Evaluating the Effects of Road Hump on Noise Level and Vehicles Speed at IIUM Institutional Area

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Abstract: Noise pollution is among the most prominent environmental problems encountered in every aspect of daily life. This paper investigates the effects of road hump on the noise level and speed of vehicle specifically on a major road in International Islamic University Malaysia (IIUM). Spot speed and noise level was collected by selecting two road humps with different design profiles on-campus. Two points at each road hump, one at the road hump and the other 15 m after the road hump were selected for the measurement of speed and noise level. The findings show that there is significant difference in noise level and speed of vehicles on and after the road humps. It is noted that redesign of the road hump especially its height is needed to ensure that the vehicles can cross the road hump without increasing noise level and vehicle speed unnecessarily especially immediately after the road hump.

Keywords: Noise level; Spot speed; Road hump; Institutional area,

1. INTRODUCTION

Good quality of life is one of the necessary factors in forming a better institutional environment. The unsuitable location of an institutional area and increasing number of vehicles can make noise level unbearable. Quality of life affected by noise levels varies at different times of the day. Normally, every institutional area is provided with major roads which are highly exposed to noise pollution. Many studies in recent years focused on causes and effects of noise pollution, as noise pollution is recognized as one of the major influences affecting urban quality of life. (Kapp, Passmore, Schneider, 2014).

In general, high exposure to noise on a daily basis causes feeling of annoyance and irritation, damage to auditory mechanisms, number of health-related effects like physiological disorders, disturbance of daily activities and performance, hypertension and schematic heart disease (Basner et. al, 2014). Moreover, the most serious health problems associated with noise pollution exposure is deafness which initially causes temporary hearing problems or deafness while prolonged exposure to high noise level cause permanent hearing damage. Long term exposure to traffic noise to residents also increases the chance of cardiovascular disease or heart disease (Selander, 2010). These factors all have negative impacts on health directly and are related to quality of life and make a subjected area not suitable for comfortable living. Noise also threatens educational atmosphere that institutions of higher learning aim to foster. While many studies focused on noise sensitive locations such as parks and hospitals, there have been far less research on educational institutions, yet campuses are especially susceptible to negative impacts from traffic (Ozer et al. 2014). Therefore, this paper investigates the effects of road hump on the noise level and speed of vehicle specifically along major road in order to mitigate the problems associated with the noise level and speed of vehicles.

2. LITERATURE REVIEW

2.1 Noise

Noise is defined as unwanted sound. Environmental noise consists of all the unwanted sounds in our communities except that which creates in the workplace. Environmental noise pollution, a form of air pollution, is a threat to health and well-being (Goines, L., & Hagler, L., 2007). Nowadays, noise can be more severe than before, and it will continue to increase because of the population growth, urbanisation and highly mobile source of noise. Over the years, several studies illustrates that noise could lead to human annoyance, reduces life quality, and might affect health and physiological well-being (Ohrstrom et.al, 2006, Nadaraja et.al, 2010). Thus, noise can be subjective and complex to be understood depending on how far it can affect the individual or parties.

2.1.1 Traffic noise pollution

In many countries, road traffic is the most widespread sources of noise and it is most prevalent cause of annoyance and interference (Ragettli et. al, 2015). The traffic noise is generated from frictional contact between the vehicle and the ground and air (WHO, 1999). Noise generated from traffic depends on the traffic volume, the speed of the vehicles and the proportion of heavy vehicles. The road traffic noise level is the aggregation of the individual vehicle noise, which is basic unit for traffic noise source. Each vehicle generates different levels of noise from its source such as engine, exhaust and braking system. The main source of noise in vehicle is the engine. Engine noise generated due to fuel combustion and due to mechanical impacts. The transmission of noise comes from the gearboxes, drive shaft and rear axles and it is in the range from 68 to 78 dBA (Seoud, 1994). Traffic noise pollution can be defined as unpleasant sound that generated from vehicles on the road. This common situation in institutional area where congestion is one of the factor contribute to high level of noise, it is always exist during rush hours where people are travelling at the same time.

According to Road Traffic flow theory by (Knoop, 2013), “there are 2 main variables determine traffic flow which is speed and density where can lead to high level of noise pollution in certain part of road. Speed and density are influencing the noise level of particular road. Two conditions of speed of vehicles which increase noise where at lower speed, congestion when huge number of vehicles gathered at one point, combination of engine and horn sound will increase noise to surrounding”, (p.18). Other is when speeds increase; vehicle engines will produce high volume of noise.

2.1.2 Effect of traffic noise pollution

Several studies have proved the hazardous effects of traffic noise. The Environmental Protection Agency in United States released a report, which argued that noise is more than just a nuisance, but also constitutes a real and danger to people health. Traffic noise pollution also gives negative impact to people health by the development of cardiovascular disease (Salendar, 2010). Report published by Environmental Agency has categorised the noise effect on public by 2 categories which is ‘behavioural’ and ‘physiological’. Behavioural category, the main effect are disturbance and annoyance. Physiological category, the main effect of noise is induced hearing loss and potential health negative effects. Disturbance due to noise will not only affect sleep but also other aspects such as communication distraction. Distraction by noise is when a person is stopped from undertaking an everyday activity such as hearing spoken conversation, concentrating while reading listening to radio or television (Environment Agency, 2012). Traffic noise in institutional area reduces the QoL of students and quality of the institutional environment and this also result in reduction of learning systems. The damage caused by noise pollution can also include productivity losses which may be caused by the exposed persons' inability to concentrate, by communication difficulties at work, or due to lack of sleep (WHO, 1999).

2.2 Traffic Calming Measure

According to O'Flaherty (1997), traffic calming measures were "changes to the horizontal and/or vertical alignment of existing roads in built-up areas in order to reduce the speed of motor vehicles" (p.465). Meanwhile, Institute of Transportation Engineers (ITE) agreed with O'Flaherty and added some other elements into their definition of traffic calming measures. ITE (as cited by Lookwood, 1997; Syazwani & Abdul Azeez, 2012) mentioned the traffic calming measure as "the combination of mainly physical measures that reduce the negative impacts of motor vehicle use, alter driver behaviour and improve conditions for non-motorised road users". Moreover, for Pardon and Average (2013), they believed that traffic calming measures of varied definitions, and indicated that all the different definitions covers the same understanding, in which the existence of traffic calming measure is aimed to "improve road safety, reduce speed of vehicle and enhance quality of life", (p.3).

In general, it can be seen that most of all traffic calming measure definitions has many similarities between scholars on their interpretations towards traffic calming measure. Hence, the explanation of traffic calming measure can be summarised as the physical measure that are installed on the existing road alignment to reduce the speed of vehicles, enhance safety of other road users, and at the same time, can give positive effects to the driver's behaviour. Furthermore, traffic calming measures encompass some changes in the alignment of existing road either horizontally or vertically. Traffic calming measure generally involve with some changes in the alignment of existing road both horizontally and vertically. Thus, it can be illustrated that traffic calming measure can be divided into two categories, which are horizontal and vertical changes in road alignment. As defined by Pline (1999), traffic calming measure generally can be separated into three types, which include vertical deflection, roadway narrowing, and closures. However, Robert Peccia & Associates (2007) agreed with ITE and added other calming method to the list. Table 1 below shows the types of traffic calming and its examples by Robert Peccia & Associates.

