EFFICIENCY OF SPEED HUMP IN REDUCING SPEED WITHIN HIGHER EDUCATIONAL INSTITUTION AREA

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EFFICIENCY OF SPEED HUMP IN REDUCING SPEED WITHIN HIGHER EDUCATIONAL INSTITUTION AREA

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ABSTRAK

Bonggol jalan adalah salah satu alat menenangkan lalu lintas yang biasa digunakan di Malaysia. Pemasangan alat menenangkan lalu lintas itu telah mewujudkan persekitaran yang lebih selamat didiami dengan peningkatan keselamatan jalan raya berikutan kelajuan yang lebih rendah digunakan. Bonggol jalan telah dilaksanakan secara meluas di Malaysia terutamanya di kawasan perumahan, tetapi keberkesanan bonggol jalan raya dalam mengurangkan kelajuan di kawasan institusi pengajian tinggi tidak diterokai dengan baik. Untuk mengukur keberkesanan jalan raya di kawasan ini, kajian perlu dijalankan untuk menilai kecekapan bonggol jalan dalam mengurangkan kelajuan di Universiti Malaysia Pahang, Kampus Gambang. Kajian ini dijalankan untuk mengukur kecekapan bonggol kelajuan dalam mengurangkan kelajuan di persimpangan empat kaki yang tiada isyarat di Jalan Persekutuan 222 yang terletak di hadapan pintu masuk utama UMP. Pistol radar digunakan untuk mengumpul data kelajuan aliran bebas kereta penumpang dengan dan tanpa adanya bonggol jalan. Pengurangan kelajuan telah dikenalpasti selepas pemasangan dua set tiga bonggol bulat dengan ketinggian 50mm-100mm dan lebar 3.7m-4.0m. Peratusan kadar pengurangan kelajuan adalah 56.5%. Ujian T sampel yang berpasangan dilakukan untuk membandingkan pengurangan kelajuan purata sebelum bonggol dipasang dan selepas bonggol dipasang. Keputusan dari analisis t-ujian menunjukkan perbezaan yang signifikan secara statistik dari segi pengurangan kelajuan purata sebelum dan selepas bonggol bulat dipasang yang membuktikan kecekapan bonggol jalan dalam mengurangkan kelajuan di kawasan institusi pengajian tinggi.

ABSTRACT

Road hump is one of the most commonly used traffic calming devices in Malaysia. The installation of such traffic calming device has created a more live-able environment with improvement on road safety as a result of lower speeds. Road humps has been widely implemented in Malaysia especially in residential area, but the effectiveness of road humps in reducing the speed within higher educational institution area is not well explored. In order to measure the effectiveness road humps within this area, a study must be carried out to evaluate the efficiency of road humps in reducing speed within Universiti Malaysia Pahang, Gambang Campus. This study was carried out at the un-signalized four legged intersection of Federal Road 222 that located in front of UMP main entrance. Radar gun was used to collect the passenger’s car free flow speed with and without the existence of road humps. It was found that the speed reduction after the installation of two sets of three round-top humps with height 50mm-100mm and width 3.7m-4.0m both-ways was calculated as 56.5%. Paired sample T-tests were carried out to compare the average speed reductions before humps were installed and after the humps were installed. Result from t-test analysis shows a statistically significant difference in terms of average speed reductions before and after the round-top humps were installed that prove the efficiency of road humps in reducing speed within higher educational institution area.

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LIST OF SYMBOLS

SBPWM	Simple Boost Pulse Width Modulation
ZSI	Z source inverter

LIST OF ABBREVIATIONS

UMP	Universiti Malaysia Pahang
MNCS	Multinational Corporations
ECE	East Coast Expressway
LPT	Lebuhraya Pantai Timur
JKR	Jabatan Kerja Raya
MHA	Malaysian Highway Authority
MEC	Malaysia Electric Corporation
FR2	Federal Road 2
FR3	Federal Road 3
SSD	Stopping Sight Distance
OSD	Overtaking Sight Distance
SPSS	Statistical Package for Social Science
MS	Microsoft

CHAPTER 1

INTRODUCTION

1.1 Introduction

Speed humps are parabolic vertical traffic calming devices, a gradual raised area in the pavement surface extending across the entire travel width which intended to reduce the traffic speeds on low volume and low speed roads. Typical speed hump measurement for round-top hump will be 50mm-100mm in height with a travel length of 3.7m-4.0m, according to Malaysia Road Hump Specifications (Bachok et al. 2016). This device will create a gentle vehicle rocking motion which results in most vehicles reduces the speed to 35 km/h. Speed hump shall be accompanied by a traffic calming strategies such as pavement markings and warning signage on the approaches as mentioned by Gonzalo-Orden et al, (2016) so that drivers are notified of their presence. This device work best when they are designed and spaced appropriately. To achieve greater speed reductions, space of speed humps need to be designed closely together. The main purpose of installing speed hump is to introduce discomfort, through shocks and vibrations as stated by Patel and Vasudevan (2016), to driver and passengers, while their vehicle passes over it with the speed greater than the designed speed (Bachok et al. 2016). By installing humps, it will give distraction to the drivers thus it reduces overall speeds of the vehicles (Yaacob and Hamsa 2013).

Speed is the scalar quantity that is the magnitude of the velocity vector. It illustrates acceleration or a high rate of motion on how fast an object is in mobile. A higher speed means an object is moving faster while lower speed means it is moving slower. The object may have been going faster or slower at different points during the time interval. It has zero speed when object is stationary. Speed is an important factor in road safety affecting both collision occurrence and extremity (Jateikiene et al. 2016). As mentioned by Ahmed et al, (2015) to achieved zero collision count, it is almost impossible but through a proper study, reduction in the severity of accident can be achieve. As drivers move faster, they have limited time to respond to road conditions and might resulting collision that will cause more harm. Annually, millions of road users are killed or wounded in traffic collisions. In developing countries, death tolls are projected to increase by over 80% and by 65% in the developed countries by 2020. Traffic collisions in Malaysia have been inclining at an average rate of 9.01% per annum from 1974 to 2010. In 2020, Malaysia is estimated to have over 20 death tolls per 100,000 people. Imprudent speed is considered to be the major contributory factor to road accidents, injuries and deaths (Ghadiri et al. 2013).

National Speed Limits is a set of speed limits applicable on Malaysia expressways, federal roads, state roads and municipal roads. Failing to obey the speed limit on Malaysian roads and expressways is an offence as subject to Malaysian Road Safety Act 1987 which can be fined up to RM300, depending on the difference between the speed limit and the driven speed. According to National Speed Limits of Malaysia, for institutional areas, the speed limit of 35 km/hr is applicable during rush hours.

This study was conducted to inspect the level of efficiency of speed humps as a traffic control device in reducing speed within higher institutional areas as there was no previous study of humps in assisting drivers to reduce the speed of the vehicle within this area was conducted

1.2 Background of Study

Universiti Malaysia Pahang (UMP) was established by the Government of Malaysia on February 16, 2002. UMP was set up as a competency based technical university which specialises in the fields of engineering and technology. UMP is located on the east coast state of Pahang, the biggest state in Peninsular Malaysia with vast areas of rainforest endowed with a wide range of bio diversities and natural resources. The campus is also strategically located in the East Coast Industrial Belt Peninsular Malaysia which hosts a large number of multinational corporations (MNCS) in the chemical, petrochemical, manufacturing, automotive and biotechnology industries. UMP offers a wide range of skills-based tertiary education programmes and hands-on-based tertiary education in engineering and technology to produce competent engineers.

For the road network outside of UMP Gambang campus, there are two classification of road. First, East Coast Expressway (ECE/LPT) (E8) which are designed under JKR R6 standard with maximum speed limit of 120 km/h and minimum lane width of 3.5 m. This expressway has full access control and being managed under the administration of Malaysian Highway Authority (MHA) that connects Karak to Kuala Nerus. Second, Federal Road (Federal Route 222) with JKR R5 standard, is a road that connecting between Gambang traffic light and Gambang toll exit. The design speed limit is 100 km/h and lane width is 3.5 m. This road is dual carriageway that has partial access control. This highway overlaps with Federal Route 3 from Kuantan Airport Interchange to Jalan Pekan Exit. The intersection in front of UMP is connecting Gambang toll plaza and signalized intersection at FR2, which is also known as Jalan Gambang and Jalan Tanah Putih, is a major highway in Kuantan that connects Gambang to Kuantan and FR3, which links the town of Bukit Ibam and Bandar Muadzam Shah to the town of Bandar Baru Rompin. The Kilometre Zero of the Federal Route 63 starts at Bukit Ibam and ends at its intersection with the FR3, the main trunk road of the east coast of Peninsular Malaysia.

GEOMETRIC DESIGN ITEMS				ROAD CATEGORY																				
Design Control & Criteria	1	Design Standard	n/a	R6			R5			R4			R3			R2			R1			R1A		
	2	Access Control	n/a	Full			Partial			Partial			Partial			None			None			None		
	3	Terrain Condition	n/a	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M
	4	Design Speed	km/h	120	100	80	100	80	60	90	70	60	70	60	50	60	50	40	40	30	20	40	30	20
Cross Section Elements	5	Lane Width	m	3.65			3.50			3.25			3.00			2.75			(5.00)			(4.50)		
	6	Shoulder Width	m	3.00	3.00	2.50	3.00	3.00	2.50	3.00	3.00	2.00	2.50	2.50	2.00	2.00	2.00	1.50	1.50	1.50	1.50	1.50	1.50	1.50
	7	Shoulder Width (Structures) > 100 m	m	1.00			1.00			1.00			0.50			0.50			0.50			0.50		
	8	Median Width (Minimum)	m	6.00	5.00	4.00	4.00	3.50	3.00	3.00	2.50	2.00	n/a			n/a			n/a			n/a		
	9	Median Width (Desirable)	m	18.00	12.50	8.00	12.00	9.00	6.00	9.00	6.50	4.00	n/a			n/a			n/a			n/a		
	10	Marginal Strip (Width)	m	0.50			0.50			0.25			0.25			0.00			0.00			0.00		
	11	Minimum Reserve Width	m	60.00			60 (50)			40(30)			20.00			20.00			12.00			12.00		
Elements of Design	12	Stopping Sight Distance	m	285	205	140	205	140	85	180	120	85	120	85	65	85	65	45	45	30	20	45	30	20
	13	Passing Sight Distance	m	n/a			700	550	450	675	500	450	500	450	350	450	350	300	300	250	200	300	250	200
	14	Minimum Radius	m	570	375	230	375	230	125	300	175	125	175	125	85	125	85	50	50	30	15	50	30	15
	15	Minimum Length of Spiral	m	n/a			n/a			n/a			n/a			n/a			n/a			n/a		
	16	Maximum Superelevation	Ratio	0.1			0.1			0.1			0.1			0.1			0.1			0.1		
	17	Maximum Grade (Desirable)	%	2	3	4	3	4	5	4	5	6	5	6	7	6	7	8	7	8	9	10		
	18	Maximum Grade	%	5	6	7	6	7	8	7	8	9	8	9	10	9	10	12	10	12	15	25		
	19	Crest Vertical Curve (K-crest)	n/a	120	60	30	60	30	15	45	22	15	22	15	10	15	10	10	10	5	5	10	5	5
	20	Sag Vertical Curve (K sag)	n/a	60	40	28	40	28	15	35	20	15	20	15	12	15	12	10	10	8	8	10	8	8

