles may lead to the decrease in noise level, but may increase the speed of vehicles. Therefore, the installation of road hump has given less effectiveness in reducing traffic volume (Bellefleur and Gagnon, 2012).

However, Parkhill et al. (2007) in a survey across North America have reported positive effects of road humps which reduced the volumes by 28%. In a study of two different roads in Rockwood City the results showed that traffic volumes decreased by 30% and 8% respectively, after the installation of road hump in an appropriate area (Tanisha, 2015).

The quality of alternate routes and proper implementation of road humps have influenced the reduction in traffic volume in residential areas (Ewing, 2002; Swanson et al., 1998; Clarke and Dornfeld, 1994; Hawley et al., 1992; McDonald and Jarvis, 1981; Richardson and Jarvis, 1981). The change in traffic volume is affected by the characteristics of the street in local circulation which influenced the motorists to shift onto the nearby routes. A before and after study analysis showed that there was a 48 % decrease in traffic volumes and surprisingly there was a 23 % increase in volumes on the adjacent streets (Kotsopoulos, 2000). It can be concluded that the installation of road hump may shift the traffic to the nearby streets. However, the installation of road humps still has inconsistent effects on traffic volume as the traffic did not necessarily change to other alternative routes (Rosli and Hamsa, 2013; Du et al., 2001; Loughery and Katzman, 1998; Cline, 1993). Moreover, the route choice depends on relative travel time (Ewing, 2002).

Traffic Speed

The installation of road hump is effective in reducing speed along the residential roads. Below are few findings on the effectiveness of road hump in controlling speed:

Table 2: Findings on Speed Reductions

AUTHOR	ROAD HUMPS DIMENSIONS	FINDINGS
Clark and Dornfeld, 1994	Height: 76 mm Length: 3.7 m	Reduced from 58 – 63 km/h to 39 – 43 km/h
Cline, 1993	Height: 70 – 76 mm Length: 3.7 m	Reduced 10 to 15 km/h (Grey Rock Rd. California); 15 to 23 km/h (West Lake Village, California)
Gorman et al., 1989	Height: 100 mm Length: 3.7 m	Reduced from 31.5 to 36.5 km/h
Walter, 1995	Height: 76 mm Length: 3.7 m	Reduced from 14 to 37 km/h

As can be seen in Table 2, Clark and Dornfeld (1994) found that the vehicle speed reduced almost 20 km/h which aligns with the results attained by Walter (1995), where the speed decreased about 23 km/h. On another annotation, a study conducted by Cline (1993) in two residential areas in California showed that the speed reduced from 5 km/h and 8 km/h respectively. With regards to the findings, it can be concluded that the installation of road hump has a positive impact on speed reduction in residential areas.

Properly designed and installed road hump would reduce vehicle speed at the humps from 15 to 20 mph (Parkhill et al., 2007; Salau et al., 2004; Smith and Giese, 1997; Watts, 1973). Ahmed and Bagchi reported that well-designed humps would positively affect vehicles speed and thus create a somewhat comfortable driving experience for those who were passing by the humps (2013). However, there were several authors who did not mention about the hump dimensions. A study in residential areas in North America showed the average percentage change of 85th percentile speed after the installation of road hump is approximately 23% (Ewing, 1999). Similarly, another study in 2004 discovered that the average speed is reduced from 36.4 to 24.4 km/h; a reduction of 33% after the implementation of road humps in residential areas (Traffic Safety Handbook, 2004).

Studies done in Australia, the United Kingdom and the United States, indicated reductions in 85th percentile speeds in the range of 3 to 14 mph between the humps and 6 to 27 mph at the hump. Additionally, Michigan community also has experienced about five mph reductions in the 85th percentile speed in a recent study during that time (Swanson et al., 1998). Again, the authors did not report on the hump dimensions.

Traffic Noise

Rosli and Hamsa (2013) have noted that the daytime and night-time noise levels in residential areas are higher than the acceptable limit. Thus, the installation of road humps in residential areas reduces not only the speed of vehicles but also the noise level produced by the vehicles (Ahmed and Bagchi, 2013). The noise level in Oxford, Norwich and Kennington recorded about 2 to 6 dBA reduction concurrently as a result of a decrease in traffic flow and speed along the road with 76 mm height and 3.7 m hump (Sumner and Baguley, 1979; Bendtsen and Larsen, 2000).

Abbott et al. (1995) reported that the installation of 75 mm height and 3.7 m length road humps lead to significant reductions in the maximum noise level of cars which is about 6.6 to 10.3 dBA due to the reductions in speed (15 to 18 km/h). Conversely, the noise level of heavy vehicles tends to increase from 2.1 to 7.9 dBA though the speed reduced from 2 to 20 km/h. However, Preise et al. (2008) concluded that speed humps are inconclusive to be considered as a noise reduction measure since there was no variation in annoyance ratings between driving with road hump and without the road hump. Besides, Harris et al. (1996) have proven that there was no difference found in noise level after measuring the L_{MAX} and L_{Aeq} of all types of humps.

Furthermore, the improper installation of road humps may lead to the increasing noise level in residential areas as a result of rapid acceleration and braking of vehicles. Zaidel et al. (1992) stated that noise and vibrations were created by the vertical and combined accelerations of vehicles crossing over the road hump and determined by the vehicle's speed, size, load and dynamics as well as the road hump profiles. Besides that, residents in San Antonio, Texas, Seattle, Washington and Omaha have also voiced out complaints about the noise levels after the installation of road humps in their neighborhoods due to the vehicles braking while approaching and accelerating away from the road humps (Hallmark and Smith, 2000, Gorman et al., 1989).

A study in San Leandro, California found that 43% of 60 residents said that the noise level along the street had increased as a result of the humps installation. Cline and Dabkowski, (1998) reported that residents in Beverly Hills, California said that 89 mm height humps were noisy while 76 mm humps were preferred. However, most authors did not publish the details of road hump installation particularly in dimensions which related to the noise reductions.

CONCLUSIONS

This paper discusses the effects of road humps on traffic volume, speed and noise in residential areas based on the literature. Based on the literature review, it is conclusive that road humps are effective in reducing speed in residential areas and, as expected, properly designed and installed road humps also reduce the noise level due to the speed reduction, but there is inconsistency in traffic volume reduction due to the existence or absence of alternative routes. Thus, most of the studies have reported on the successful implementation of road humps as a speed reducing and controlling measure, but less conveyed on the traffic volume and noise levels.

Many studies have investigated the relationship between these two variables; speed and noise, however, the relationship between the three variables (traffic volume, speed and noise) are not adequately established which should be addressed in further studies. The significance of this study is to explain the effectiveness of road hump in improving the living environment in residential areas. This study can be a reference for further studies concerning the efficacy of humps on traffic volume, speed and noise level.

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