Table 1. Categories of traffic calming in Malaysia and its examples by HPU

NO	TYPES OF TRAFFIC CALMING MEASURES	EXAMPLES
1	Speed control device	• speed bump • speed hump • speed table • centre table • centre island narrowing • raised crosswalks • raised intersections

		• textured pavement • traffic circle • transverse bar
2	Volume control device	• full closure • semi diverter • diagonal diverter median • median barrier • forced turn island

Source: HPU (2002)

2.3 Impact of Road Hump Installation

Road hump frequently gives a positive impact of noise and speed reduction if it was being installed in a suitable manner, which involved thorough consideration on its planning and design specification. This statement was supported by Parkhill (2009), "it was noted that the effectiveness of road hump in controlling vehicle speeds along a road is affected by the spacing in between a series of humps". This generally illustrated the important of proper consideration being given on the planning and design of road hump in ensuring the effectiveness of the device implemented. Hallmark and Smith (2002) at the same time also agreed with this idea by mentioned "the speed hump also reduced the number of vehicle exceeding the speed limit in the immediate vicinity of the device" (pp.3).

The introduction of speed reduction measure such as a road hump can influence traffic noise levels in a number of ways. According to the previous studies done by Layfield and Webster (1998), traffic calming installation such as road hump shows the successful result in reducing traffic accidents, speeds and also noise level. For 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, leading to reduction in noise levels. However, vehicle noise emissions may also depend on the way vehicles are driven; a passive style of driving, at a lower but constant speed, contributes to lower noise level; an aggressive style, with excessive braking and acceleration between speed control device, gives rise to a highly fluctuating noise level. Furthermore, the use of road humps to reduce speed may give rise to vehicle body noise which may be a cause of noise disturbance.

On the other hand, some studies indicated that residents are often concerned that traffic calming devices such as humps will raise noise levels in the community (Hidas, 1998). However, a study conducted in the United States (Clark, 2000) 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%.

3. RESEARCH METHODOLOGY

3.1 Background of Study Area

The study area of this research is the International Islamic University Malaysia (IIUM) Gombak campus with the area of 710 acres and 727,279 m² of built-up area (IIUM Development Division, 2014). The location of the campus is situated in Gombak district which is 10km away from the Kuala Lumpur city centre. The campus accommodates about 23,454 student population (IIUM Development Division, 2013).

With increase in the registered vehicles (staff and student) in IIUM Gombak, motorcars from 8895 in 2015 to 8915 in 2016 (0.22% increase) and motorcycles from 4189 in 2015 to 4386 in 2016 (4.5% increase) (IIUM Traffic Unit, 2016), it shows that staff and student in IIUM Gombak are depending on private transport for their movement on-campus and off-campus. The increasing number of private transport on-campus has been subjected to traffic congestion and other related problems. This study area is selected because of the increasing number of private vehicles on-campus. The increasing number of vehicle which may cause detrimental effects to the University environment, if not controlled properly, were the reasons for selecting IIUM Gombak institution as a study area. Circular road hump is the only vertical deflection traffic calming measure used in the study area, mainly due to easy installation.

3.2 Field Survey

A field survey was conducted on noise level and vehicle speed at selected road humps along the IIUM circular road. Two road humps along the major road on-campus were chosen having different road hump profiles. Road hump A was located in front of IIUM Sayyidina Hamzah Stadium, while road hump B in front the IIUM library entrance (refer figure 1). The survey was conducted at the study area for two days (24th and 27th June 2016). The details of the measurement of noise level and speed of the vehicles are described in the following subsections.

3.2.1 Noise level survey

The noise level survey was conducted on 24th June 2016 and 27th June 2016, starting from 9.00 a.m until 1.00 p.m. Two road humps were selected for the measurement of the noise levels. Two measurement points at each of the selected road humps, one at the road hump and other at a distance of 15 meters after the road hump were chosen. The noise level was measured at every 15 minutes time interval. The survey was administered during off-peak hours in order to get the actual noise level due to increasing speed of the vehicles. The noise level meter was stationed at the selected points near the roadside of the chosen road humps. The noise level was set-up at a distance of 1 meter from ground level. Figure 2 and figure 3 depicts the measurement points and the setting-up of noise level meter. Furthermore, noise level data such as $L_{Aeq,}$ $L_{max,}$ L_{10} and L_{90} was analysed by using Noise Tools software.