Figure 1-1 Geometric Design for Rural Standards

Based on the figure shown, the rural standard of road design has been classified into three different classes which are design control and criteria, cross section elements and elements of design. In each class, there are few sub units. In cross section elements for JKR R5, the sub units are minimum median width is 4m with desirable median width is 12m. The width of marginal strip is 0.5m and minimum reserve width is 60m. The design of highway elements includes alignment, lane capacity and sight distance. Sight distance is length of the road surface at which object stationary or moving are visible by the driver while driving. There are two types of sight distance which are Stopping Sight Distance (SSD) and Overtaking/Passing Sight Distance (OSD). From Figure 1, the SSD is 205m for R5 standard while OSD is 700m.

Referring to the Universiti Malaysia Pahang traffic rules of 2016, the speed limit within the campus area is 35km/h. This rule applies to all students, staffs and visitors while on campus. The purpose of this regulation is to safeguard traffic safety within the university campus area. On a typical class day, more than hundreds of students and staffs travel within campus area. In UMP, where the private automobile dependency is considered high as most of the students and staffs prefer to travel within the campus using their own vehicles, a safer traffic environment for all road users need to be ensure so that the road user can travel safely without involving in any collisions and it also to ensure all drivers can educate themselves on the importance of the campus traffic's rules and regulations so that all traffic users will be using the road safely.

1.3 Problem Statement

On roadway systems, intersections are among the most perilous locations. Un-signalized intersections can be distinguished from other intersection in that their operation takes place without any existence of a traffic control. According to previous research by Abdel-Aty & Haleem (2010), many studies have extensively analysed safety of signalized intersection but did not focus on the un-signalized intersection. The main motive is the scantiness and exertion to obtain data at intersections, as well as the limited collision tallies (Abdel-Aty & Haleem, 2010).

Over the period of time, scientific study of collision incidence and its causes has influenced the design of road infrastructure. Un-signalized intersection has instigated a high number of total collisions that occur on Malaysian traffics (Ahmed et al., 2015). From previous study, (Loukaitou-sideris et al. 2014) mentioned that crashes can be occurred on major road near campus. It is due to high traffic flow and drivers tend to speeding especially during peak hours.

On 16th September 2017, the first lethal accident occurred at the intersection in front of the UMP campus main entrance. The accident involves two students of Universiti Malaysia Pahang, a male student from the Faculty of Chemical Engineering and female students from the Civil Engineering Faculty. The male student died at the scene due to severe bleeding while the female student suffered minor casualties. This collision occurred following a car driven by the victim who wanted to enter the campus was hit by a vehicle coming from the direction of the toll plaza to Kuantan. One week later, on 21st September 2017, another accident occurred and killed a female student. The student was believed to have dropped off a motorcycle ridden by his friend, and was hit by a car passing through the road.

Due to those cases, Public Work Department (JKR) had constructed two sets of three round-top humps at the intersection in front of UMP Gambang Campus main entrance. In order to measure the effectiveness road humps within this area, a study must be carried out to evaluate the efficiency of road humps in reducing speed within Universiti Malaysia Pahang, Gambang Campus. This study was carried out to measure the efficiency of speed humps in reducing speed at the un-signalized four legged intersection of Federal Road 222 that located in front of UMP main entrance.

1.4 Objectives

The primary objective of this study is to measure the efficiency of speed humps in reducing speed. In order to achieve the main objectives, another secondary objective are listed below must be achieved. The secondary objectives are:

- To produce the trend of vehicles speed (without speed humps),
- To produce trend of vehicles speed (with speed humps)

1.5 Scope of Study

The scope of study has been determined in order to ensure that the data collection and analysis is focusing on certain field only. The limitations of this study are listed below:

i. The study area focused on un-signalized four legged intersection of main road which located in front of UMP Gambang campus main entrance.

ii. The data of spot speed are collected during peak hours which are morning (7-9am), afternoon (12-2pm) and evening (4-6pm).

iii. The devices used in this study are handheld radar gun.

iv. Area of conducting study is within 30 metre from the centre of the intersection.

v. The speed data before installation of speed humps are taking on Thursday for weekday, and Saturday for weekend. Both are taking one time only.

vi. The speed data after the installation are taking for three times with the interval of three weeks.

1.6 Significant of Study

This study is carried out to spread more awareness to all parties involved in producing a safer environment to all road users. This research will allow for an explicit study on the traffic volume and speed on the intersection which may be helpful to the Public Work Department (JKR), Ministry of Work (MOW) and local authority to overcome the problem on the intersection design and construction. Furthermore, this study is useful for government and local authority in order to assist in identifying many road defectives.

CHAPTER 2

LITERATURE REVIEW

2.1 Malaysian Crash Trend

Although road crash are intensely common issues around the world over many decades, many researchers are still anticipating to trims these worldwide problems. Accidents happen due to the combination of many factors. In 2030, road traffic injury is believed to be the 8th leading cause of death as mentioned by (Masuri et al. 2015). There are three major components in road transport systems which are road users, the vehicle and the environment. The increment of the number of accident happened in Malaysia is linked to the rapid growth in population, economic, industrialization and motorization industries as stated by Masuri et al, (2015) which were believed is a contributing factors to the road accidents.

2.1.1 Crash Trend by Type of Vehicle

Malaysian road generally carry different type of traffic such as motorcycles, cars, lorries, buses etc. The various of vehicles have different speeds, size and capacity. Table 2.1 focuses on the number of vehicle involved in road crash by type of vehicle from year 2007 till year 2016. The data are extracted from the police traffic branch of Bukit Aman database on road crash.

Table 2-1 Total Motor Vehicles Involved In Road Crash by type of vehicle, Malaysia, 2007-2016

Year	Motorcycle	Motorcar	Van	Bas	Lorry	Four Wheel Drive	Taxi	Bicycle	Other	**Total**
2007	111765	426941	21109	10285	47696	21823	8809	2690	14909	**666027**
2008	111819	435665	20392	9356	48250	22793	8769	2463	11571	**671078**
2009	113962	472307	19220	9380	46724	23581	8669	2486	9294	**705623**
2010	120156	511861	18788	9580	50438	25777	9899	2178	11756	**760433**
2011	129017	546702	17916	9986	53078	30828	11197	2033	16394	**817151**
2012	130080	655813	15143	10617	42158	32891	11680	1310	21540	**921232**
2013	121700	632602	17148	10123	39276	52512	11651	1370	15441	**901823**
2014	125712	617578	15041	9193	37481	41464	10856	1275	27743	**886343**
2015	123408	625758	14565	8804	34942	46163	9591	1119	29924	**894274**
2016	135181	670935	14470	9462	35064	48907	8399	1318	36833	**960569**

Source : Traffic branch Bukit Aman (Pengangkutan, n.d.)

Generally the figure above indicates that the highest total number of type of vehicle involved in road crashes is in year 2016 with the number of motorcycle was 135181, motorcar 670935, van 14470, bas 9462, lorry 35064, four wheel drive 48907, taxi 8399, bicycle 1318 and other was 36833. The total for the vehicle collisions for the year of 2016 alone was estimated for about 960569 numbers of collisions. This has been indicated that each year, the vehicle collisions have been increasing not only from one specific type of vehicles. As for 2016, it has the highest total of collisions for overall vehicles which in approximately 960569. It has the highest total collisions from the statistics shown starting from 2007. The lowest total of collisions involved all types of vehicles were stated in 2007 which has for about 666027. From the table shown above, we can conclude that the total of collisions has been increased each year and it shows that more traffic users were not really paid attention to the importance of the road safety and this may causes the accidents to increases in numbers each year.

Furthermore, based on the tables shown from the source of Bukit Aman Traffic, the type of vehicle that has the highest numbers that has been involved in the collisions were motorcycles. From the tables shown, motorcycle has the highest number of crashes from 2007 and it has been increasing up until 2016. The increasing in numbers were concerning and it is because most of the motorcyclist did not really obeyed the law of the traffic which they have their own motorcycle path but mostly they risk their life and safety by using the same traffic as the other big vehicles on the road. Other than that, most of the collisions may involves motorcycle because they were always on the other vehicle's blind spots and it has higher possibilities for other vehicles to did not see or aware of the presence of the motorcyclist on the road.

2.1.2 Crash Trend Caused by Road Crashes

Table 2.2 shows the statistic of different type of casualties happened from Year 2007 until 2016.

Table 2-2 Total Casualties and Damages caused by Road Crashes, Malaysia, 2007-2016

Year	Total no. of accident	Casualties			
		Death	Serious	Minor	**Total**
2007	363319	6282	9273	18444	**33999**
2008	373071	6527	8868	16879	**32274**
2009	397330	6745	8849	15823	**31417**
2010	414421	6872	7781	13616	**28269**
2011	449040	6877	6328	12365	**25570**
2012	462423	6917	5868	11654	**24439**
2013	477204	6915	4597	8388	**19900**
2014	476196	6674	4432	8598	**19704**
2015	489606	6706	4120	7432	**18258**
2016	521466	7152	4506	7415	**19073**

Source : Traffic Branch Bukit Aman (Pengangkutan, n.d.)

As stated in this table, the total of casualties has been divided into three stages of injuries. It has death casualties that involve fatal death for the victims, serious or critical casualties which involves serious injuries which is life threatening and also minor casualties which only involves injuries that is not critical and not life threatening cases. As from what we seen, the table also stated the statistics from 2007 up until 2016.

As from the statistics above, the major total casualties that we can see occurred on 2007 which has for about 33999 totals of casualties combined all three levels of casualties. It might be caused by the rules that have been ignored by the traffic users and it can cause the casualties to be bad and concerning. As the time goes on, the total of the casualties has been decreasing but it increases a bit on 2016. Even though the totals of crashes are the highest on 2016, but the casualties were lesser than 2007 which has the highest total of casualties throughout the years.

As to states the fatal casualties throughout the years, 2016 has the highest numbers of fatal crashes and 2007 has the lowest fatal casualties recorded. It may cause by the drivers that did not obeyed the traffic rules and also did not obeyed the speed limit on the road. Next is for the serious casualties, the highest recorded statistics are from 2007 which were 9273 casualties that were life threatened casualties whereas 2015 recorded as the lowest serious casualties involved during the crashes. Lastly for the minor casualties, 2016 has states the lowest casualties whereas the highest were on 2007 which total up to 18444 total of casualties.

In the nutshell, the total of casualties might have been decreasing throughout the years. Unfortunately, the total of fatal death of crashes have been increasing and it might be because most of the drivers were driving in dangerous ways and they did not really obeyed the speed limit that has been stated for them to followed.

2.2 Crash Trend Nearby Higher Educational Institutional Area

In the last decade, there are many researchers studied on pedestrian and bicycle safety due to many crash happened within educational areas involving these two type of road users but limited studies have focused on campus areas as mentioned by Loukaitou-sideris et al, (2014) since most of researchers targeted school students as their targeted group as stated by Pollack et al, (2014) which they believed it is important for parents and teachers to ensure the safety of students is guaranteed during the school session. The reason why researchers are not focusing on university students might be due to all the students were adults which results in lack of safety environment evaluation on universities areas. The safety of every individual is really important without prejudice about their age number. Loukaitou-sideris et al, (2014) who have studied about crashes happened in campus area located in United States mentioned that pedestrians and bicyclists should be a priority when considering campus design as they are the main road users in the campus as most of the students chose walking as their mode of travelling around campuses. Therefore, a safe environment for campus area must be created as many people are in the campus area especially during class hour.

To reduce the crashes incident, some researchers suggested the reduction of using private automobile should be made as they can results in traffic congestion within campus area (Loukaitou-sideris et al. 2014). To avoid the campus areas from excessive ~~of~~ vehicles uses especially during peak hours, staffs and students can implement the car-sharing concept where they will travel around campus area by sharing car with other people. In fact, this concept will also save the uses of petrol. Previous study by Loukaitou-sideris et al, (2014) have found that crashes are highly happened on major road near the campus area while Pollack et al, (2014) shows the positive relationship between traffic volume and number of collision where he believed high traffic volume will increasing the risk of collision. Although speed regulations around campus area have been widely implemented, some of the drivers did not take the rules seriously because some of the road users felt that the fine imposed is not severe for them.

From the survey conducted by Loukaitou-sideris et al, (2014), minority of respondents made a report to the authorities about the crashes happened within the campus area while majority of respondents felt that the injury was minor and some said that nothing action can be taken by the university authorities. The perception having by the respondents has made the improvement for a better plan of safeness within campus area become more difficult due to lack of crash data can be recorded by the local authorities. Every people should educate themselves by joining safety program or take serious consideration about their life.

2.3 Crash Trends at Non-signalized Intersection Area

(Ashar Ahmed, Farhan, and Sadullah 2014) studied about 448 non-signalized intersections in Malaysia which non-signalized intersections are one of the road infrastructures which is generally implemented for roads with low traffic volume. Since there is obstacles to get the exact data from previous study, Ashar Ahmed et al, (2014) has come out with an alternative by identified critical conflicts of the non-signalized intersection to measure the probability of crashes happened at intersections. The obstacles is due to the record of crash happened at intersection area is old to be used and there is limitation of data collection about intersection which results in making the researcher faced serious issue to use previous data recorded for current situation. It proved that intersections with lack of road marking has become main factor to high number of accidents occurred as mentioned by (Ashar Ahmed et al, (2014), they discovered that different type of severity facing by the victim caused by several parameter such as lane marking and traffic control. Drivers use high speed when crossing the intersection on road where lack of traffic control resulting in accidents (Ashar Ahmed, Farhan, and Sadullah 2014). It might because of drivers not be able to see the cars crossing the intersection or the difficulty in making decision to cross the intersection since there is limitation in signages to inform the drivers. It clearly shows that road width has become one of major factor that contributing to risk of crashes when 40% of the crashes happened on non-signalised intersection were on width between nine to twelve meters which believed due to most of the drivers felt they have enough time to crossing the non-signalized intersection since the road width is bigger enough for them to speeding.

From previous research by Manan et al, (2011) based on data developed by using multiple regression model, the researcher predicted the models of intersection based on traffic flow. Since intersection area gives high influence to vehicles especially to drivers when considering their decision on crossing road, the construction of channelization is an effective way in ensuring the safety of road users. Manan et al, (2011) discovered that intersection conflicts occurred when high number of traffic streams moving in different direction which can increase the risk of collision. It might happen because of the lack of tolerances between the road users. Besides, there are several factors contributes to the crash happened at intersection as stated by Manan et al, (2011) which proved that signalized intersection is safer than non-signalized intersection as there are presence of several traffic calming measures and three legged intersection were safer as compared to the four legged intersections as similar to previous study by Schorr and Hamdar (2014) they also have found that the safety will decrease as increasing the number of intersections leg.

2.4 The Effect of Speed Hump in Reducing Speed

By referring to (Zainuddin et al, (2014) which study about the correlation between specification of speed hump and speed reduction, speed hump has been widely being used as a treatment in reducing speed as stated by Rahman et al, (2009) within the residential areas. With the presence of speed hump, drivers will slow down their vehicles when they cross over hump as hump will give distraction to the drivers by giving vibration to the body of drivers and passengers. The optimal designs of speed hump to be used at different location has been identified by developed the 85th percentile speed reduction model. Through proper construction and standard specification of hump being used, the speed of vehicles can be reduced maximally. Other researchers who studied about incident rates between pedestrian and vehicle collision has mentioned that the installation of humps was associated with a 22% reduction of collision rates (Rothman et al. 2015). Therefore, the uses of speed hump in reducing crashes have been proved.

2.5 Analysis Method using Statistical Analysis

Statistical analysis is the process of collecting and interpreting of data use to identify the patterns and trends of past situation and the current situation. It has been used by many researchers in their studies.

2.5.1 T-test

A t-test is an analysis of two population's means through the use of statistical examination which commonly used with small sample sizes, testing the level of significance difference between the samples when the variances of two normal distributions are not known. There are three types of t-test :

1. An independent Samples t-test which compares the means for two groups

2. A Paired sample t-test compares means from the same group at different times

3. A One sample t-test which tests the mean of a single group against a known mean

2.5.2 Paired Sample T-test

A paired sample t-test is used when the samples taken from the same population. An example of a paired sample is a pre-test/post-test study design in which a factor is measured before and after an intervention or treatment being done. On the other hand, it can also be applied to two populations provided that they are homogeneous (having the same characteristics and criteria) and both populations must be approximately normally distributed.

2.6 Summary

In the nutshell, we can conclude that the increment of rate of accidents happened is due to populations' increases. Due to lack of previous study has been conducted to identify the crash patterns around the university area, this research would be helpful for authorities in keeping the record for future and students for ensuring their safety during being around the campus area.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Methodology is an initial stage of the study. On the other word, methodology is planning and scheduling process which important to ensure the smoothness of the study progress. A clear step in every stage is to minimize problem in this study. The process will be divided into three stages. The stages are including data collection, data interpretation and data analysis.

The study was expected to yield result on speed before installation of hump and speed after installation of hump at four legged un-signalized intersection in front of UMP Gambang Campus main entrance.

3.2 Research Flowchart

In this study, there are two stages of research flowchart. In Stage 1 and Stage 2, there are three steps that have been conducted which are Data Collection, Data Interpretation and Data Analysis. Stage 1 represents the flowchart of work before installation of humps while Stage 2 shows the sequences of work after humps' installation.