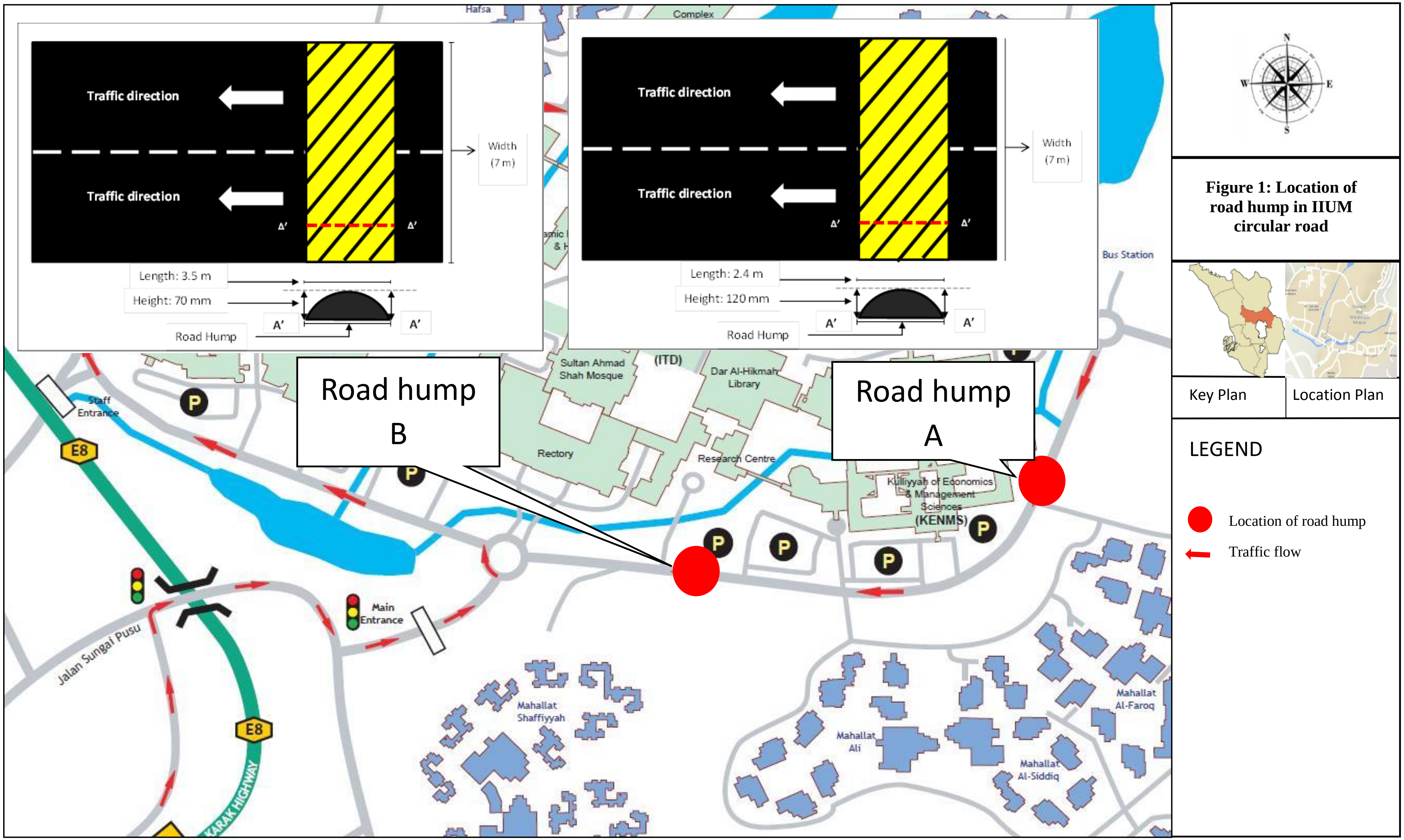

Figure 1: Location of road hump in IIUM circular road

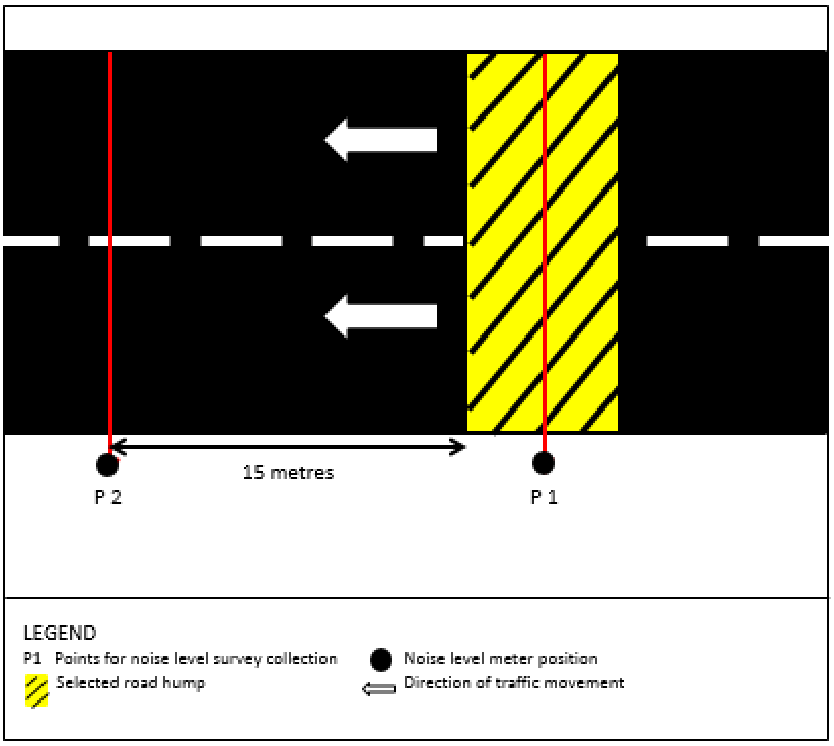

Figure 2. Illustration on the selection of measurement points for the measurement of noise level

Source: Field survey 2016

Figure 3. Position of Noise level meter

Source: Field survey 2016

3.2.2 Spot speed survey

The spot speed was measured on 24th and 27th June 2016, from 9.00 a.m. to 1:00 p.m, the same day and time where noise level was measured. Radar gun was used to measure spot speed. The spot speed of the vehicles was measured both at the road hump and 15 meters after road hump. Two enumerators were involved for the measurement of spot speed of the vehicles. One of the enumerators was assigned to measure spot speed by using a radar speed meter and the other enumerator was tasked to note down the spot speed data.

4. RESEARCH FINDINGS

4.1 Design Profile of Road Hump

Table 2 shows the design profiles of the selected road humps on-campus. Figure 4 and figure 5 illustrates the design profiles of the selected road humps.

Table 2. Comparison of dimension of road hump A and B with Ministry of Work specifications

DESIGN PROFILE	DIMENSION OF ROAD HUMP		MALAYSIAN MINISTRY OF WORK (2012) SPECIFICATION
	A	B	
Height	120mm	70mm	75mm-100mm
Width of road Hump	7m	7m	12.5m
Length	2.4m	3.5m	3.7m-4.25m

Source: Field Survey (2016)

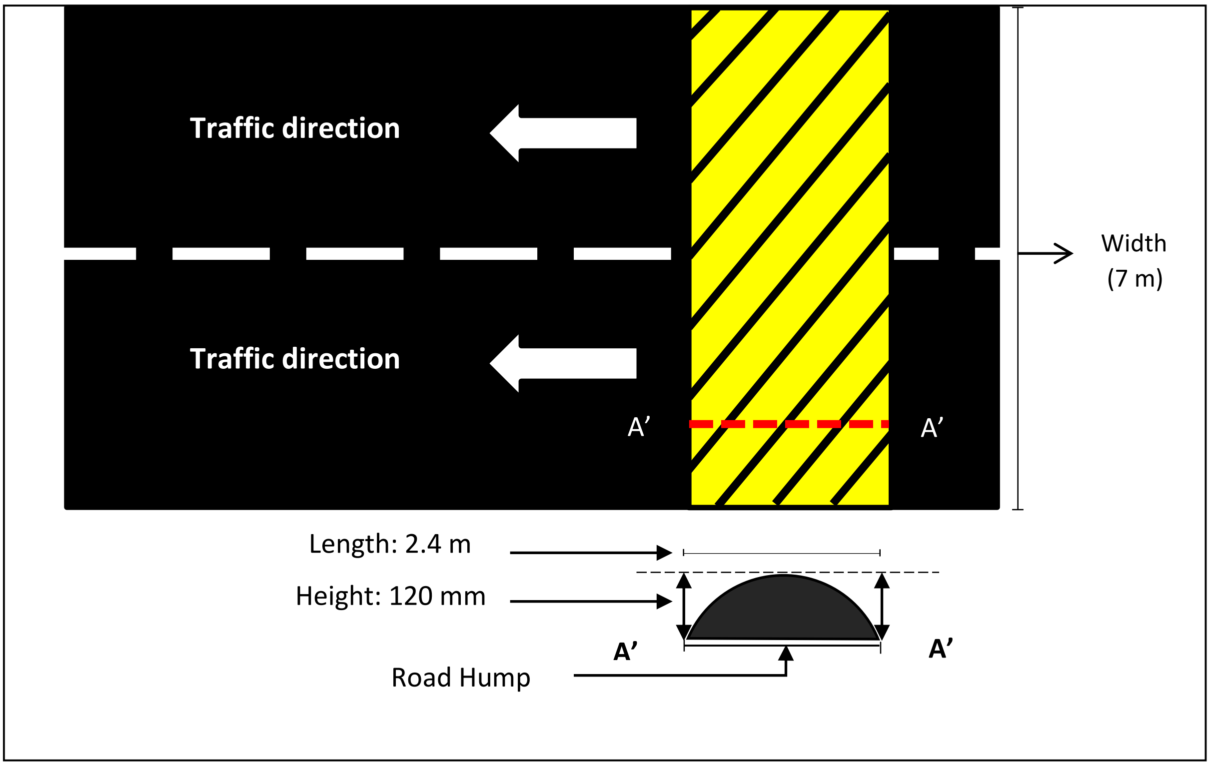

Figure 4. Dimension of road hump A

Source: Field Survey (2016)