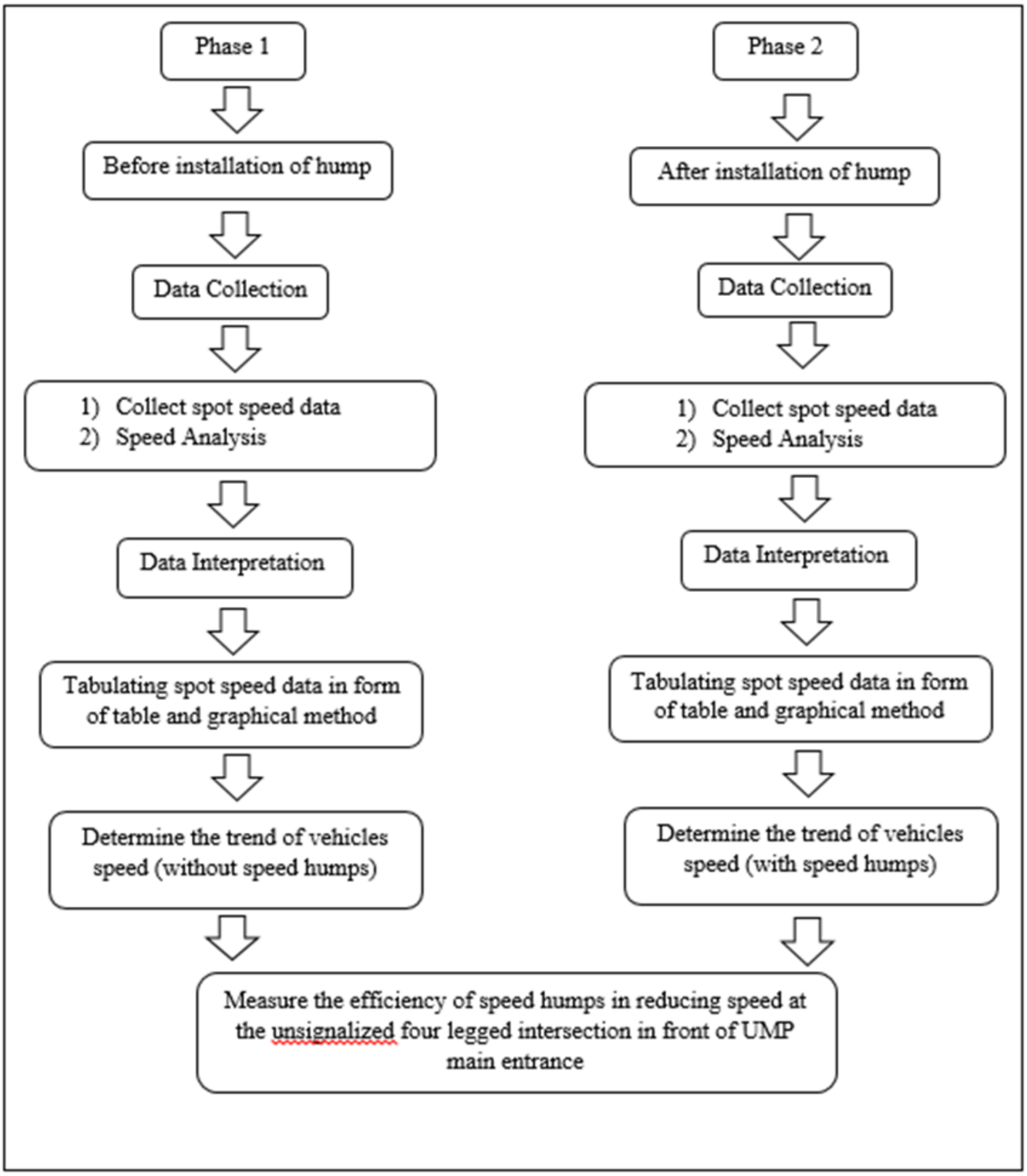


Figure 3-1 Research Flowchart

Figure 3.1 shows the methodology of this study. At the end of both stages, the efficiency of hump in reducing speed was been identified.

The study were implemented in three stages which are data collection at the four legged un-signalized intersection in front of UMP Gambang Campus main entrance, data interpretation by using MS Excel and speed analysis by using SPSS software (Statistical Package for Social Science). The analysis was done to see the difference between speed data according to installation of hump.

3.2.1 Data Collection

The study area is focusing on the un-signalized four legged intersection that located in front of UMP Gambang Campus main entrance. This area involves Federal Road 222 (Jalan Gambang-Kuantan), road connecting Gambang toll plaza and Gambang Intersection as shown in Figure 3-2.

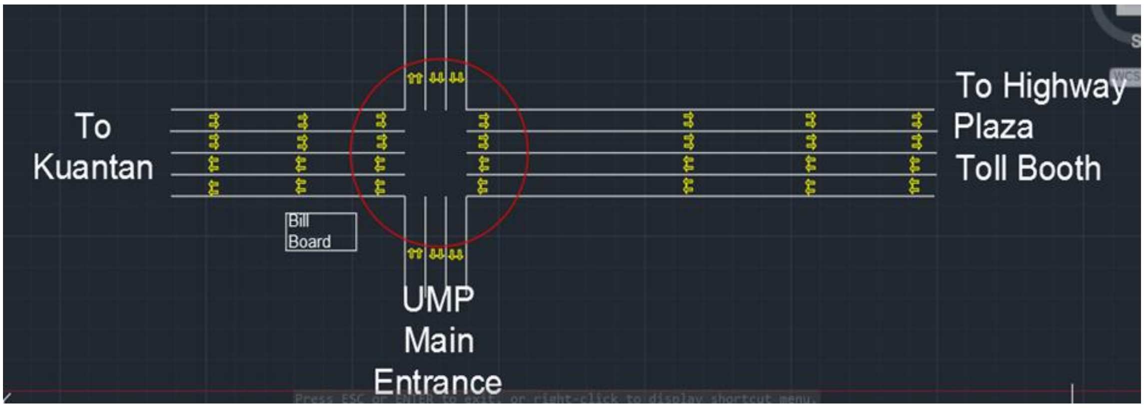


Figure 3-2 The Study Area

The circle of red line shows the intersection that has been picked as the study area where two fatal accident occurred. The crashes were believed to be caused by high speed vehicles coming from Gambang toll plaza area. The area of study is within 30 metre from the centre of the intersection as shown in Figure 3-3.

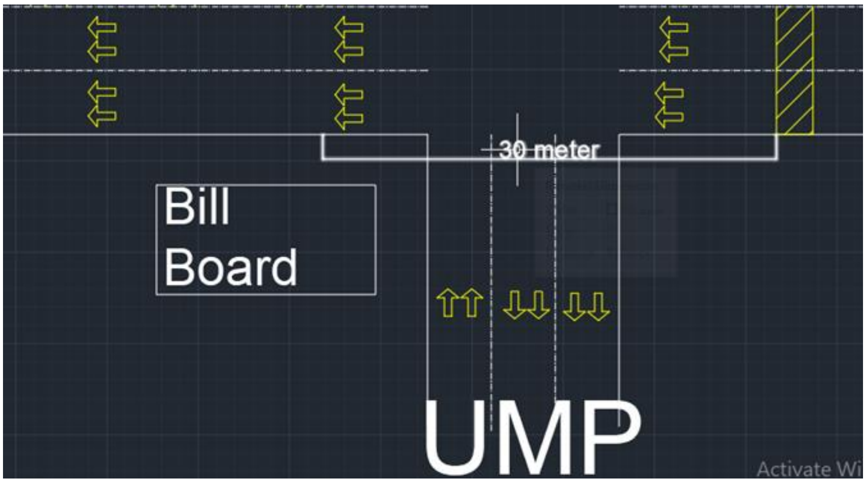


Figure 3-3 Location of Data Collection

The spot speed study is conducted manually on un-signalized intersection. In order to do it, the apparatus needed is as shown in Figure 3-4.

Figure 3-4 Radar Gun and Meter Roller

Handheld radar gun are used for measuring the traffic speed while roller metre are used for measuring the distance of location of spot speed data being collected. The spot speed data was collected during peak hours which are Morning (7-9AM), Afternoon (12-2 PM) and Evening (4-6 PM). The speed data before the installation of humps were taken on Thursday for weekday (two times) and three times on Saturday for weekend while the speed data after the installation were taken for three times within the period of three weeks. The weather during the data collection was sunny. For data collection before installation of humps, it just one day for each weekday and weekend can be recorded. This is due to the construction of humps being done by the contractor. This field work is taking two hours for every session. Figure 3-5 shows the example of raw data sheet and Figure 3-6 shows example of filled data sheet.

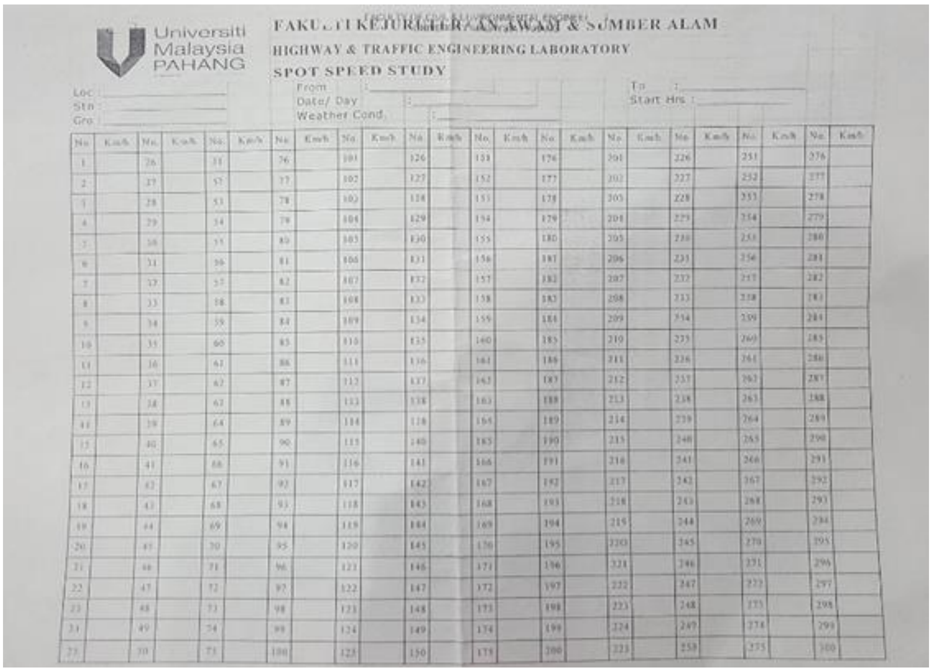


Figure 3-5 Raw Data Sheet

The raw data sheets are obtained from Highway and Traffic Laboratory which intended to record all the traffic speed during two hours of fieldwork sessions.

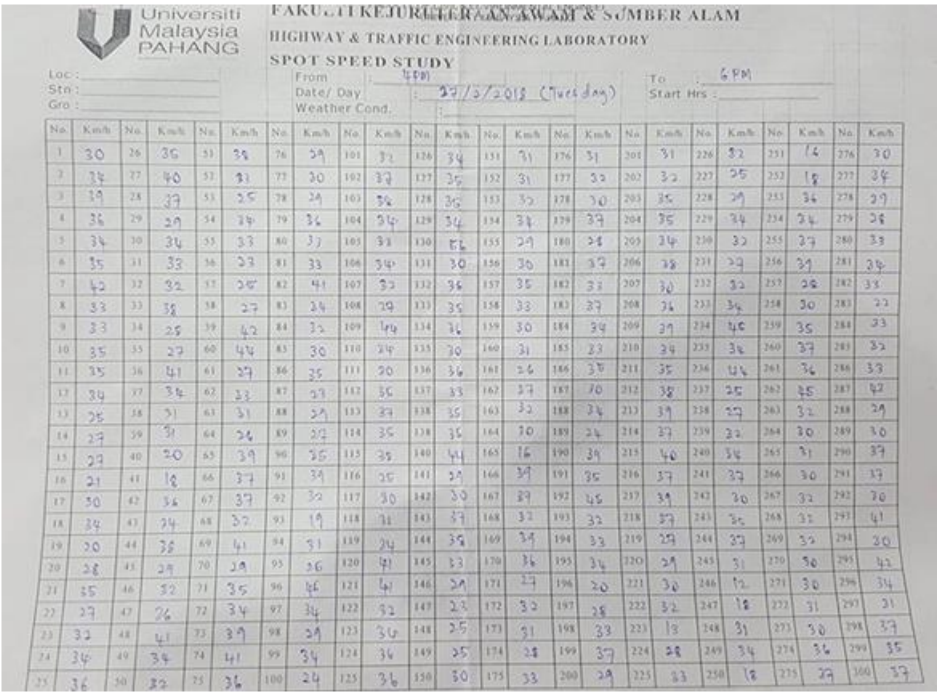


Figure 3-6 Filled Data Sheet

The second step of flowchart which is data interpretation is being carried out after the data before installation of humps and after humps were installed has been recorded.

3.2.2 Data Interpretation

After all the data has been collected, data interpretation is carried out to determine the trend of vehicles speed before installation of hump and to produce vehicles speed with humps. First, the data before and after installation of hump that has been collected is recorded and tabulated in Microsoft Excel, as shown in Table 3-1.

Table 3-1 Example of Raw Data Interpretation Using MS Excel

SPEED GROUP	MEAN SPEED, v	NO. OF FREQUENCY	% OF TOTAL OBSERVATION	CUMULATIVE %	fv	v^2	fv^2
0-19.9	10	0	0	0	0	100	0
20-39.9	30	3	0.408163265	0.408163265	90	900	2700
40-59.9	50	85	11.56462585	11.97278912	4250	2500	212500
60-79.9	70	381	51.83673469	63.80952381	26670	4900	1866900
80-99.9	90	225	30.6122449	94.42176871	20250	8100	1822500
100-119.9	110	38	5.170068027	99.59183673	4180	12100	459800
120-139.9	130	3	0.408163265	100	390	16900	50700
140-159.9	150	0	0		0	22500	0
TOTAL		735	100		55830	68000	4415100

After that, the speed data were arranged and calculated using several parameters:

$$\text{Mean , x} = \frac{\Sigma fv}{n} \qquad 3.1$$

$$\text{Median} = L + \left(\frac{\left(\frac{n}{2}\right) - fL}{fm}\right) \text{ x C} \qquad 3.2$$

$$\text{Standard Deviation, s} = \sqrt{\left(\frac{\Sigma fv^2}{n-1} - \frac{(\Sigma fv)^2}{n(n-1)}\right)} \qquad 3.3$$

From Table 3.1, the mean, median and standard deviation of speed data were obtained. A graph of frequency distribution curve as shown in Figure 3.7 drawn using MS Excel to identify the average of speed used at the intersection.

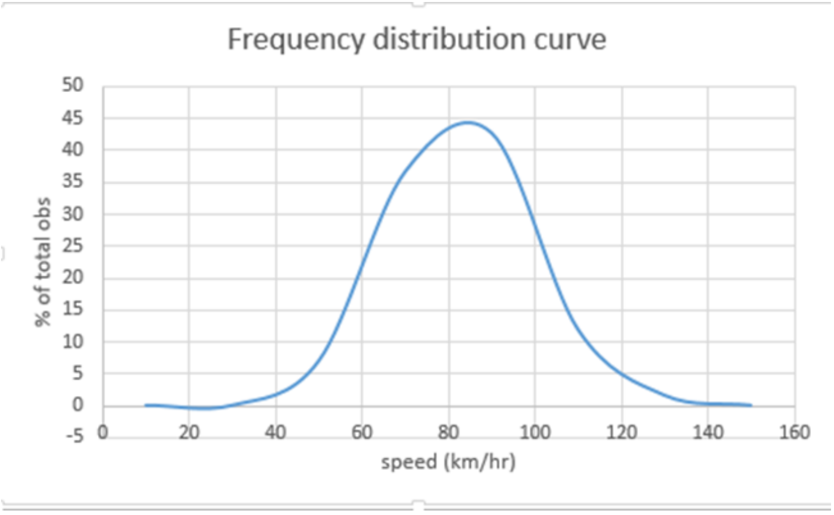


Figure 3-7 Frequency Distribution Curve

Figure above shows the average vehicles speed used by drivers at the un-signalized four legged intersection of Federal Road 222.

Table 3.2 shows the data that has been collected being tabulated ~~by~~ according to three parameters which are mean, median and standard deviation during their peak hours.

Table 3-2 Example of Tabulated Data by Mean, Median and Standard Deviation by According to Peak Hours Using MS Excel

	Mean	**Median**	**Std.Deviation**
7-9 AM	78.07 km/hr	70.42 km/hr	26.12 km/hr
	Mean	**Median**	**Std.Deviation**
12-2 PM	75.96 km/hr	74.60 km/hr	15.41 km/hr
	Mean	**Median**	**Std.Deviation**
4-6 PM	82.88 km/hr	82.93 km/hr	16.78 km/hr

From the table above, the mean, median and standard deviation of vehicles speed during peak hours can be differentiated.

3.2.3 Data Analysis

3.2.3.1 Using Microsoft Excel

After the speed data has been obtained from both stages of research flowchart, a graph was drawn using MS Excel to analyse the speed used by vehicles at the intersection of Federal Road 222 in front of UMP Gambang Campus main entrance.

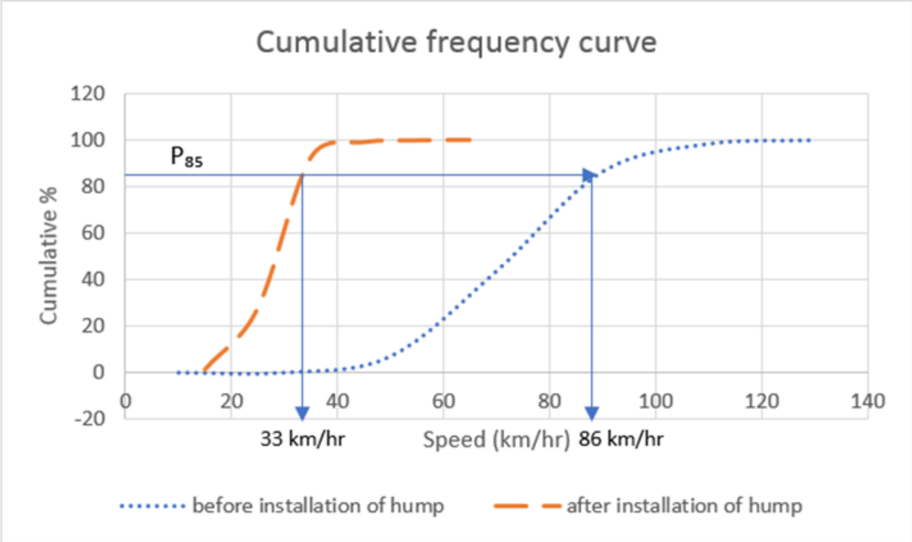


Figure 3-8 Speed used by the vehicles before and after installation of humps

Figure above shows the speed used by the vehicles when crossing the intersection. Speed data from both stages are tabulated by using MS Excel in order to determine the average speed used at the intersection. The average speed before installation of hump and after hump were installed on the un-signalized intersection being compared by using MS Excel as shown in Table 3.3.

Table 3-3 Tabulated Speed Using MS Excel

Speed (km/hr)	
Before hump	After hump
55	34.47
110	34.47
70	34.47
82	34.47

From Table 3.3, there is a parameters can be identified which is percentage of speed reduction,

$$= \frac{\sum(after - before)}{\sum Speed\ before} \text{ x } 100 \qquad 3.4$$

3.2.3.2 Using SPSS Software

All data will be analysed using statistical software called Statistical Package for Social Science (SPSS). At the end of this study, the efficiency of hump in reducing speed will be evaluated to fulfil the primary research objectives of this study.

SPSS has been widely used in the analysis data by many previous researchers in various field. It has been recognized as one of the most relevant analysis software that can produce reliable outcomes. This method can be used in making a decision whether the null hypothesis can be accepted or should be rejected. The decision whether to accept or reject depended on the significant level (2-tailed) values given at the end of the analysis.

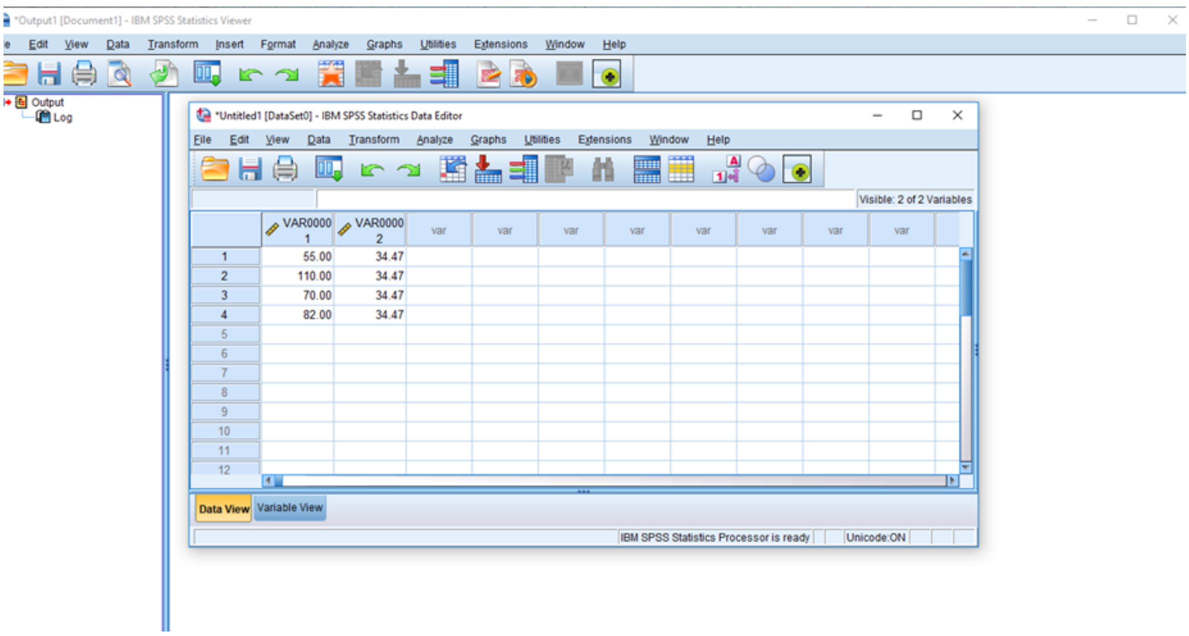


Figure 3-9 Starting screen (Screen 1)

On screen 1, the data before installation of hump (variable1) and after installation of hump (variable2) were inserted.