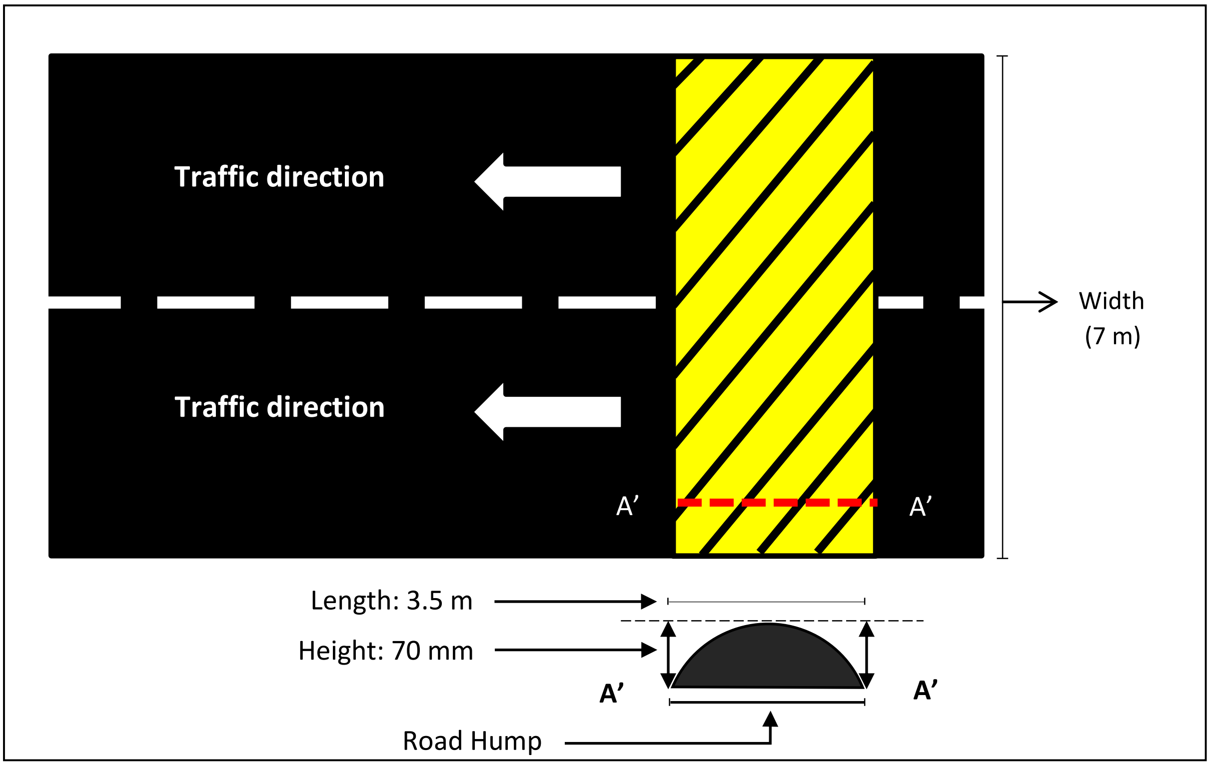

Figure 5. Dimension of road hump B
Source: Field Survey (2016)

4.2 Noise Level

4.2.1 Road hump A (at the road hump)

Figure 6 below illustrates variation of traffic noise over four hours. The noise level meter which was located beside road hump A (point 1), measures the noise level of the vehicles approaching and passing the road hump. The fluctuation of noise level along the road hump A (point 1) at 15 minutes interval is shown in Figure 6. The findings show that noise level at every 15 minutes interval during survey period has exceeded the recommended noise level by the Department of Environment. The maximum permissible day time noise level for an institutional area is only 50 dB(A).

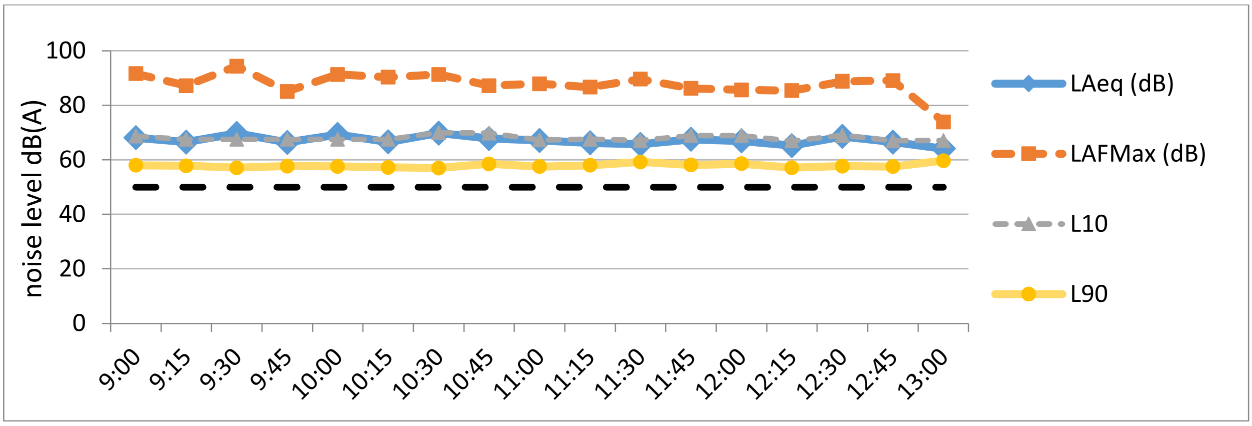

Figure 6. Fluctuation of noise level at 15 minutes time intervals (road hump A point 1)

4.2.2 Road hump A point 2 (after road hump)

Figure 7 below shows the fluctuation of noise level at 15 minutes time interval at point 2 of road hump A. The findings show that the highest noise level was 72.5 dB(A) at 11.00 am and the lowest was 67 dB(A) at 11.15 am. The variations of noise level at this point of the road hump are almost similar to that of at the road hump A.

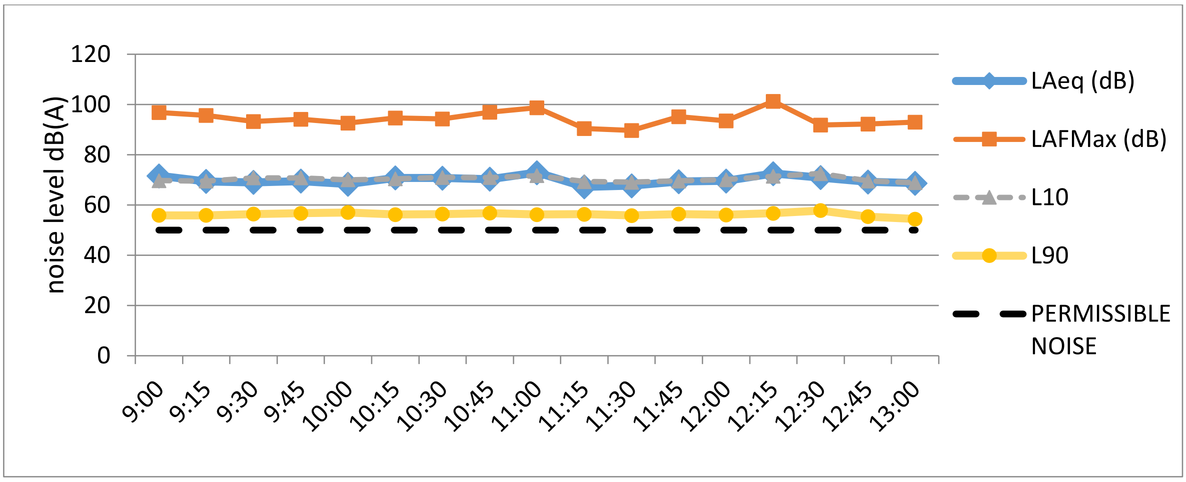

Figure 7. Fluctuation of noise level at 15 minutes time intervals (road hump A point 2)

4.2.3 Road hump B point 1 (at the road hump)

Figure 8 illustrates the fluctuation of noise level at 15 minutes time interval at road hump B (Point 1). The findings show that the highest noise level was 69.3 dB(A) at 10.45 am, while the lowest was 51.5 dB(A) at 9.00 am. The different statistical noise level except L_{90} at this point during the four hour survey period was measured higher than the permissible noise level.