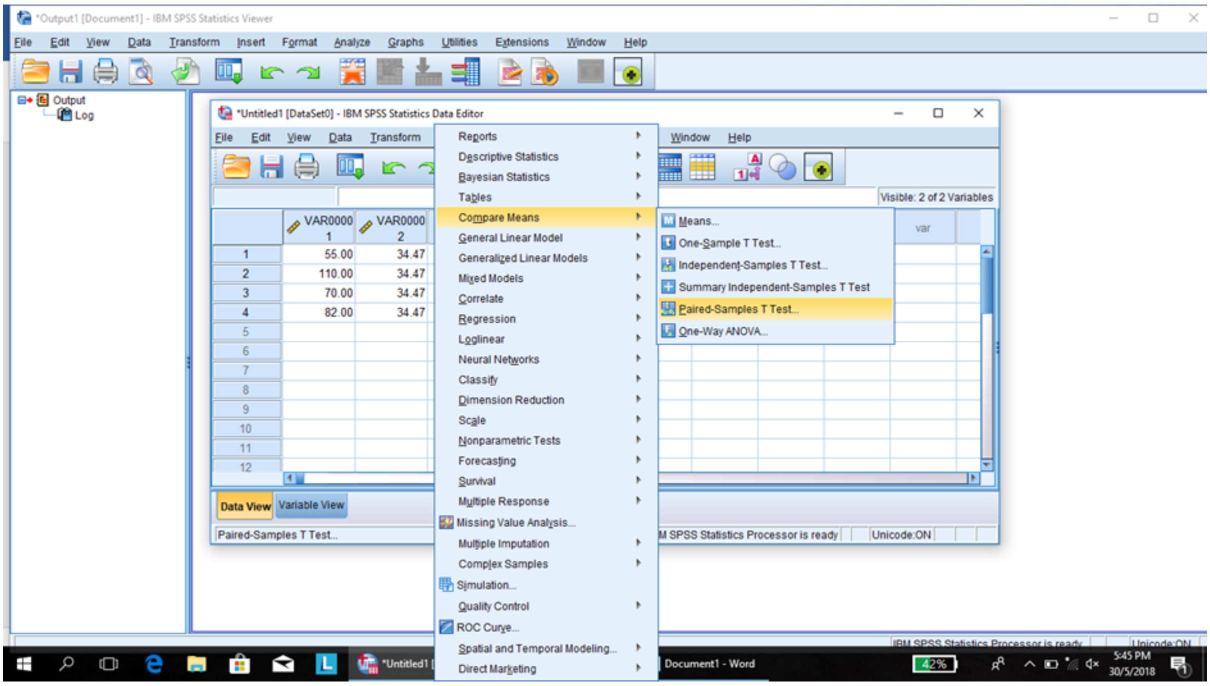


Figure 3-10 The type of analysis selected

The paired-samples t-test were selected as shown in Figure 3.10. This analysis was focused on identifying the relationship between two different conditions by measures their significant different.

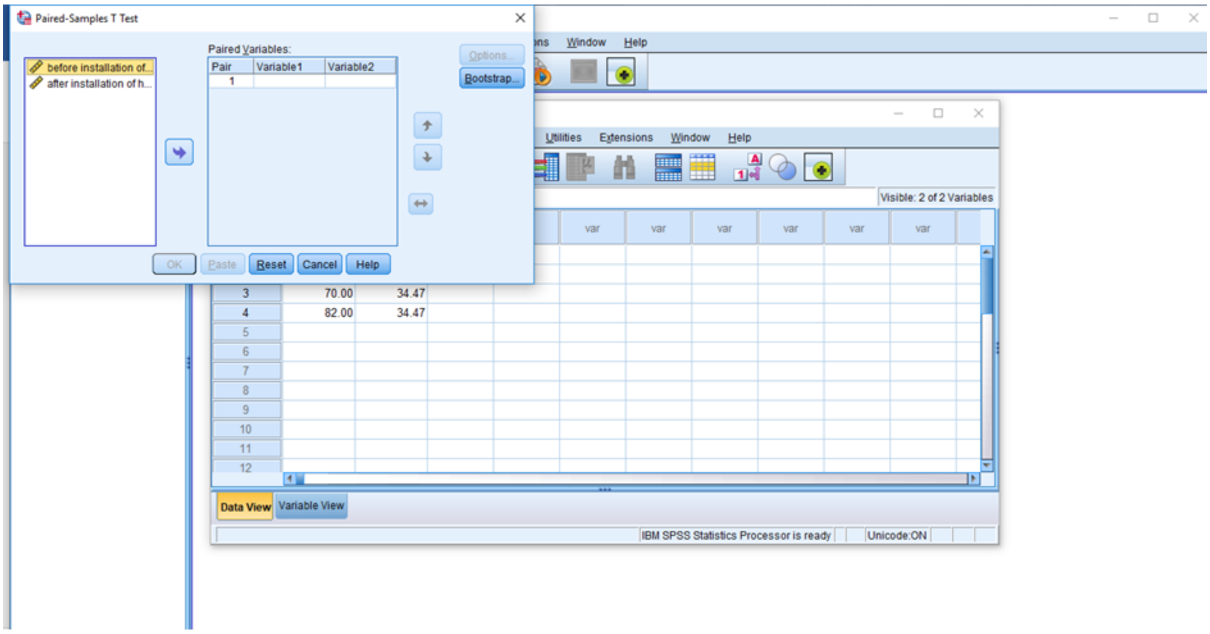
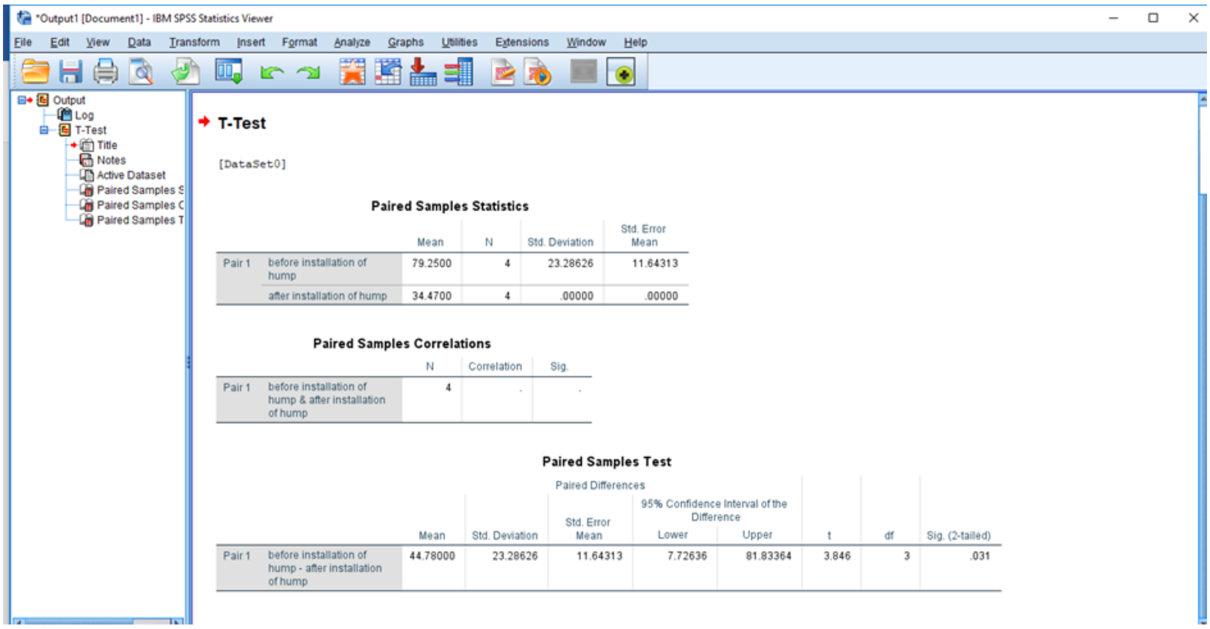


Figure 3-11 Execution of data

To execute the analysis, the two items as shown in figure above were selected.



T-Test

[DataSet0]

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	before installation of hump	79.2500	4	23.28626	11.64313
	after installation of hump	34.4700	4	.00000	.00000

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	before installation of hump & after installation of hump	4	.	.

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	before installation of hump - after installation of hump	44.78000	23.28626	11.64313	7.72636	81.83364	3.846	3	.031

Figure 3-12 Result from SPSS software

From figure above, summary of results was displayed. From Figure 3.9, there are several parameters can be identified :

1. Average mean
2. Standard deviation, s
3. Standard error mean
4. 95% confidence interval of the difference
5. t-value
6. df (degree of freedom)
7. Significance difference, p

In order to measure the efficiency of humps in reducing speed within higher educational area, the percentage of speed reduction between before and after installation of humps were analysed through the results from t-test.

3.3 Summary

The purpose of this study is to evaluate the efficiency of hump in reducing speed within higher educational area. The variables was determined properly to ensure it will pictured the problem in this study. At the end of this research, it is hoped that this study were able to evaluate the efficiency of speed humps in reducing speed from the result obtained.

Therefore, the next chapter will be discussed on the results and discussion after the data has going through the screening process in collection, interpretation and data analysis.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

In this chapter, results of traffic speed at the intersection in front of UMP Gambang Campus main entrance were presented according to Chapter 3 (Methodology). The data of traffic speed that has been collected were analysed using MS Excel and SPSS Software, which have been explained in Chapter 3. The outputs of the analyses are important ~~in~~ to know the speed differences on the study area. The result from the analysis can help the authorities such as Public Work Department (JKR), Police Traffic and local authority to overcome the problem on the intersection design and construction. The quantitative analysis was done using statistical software, Statistical Software for Social Science (SPSS). The data analyses were done in order to know the relationship between the variable.