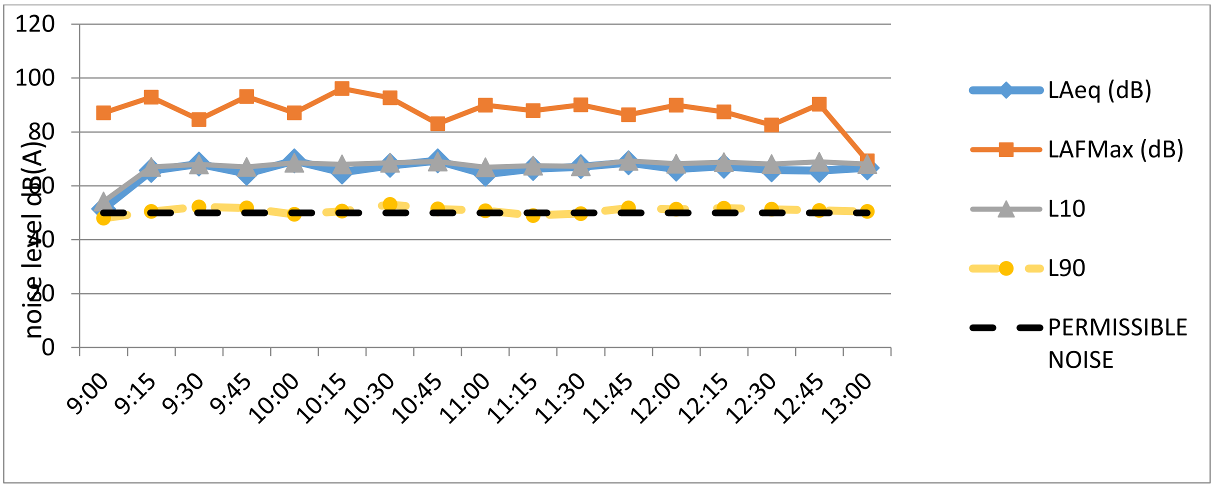

Figure 8. Fluctuation of noise level at 15 minutes time intervals (road hump B point 1)

4.2.4 Road hump B point 2 (after road hump)

Figure 9 shows the fluctuation of noise level at 15 minutes time interval at point 2 of road hump B. The highest noise level was observed in the afternoon at 12.15 pm measuring 72.9 dB(A) and the lowest was at 11.15 pm measuring 67.2 dB(A). Again, the different level of noise except L_{90} was higher than the permissible noise level at this point of the road hump.

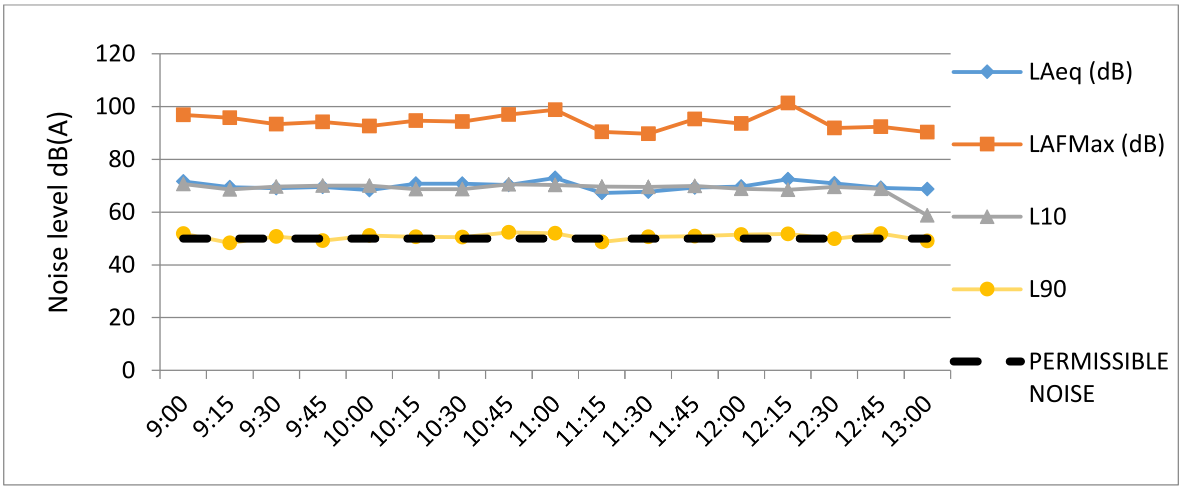

Figure 9. Fluctuation of noise level at 15 minutes time intervals (road hump B point 2)

4.3 Spot Speed

4.3.1 Road hump A point 1 (on road hump)

Referring to the figures 10 and 11 below, it can be seen that both of these road humps have an exactly different pattern of spot speed. The highest speed for road hump A point 1 was car with 35km/h and the lowest speed was bus with 8km/h. Generally, according to the figure 10 and 11 below, it indicates that all type of vehicles follow the speed limit that have been posted, which is 30km/h. However, there was one car that exceeds speed limit at road hump area with 35km/h.

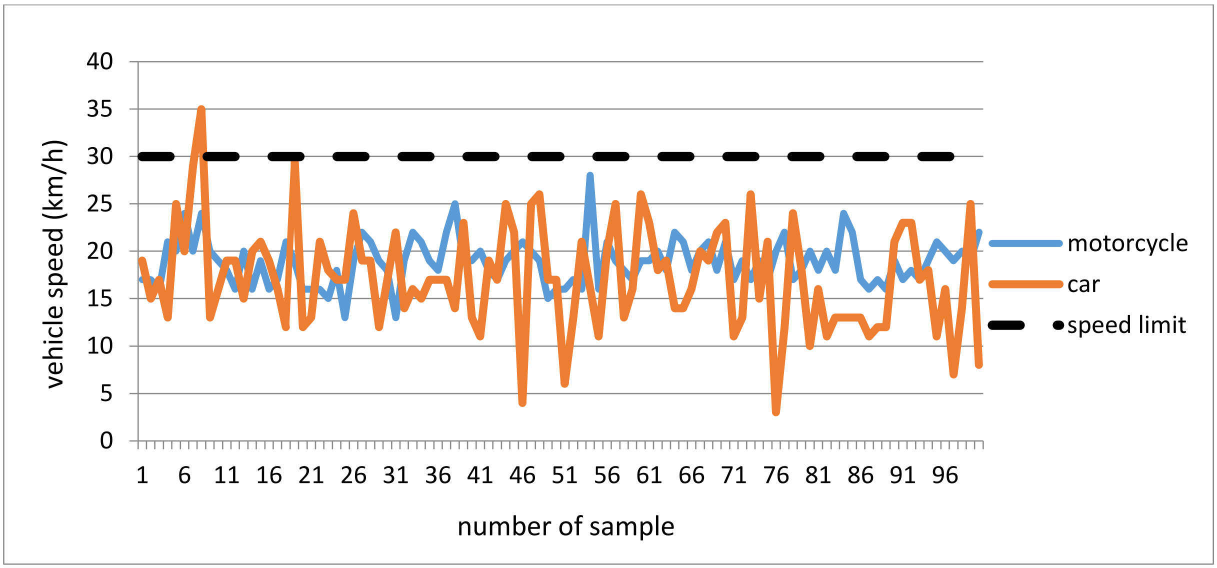

Figure 10. Spot speed data at road hump A (on the road hump)