4.2 Traffic Speed Data

Traffic speed data is the most important data in this study as it will act as the main variable and the relationship between the two variables will be measured by evaluated the significant difference. The frequencies distributions of traffic speed data were done in order to condensed data into more manageable form. The central tendency of the data was measured by mean, median and standard deviation while the variability of the data was check using the significant difference value.

Traffic speed data were collected at the un-signalised four legged intersection of Federal Road 222 in front of UMP Gambang Campus main entrance. For the purpose of the data collection, the traffic speed data will be collected in two different conditions which are before installation of hump and after hump were installed.

4.3 Identification of Speed used at the Intersection

After all the data has been recorded, tabulation of data has been made ~~by~~ separately according to their peak hours.

Table 4-1 Tabulation of data before installation of hump

SPEED GROUP	MEAN SPEED, v	NO. OF OBSERVATION	% OF TOTAL OBSERVATION	CUMULATIVE %	fv	v^2	fv^2
0-19.9	10	0	0	0	0	100	0
20-39.9	30	0	0	0	0	900	0
40-59.9	50	31	6.98	6.98	1550	2500	77500
60-79.9	70	163	36.71	43.69	11410	4900	798700
80-99.9	90	190	42.79	86.49	17100	8100	1539000
100-	110	53	11.93	98.42	5830	12100	641300
120-	130	7	1.58	100	910	16900	118300
140-	150	0	0		0	22500	0
TOTAL		444	100		36800	68000	3174800

The number of observation recorded for speed group (80-99.9) km/hr had the highest value with 190 vehicles with the percentage of total observation was 42.79%. From table above, a graph of frequency distribution curve was drawn.

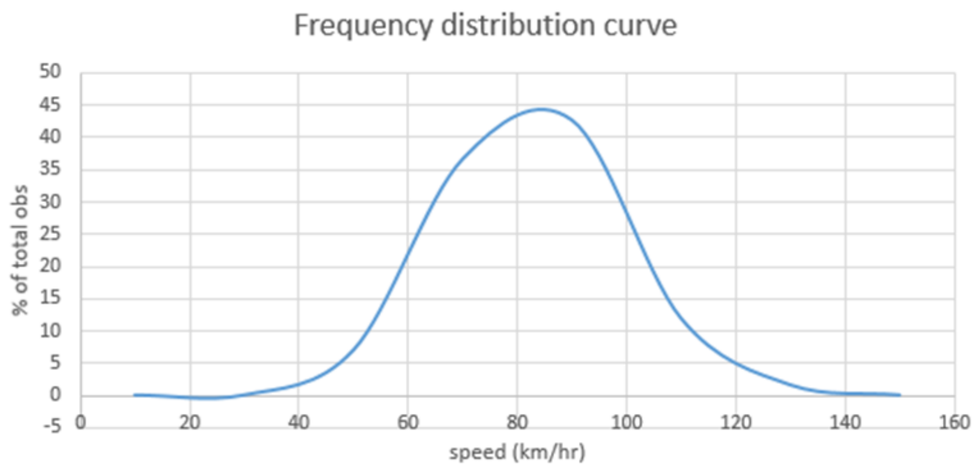


Figure 4-1 Frequency distribution curve for before installation of hump

Figure above shows the frequency distribution curve before installation of hump. The reduction of vehicles speed after hump were installed are presented in Table 4.2.

Table 4-2 Tabulation of data after installation of hump

SPEED GROUP	MEAN SPEED	NO. OF OBSERVATION	% OF TOTAL OBSERVATION	CUMULATIVE %	fv	v^2	fv^2
10-19.9	15	5	1.7	1.7	75	225	1125
20-29.9	25	59	20.2	21.9	1475	625	36875
30-39.9	35	205	70.2	92.1	7175	1225	251125
40-49.9	45	21	7.2	99.3	945	2025	42525
50-59.9	55	1	0.3	99.6	55	3025	3025
60-69.9	65	1	0.3	100	65	4225	4225
total		292			9790		338900

From table above, the most frequent speed group used by 205 vehicles is speed group 30-39.9 km/hr with percentage of total observation number was 70.2%. Figure 4.2 shows the frequency distribution curve for after humps were installed.

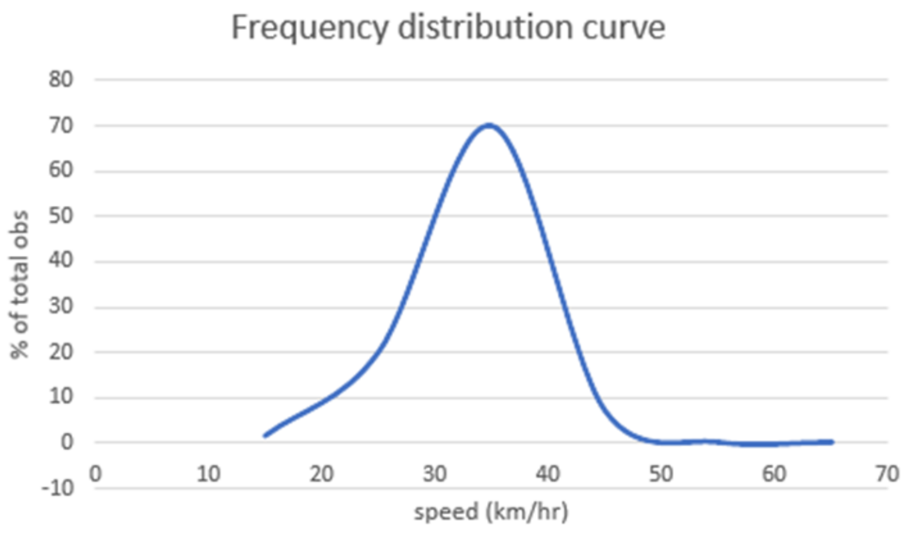


Figure 4-2 Frequency of distribution curve after installation of hump

From the curve above, the pattern of traffic speed after installation of hump being done reached its peak point at in between 30-40 km/hr. The analysis was done for both conditions to know the trend of frequency of speed used between those two conditions.

Table 4-3 Mean, median and standard deviation

	Peak hour	Mean	Median	Std. Deviation
Before	7-9 AM	78.07 km/hr	70.42 km/hr	26.12 km/hr
	12-2 PM	75.96 km/hr	74.60 km/hr	15.41 km/hr
	4-6 PM	82.88 km/hr	82.93 km/hr	16.78 km/hr

	Peak hour	Mean	Median	Std.Deviation
After	7-9 AM	33.53 km/hr	33.96 km/hr	6.05 km/hr
		33.73 km/hr	34.16 km/hr	6.36 km/hr
		33.42 km/hr	33.81 km/hr	6.34 km/hr
		33.65 km/hr	34.01 km/hr	5.83 km/hr
		34.17 km/hr	34.2 km/hr	6.31 km/hr
		34.39 km/hr	39.56 km/hr	6.25 km/hr
		33.53 km/hr	33.96 km/hr	6.05 km/hr
		34.27 km/hr	34.5 km/hr	6.37 km/hr
		33.96 km/hr	34.42 km/hr	7.41 km/hr
		33.78 km/hr	34.06 km/hr	7.41 km/hr
		34.28 km/hr	34.31 km/hr	7.57 km/hr
		33.73 km/hr	34.11 km/hr	6.69 km/hr
	12-2 PM	34.29 km/hr	34.54 km/hr	5.26 km/hr
		33.96 km/hr	34.19 km/hr	6.39 km/hr
		33.7 km/hr	34.06 km/hr	5.09 km/hr
		33.7 km/hr	34.15 km/hr	4.03 km/hr
		33.62 km/hr	34.04 km/hr	5.07 km/hr
		33.84 km/hr	34.2 km/hr	5.26 km/hr
	4-6 PM	33.38 km/hr	33.92 km/hr	5.77 km/hr
		33.68 km/hr	34.1 km/hr	5.1 km/hr
		34.19 km/hr	34.45 km/hr	4.88 km/hr
		33.02 km/hr	33.23 km/hr	6.59 km/hr
		34.16 km/hr	34.36 km/hr	5.48 km/hr
		33.42 km/hr	33.81 km/hr	5.81 km/hr
		33.36 km/hr	33.80 km/hr	6.6 km/hr
		33.69 km/hr	34.08 km/hr	6.11 km/hr
		34.03 km/hr	34.25 km/hr	5.89 km/hr
		34.04 km/hr	34.36 km/hr	4.47 km/hr
		33.03 km/hr	33.43 km/hr	6.18 km/hr
		33.52 km/hr	34.03 km/hr	4.33 km/hr

The mean speed for traffic data between two conditions shows that the highest speed before hump were installed is in between 75 km/hr to 83 km/hr. The highest speed before hump were installed was recorded during Evening peak hours in between 4-6 PM. This may be caused by drivers wanting to avoid getting involved in traffic congestion when returning from their workplace. Meanwhile, the mean speed after hump were installed shows an average value in range 33 km/hr to 34 km/hr. From this table, the efficiency of a speed hump in reducing speed can be evaluated.