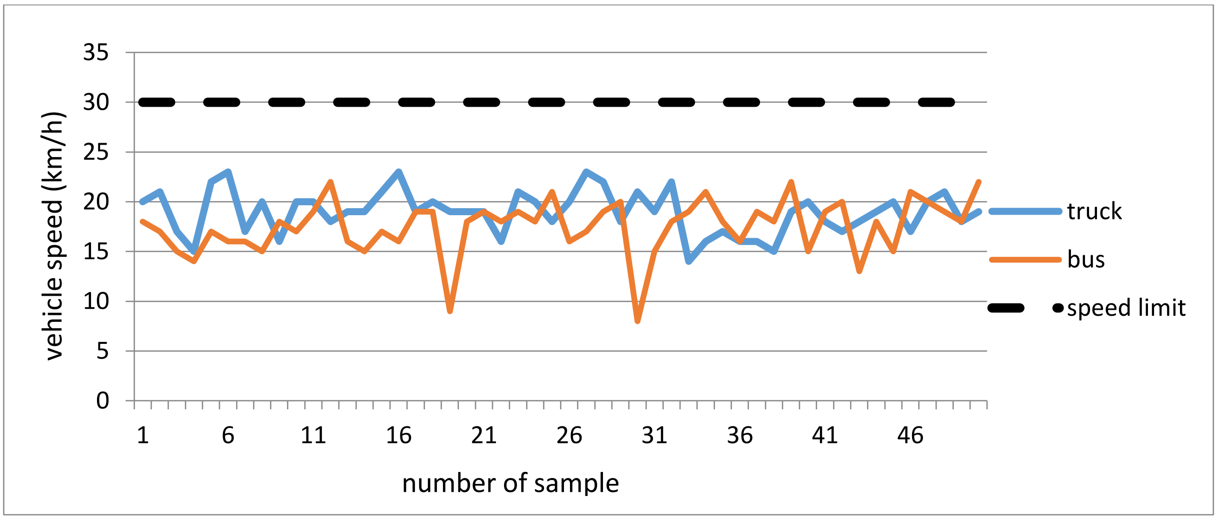

Figure 11. Spot speed data at road hump A (on the road hump)

4.3.2 Road hump A point 2 (after road hump)

According to the figure 12 and 13 below, the road hump does not give similar impact to the vehicles speed, as what happened at Point 1. Drivers seem to increase their speed after they approach the road hump, thus causing the vehicle speed at Point 2 to be much higher than Point 1.This can be visualized from the highest and lowest speed recorded at point 2 that is 35km/h for car and 16km/h for motorcycle, bus and truck. Furthermore, at this point 4 cars were identified exceeding speed limit, while others were following speed limit.

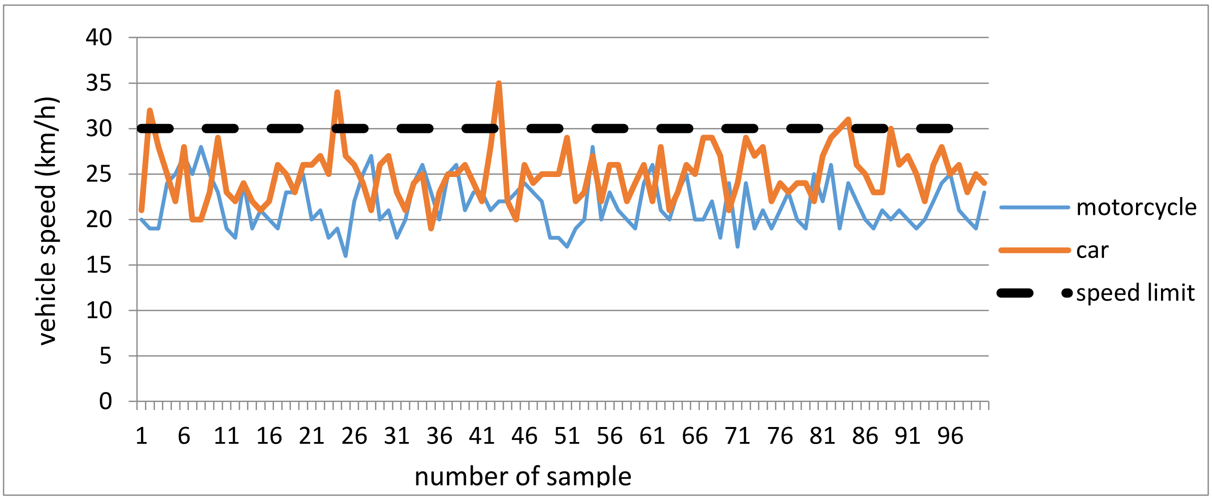

Figure 12. Spot speed data at road hump A (after road hump)

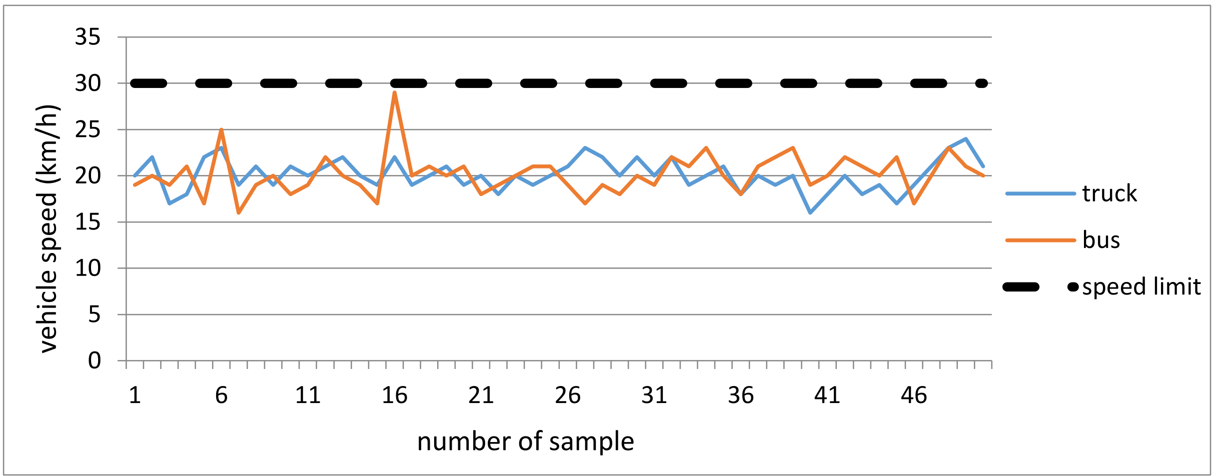

Figure 13. Spot speed data at road hump A (after road hump)

4.3.3 Road hump B point 1 (on road hump)

Based on the figure 14 and 15 below, the vehicle speeds rapidly increased compared to the previous road hump A Point 1. This graph indicates the highest speed remain the same which is 35km/h for car and lowest were 14km/h for truck. Nevertheless, the line graph shows fluctuated pattern with higher speed compared to the road hump B. The increase in the speed of vehicles from road hump A point 1 to road hump B point 1 indicates that are the different dimension for each road hump. The height of road hump B was lesser than road hump A, thus it gives less level of discomfort to drivers.

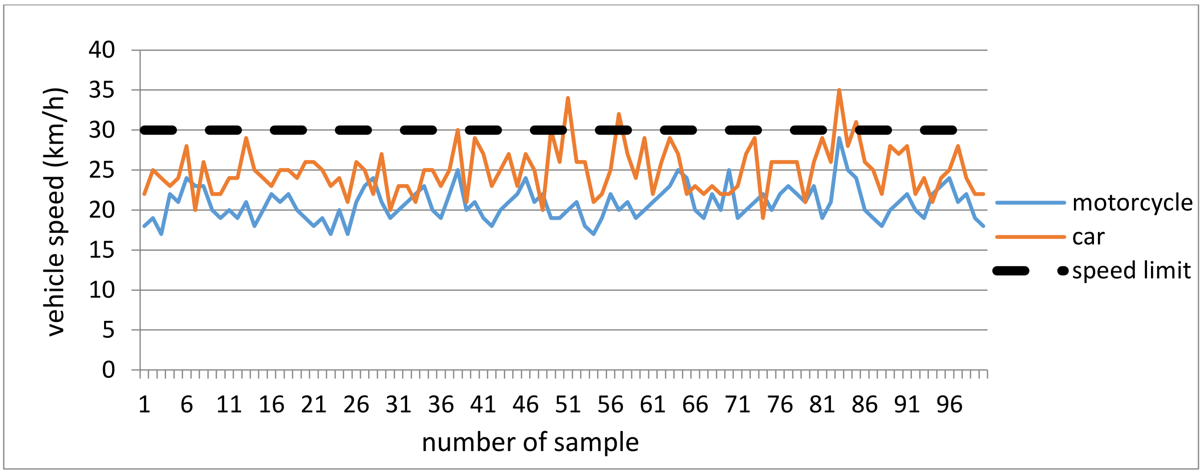

Figure 14. Spot speed data at road hump B (on road hump)

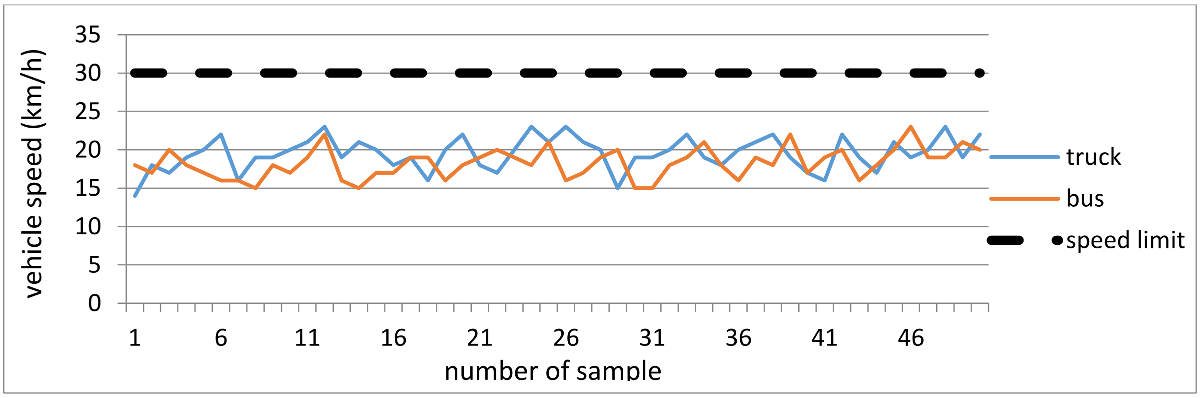

Figure 15. Spot speed data at road hump B (on road hump)

4.3.4 Road hump B point 2 (after road hump)

According to the figure 16 and 17 below, it was identified that the speed of vehicles fluctuated. At this point, the highest speed recorded is 45km/h for car and the lowest is 17km/h for bus. The increase in the speed of vehicles indicates that the road hump dimensions affect the pattern of spot speed, since the selected road hump are totally different in dimension. Furthermore, it clearly shows that most cars and motorcycles passing over the road hump B at point 2 exceeded speed limit that has been posted. In addition, road hump B does give similar impact to trucks and buses as their speed mostly remain the same, which are between 15km/h to 23km/h.

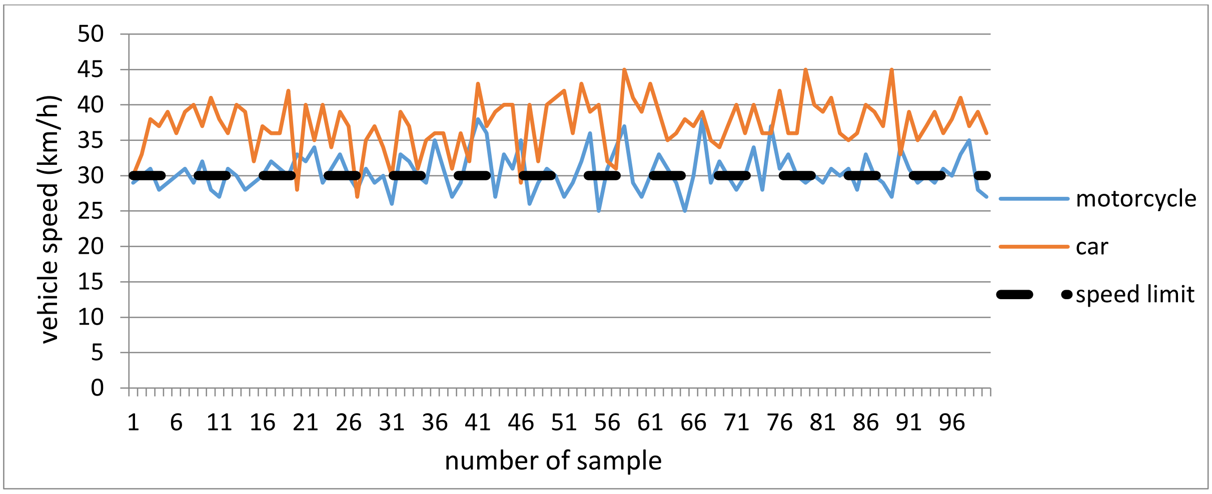

Figure 16. Spot speed data at road hump B (after road hump)

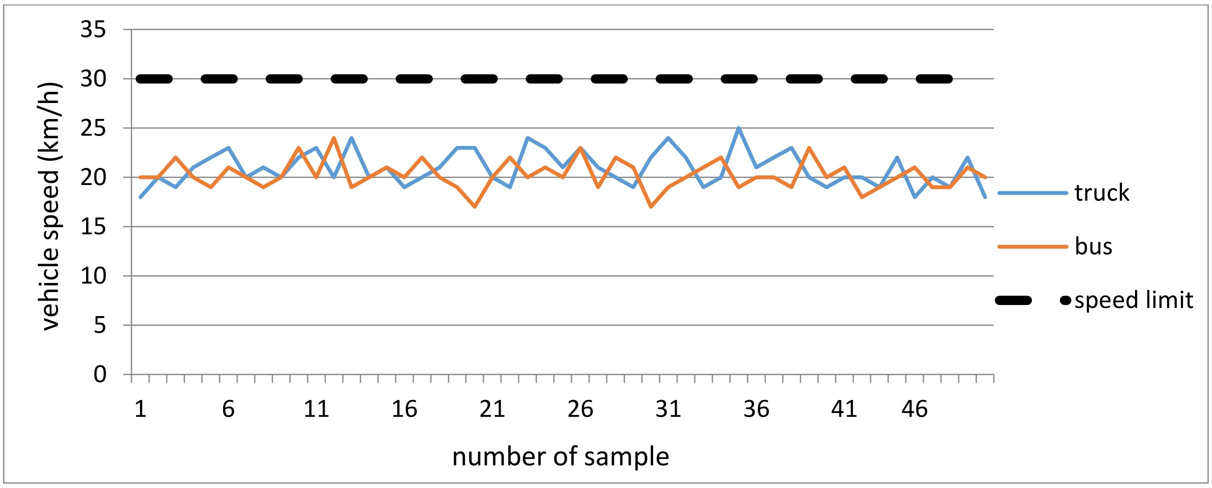

Figure 17. Spot speed data at road hump B (after road hump)

4.4 Spot Speed Characteristics

Spot speed characteristics of motorcycles, motorcars, truck and buses at road hump A and road hump B are given in table 3-6. The 85th percentile speed at each of the selected road hump are given in table 7 and 8. The average speed of each type of selected vehicle was low at road hump A when compared with road hump B. It is due to the difference in height between these two road humps. The height of road hump A was higher than road hump B.

Table 3. Mean, mode and median speed of motorcycles at road hump A and B

ROAD HUMP	DESIGN PROFILE	DIMENSION	POINT 1 (ON ROAD HUMP)			POINT 2 (AFTER ROAD HUMP)		
			MEAN	MODE	MEDIAN	MEAN	MODE	MEDIAN
A	Height	120mm	18.8km/h	19km/h	19km/h	21.6km/h	20km/h	21km/h
	Width	7m						
	Length	2.4m						
B	Height	70mm	20.8km/h	20km/h	21km/h	30.5km/h	30km/h	30km/h
	Width	7m						

	Length	3.5m						

Source: Site survey (June 24th and 27th ,2016)

Table 4. Mean, mode and median speed of cars at road hump A and B

ROAD HUMP	DESIGN PROFILE	DIMENSION	POINT 1 (ON ROAD HUMP)			POINT 2 (AFTER ROAD HUMP)		
			MEAN	MODE	MEDIAN	MEAN	MODE	MEDIAN
A	Height	120mm	17.2km/h	17km/h	17km/h	24.9km/h	26km/h	25km/h
	Width	7m						
	Length	2.4m						
B	Height	70mm	24.9km/h	26km/h	25km/h	37.2km/h	36km/h	37km/h
	Width	7m						
	Length	3.5m						

Source: Site survey (June 24th and 27th ,2016)

Table 5. Mean, mode and median speed of truck at road hump A and B

ROAD HUMP	DESIGN PROFILE	DIMENSION	POINT 1 (ON ROAD HUMP)			POINT 2 (AFTER ROAD HUMP)		
			MEAN	MODE	MEDIAN	MEAN	MODE	MEDIAN
A	Height	120mm	18.9km/h	20km/h	19km/h	20.1km/h	20km/h	20km/h
	Width	7m						
	Length	2.4m						
B	Height	70mm	19.5km/h	19km/h	19.5km/h	21km/h	20km/h	21km/h
	Width	7m						
	Length	3.5m						

Source: Site survey (June 24th and 27th ,2016)

Table 6. Mean, mode and median speed of buses at road hump A and B

ROAD HUMP	DESIGN PROFILE	DIMENSION	POINT 1 (ON ROAD HUMP)			POINT 2 (AFTER ROAD HUMP)		
			MEAN	MODE	MEDIAN	MEAN	MODE	MEDIAN
A	Height	120mm	17.4km/h	18km/h	18km/h	20.2km/h	20km/h	20km/h
	Width	7m						
	Length	2.4m						
B	Height	70mm	18.2km/h	19km/h	18km/h	20.3km/h	20km/h	20km/h
	Width	7m						
	Length	3.5m						

Source: Site survey (June 24th and 27th ,2016)

Table 7. 85th percentile speed of samples at road hump A

Road hump	**Road hump A (POINT 1)**			**ROAD HUMP A(POINT 2)**		
Types of vehicle	**Motorcycle**	**Car**	**Truck & Bus**	**Motorcycle**	**Car**	**Truck & Bus**
85th percentile	21km/h	23km/h	21km/h	25km/h	28km/h	22km/h

Source: Site Survey,24th and 27th, 2016

Table 8. 85th percentile speed of samples at road hump B

Road hump	**Road hump B(POINT 1)**			**ROAD HUMP B(POINT 2)**		
Types of vehicle	**Motorcycle**	**Car**	**Truck & Bus**	**Motorcycle**	**Car**	**Truck & Bus**
85th percentile	23km/h	28km/h	20.8km/h	**33km/h**	**40km/h**	21km/h

Source: Site Survey,24th and 27th, 2016

5. CONCLUSIONS

Urban noise pollution has a significant impact on the quality of life and thus potentially on public health. Noise pollution is among many environmental problems that are faced by University campuses. It is well-known that the increase in speed of vehicles increases noise levels. The negative relationship between learning performance and noise levels in educational centres has been determined and noise pollution has been found to reduce learning capabilities (Koszarny 1978, Ko 1979; Sargent et al. 1980, Green et al. 1982, Aydın 1998, Arı 1999). According to a research, students who have high resting blood pressure, high stress levels and also experience reading delays are those exposed to noise pollution during learning. In addition, students who suffer from noise pollution learn to not pay attention to the lecturer, which can harm their reading and language skills (Debnath, Nath and Barthakur, 2012). Traffic calming measure is one of the measures which can help overcome problems on the noise level in institutional area. Therefore, the investigation on the effects of road hump on noise level and speed of vehicle, specifically in IIUM circular road was executed to improve the quality of life especially for students within IIUM community.

This research was executed on two of the road humps in IIUM circular road in IIUM Gombak campus, namely Road Hump A and Road Hump B. The noise level and spot speed data of vehicles on, and after the road humps were collected to analyse the changes in noise level and speed. The findings show that there are significant differences in the noise level and speed of vehicle on and after the road humps. The findings also show that road hump profiles give influence on the noise and speed of vehicles that cross the road humps. This can be seen from the different patterns of noise level and spot speed recorded at both road humps. On the other hand, each type of vehicle has started to increase its speed after passing over the road humps. Additionally, the inappropriate height of road hump has caused discomfort to the drivers, and resulted in high noise level especially involving heavy vehicles.

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