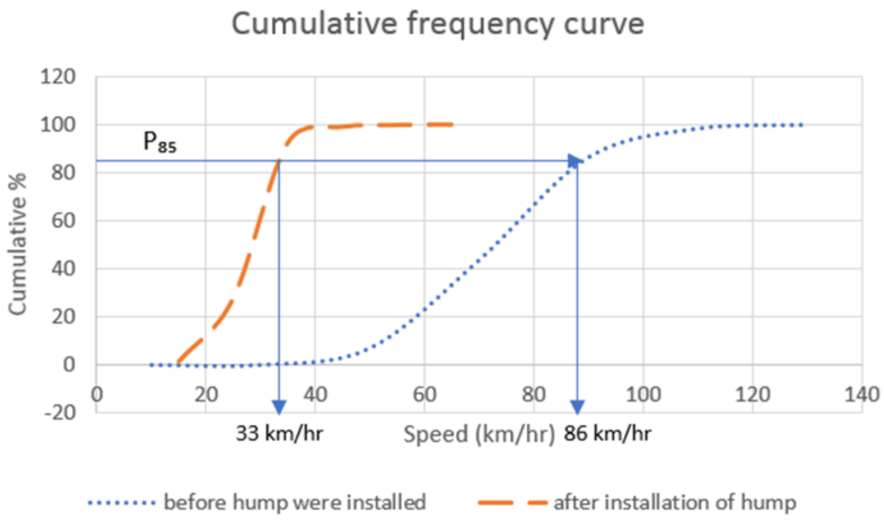


Figure 4-3 Cumulative frequency curve for both conditions

Figure 4.3 shows the graph of cumulative frequency curve at un-signalized four legged intersection in front UMP Gambang Campus main entrance. This graph is used to determine the comparison of 85th percentile between two conditions. By referring to round-dot line in Figure 4.3, it was found that the 85th percentile of free flow speed before the installation of hump were around 86 km/hr. This means that most of the car drivers drive at a speed of 86 km/hr freely at the intersection in front of UMP main entrance without the influence by road humps. According to regulation, this free flow speed is below the speed limit by authority, which is 90 km/hr. Long-dash line shows the 85th percentile of free flow speed after the installation of hump were around 33 km/hr. By the installation of the hump, all the car driver managed to reduce their speed under the speed limit, which is considered safer to road users in the campus. From this results, it shows that the difference of speed used by the car drivers were around 53 km/hr.

Table 4-4 Traffic speed of two conditions

speed (km/hr)	
Before installation of hump	After installation of hump
55	34.47
110	34.47
70	34.47
82	34.47

The value of speed after installation of hump is equal because an average value from sums of all peak hours is taken to compare with the speed before hump were installed. This is due to lack of data before hump were installed regarding installation of humps done by the authority. From Table 4.4, the percentage of speed reduction has been calculated which 56.5 %.

A paired samples t-tests was conducted to evaluate the efficiency of hump in reducing speed within higher educational area.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Before	79.2500	4	23.28626	11.64313
	After	34.4700	4	.00000	.00000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	before installation of humps - after installation of humps	44.78000	23.28626	11.64313	7.72636	81.83364	3.846	3	.031

Figure 4-4 T-test for average speed reduction

There was a statistically significant difference between before hump were installed (Mean = 79.25 km/hr, Std. Deviation = 23.29 km/hr) and after installation of hump (Mean = 34.47 km/hr, Std. Deviation = 0.00 km/hr). Since the result in Figure 4.4 shows that average mean is 44.78 km/hr, the mean speed before hump was installed (79.25 km/hr) is higher than after hump was installed (34.47 km/hr). The p value is 0.031 which is less than 0.05, shows that there is statistically significance difference for the average speed between before and after installation of hump. Based on the 95% confidence level, the p-value of 0.031 is less than 0.05 shows that there is a significant difference in speed before and after humps were installed.

From this analysis, it can be concluded that there is a statistically significant difference between those two conditions. The four legged intersection of Federal Road 222 in front of UMP Gambang Campus main entrance was chosen as the research area due to two crashes were believed to be caused by high speed vehicles coming from Gambang toll plaza.

Based on this reason, this study was conducted to evaluate the efficiency of speed hump in reducing speed within higher educational area on the research area. From the analysis, the speed reduction have been determined by using a paired sample t-test.

4.4 Efficiency of Humps in Reducing Speed

Recommendation is a suggestion or proposal as to the best course action. In order to overcome the problem in un-signalized intersection, some of the recommendation can be made. As a developing country, Malaysia is still lack with completed and updated data including the traffic crash data at the intersection. The data is important in order to know the current condition of the intersection crash data in Malaysia. The data is the core element in future planning of any treatment and prevention of the crashes.

From the study, it was found that the vehicles mean speed before installation of hump was higher compared to the vehicles mean speed after hump were installed. With the value of percentage of speed reduction from this study was 56.5 %, it is shows that the installation of hump are effective in reducing speed especially within higher educational area. This issue was similar as discussed by (Hui Min & Che Ros, n.d.). Although it is proved that humps were effective in reducing speed within educational area through t-test, they study the effect of different heights of hump being used with percentage of speed reduction. From the study it stated that the lower hump will give less reduction of vehicles speed. In other words, if the design of humps is accordance to their standard and function, the percentage of speed reduction can be increases.

Moreover, Public Work Department (JKR) should collaborate with local authorities and Police Traffic together in storing and assessing the data of road accidents of Federal Road 222 (Persiaran MEC) to know the effectiveness of the study that has been done at the location and to plan for more effective methods in preventing the road accidents at the intersection.

4.5 Summary

This research was conducted to produce speed trend of two conditions, without speed hump and with speed hump being installed and to evaluate the efficiency of speed hump in reducing speed within higher educational area. The end of these research are hoped to fill in gap between Public Work Department (JKR) and Local Authorities in overcoming crashes at intersection problems.

Main objectives of this study are to evaluate the efficiency of speed hump in reducing speed within higher educational area. The data collection of this study was accordance with number of variable in this research which are before installation of hump and after hump were installed. The traffic speed data was taken during peak hours of time which are Morning (7-9 AM), Afternoon (12-2 PM) and Evening (4-6 PM) to ensure that the data was significant and reliable in terms of traffic speed.

All the data were then inserted into SPSS software to test the significant difference of two conditions. This method was chosen because it can measure the two different condition in term of significant level.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

From the discussion, it can be concluded that all the objectives for this study are successfully achieved. In this section also, there were discussion on the suggestion for the future research focusing on the improvement in designing and constructing intersection. Certain result could be different if the researcher changes that way the data was collected, selection of variables and using different method of analysis.

The primary objective of this research is to measure the efficiency of speed hump in reducing speed within higher educational area. In order to achieve the main objectives, another secondary objectives which are to produce the trend of vehicles speed (without speed humps) and to produce trend of vehicles speed (with speed humps) must be achieved first. Through sets of analysis, the objectives have been achieved. The result from this research were hope to help Public Work Department (JKR) and local authorities by keeping the record of the traffic speed of the intersection for a better planning in designing the speed humps. This research will not only be useful for authorities but also the residences who lives near to the study area especially students of UMP Gambang Campus. From this research, it can help save people life who exposed to the road intersection traffic system in their daily life.

There are some limitations for this study :

i. There are only one radar gun to be used to collect the spot speed data. This made the data collection more difficult as the traffic volume is high during peak hours.

ii. The drivers may not drive at their normal travelling speed due to there is no place or shelter for the observer to hide.

5.2 Recommendation

Recommendation is a suggestion or proposal as to the best course action. In order to overcome the problem in non-signalized intersection in future, some of the recommendation can be made:

i. A better instrument such as the total station or GPS device can be used to measure the dimensions of the road humps to collect more accurate data.

ii. Make comparisons on speed reduction between road humps with different widths and heights.

iii. The comparison of the specifications of road humps can be made with other standards including the standard by foreign countries.

As a developing country, Malaysia is still lack with completed and updated data including the traffic crash data at the intersection. The data is important in order to know the current condition of the intersection crash data in Malaysia. The data is the core element in future planning of any treatment and prevention of the crashes.

Moreover, Public Work Department (JKR) should collaborate with local authorities and Police Traffic together in storing and assessing the data of road accidents of Federal Road 222 (Persiaran MEC) to know the effectiveness of the study that has been done at the location and to plan for more effective methods in preventing the road accidents at the intersection.

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APPENDIX A
LOCATION MAP

APPENDIX B
SPOT SPEED DATA BY HOURS

Before installation of hump

Peak hours : Morning (7-9 AM)

SPEED GROUP	MEAN SPEED, v	NO. OF FREQUENCY	% OF TOTAL OBSERVATION	CUMULATIVE %	fv	v²	fv²
0-19.9	10	0	0	0	0	100	0
20-39.9	30	1	0.917431193	0.917431193	30	900	900
40-59.9	50	35	32.11009174	33.02752294	1750	2500	87500
60-79.9	70	28	25.68807339	58.71559633	1960	4900	137200
80-99.9	90	14	12.8440367	71.55963303	1260	8100	113400
100-119.9	110	26	23.85321101	95.41284404	2860	12100	314600
120-139.9	130	5	4.587155963	100	650	16900	84500
140-159.9	150	0	0	100	0	22500	0
TOTAL		109	100		8510	68000	738100

Afternoon (12-2 PM)

SPEED GROUP	MEAN SPEED, v	NO. OF FREQUENCY	% OF TOTAL OBSERVATION	CUMULATIVE %	fv	v²	fv²
0-19.9	10	0	0	0	0	100	0
20-39.9	30	3	0.408163265	0.408163265	90	900	2700
40-59.9	50	85	11.56462585	11.97278912	4250	2500	212500
60-79.9	70	381	51.83673469	63.80952381	26670	4900	1866900
80-99.9	90	225	30.6122449	94.42176871	20250	8100	1822500
100-119.9	110	38	5.170068027	99.59183673	4180	12100	459800
120-139.9	130	3	0.408163265	100	390	16900	50700
140-159.9	150	0	0		0	22500	0
TOTAL		735	100		55830	68000	4415100

Evening (4-6 PM)

SPEED GROUP	MEAN SPEED, v	NO. OF OBSERVATION	% OF TOTAL OBSERVATION	CUMULATIVE %	fv	v^2	fv^2
0-19.9	10	0	0	0	0	100	0
20-39.9	30	0	0	0	0	900	0
40-59.9	50	31	6.981981982	6.981981982	1550	2500	77500
60-79.9	70	163	36.71171171	43.69369369	11410	4900	798700
80-99.9	90	190	42.79279279	86.48648649	17100	8100	1539000
100-	110	53	11.93693694	98.42342342	5830	12100	641300
120-	130	7	1.576576577	100	910	16900	118300
140-	150	0	0		0	22500	0
TOTAL		444	100		36800	68000	3174800

After installation of hump (Peak hours : Morning (7-9 AM)

SPEED GROUP	MEAN SPEED	NO. OF OBSERVATION	% OF TOTAL OBSERVATION	CUMULATIVE %	fv	v^2	fv^2
10-19.9	15	5	1.7	1.7	75	225	1125
20-29.9	25	59	20.2	21.9	1475	625	36875
30-39.9	35	205	70.2	92.1	7175	1225	251125
40-49.9	45	21	7.2	99.3	945	2025	42525
50-59.9	55	1	0.3	99.6	55	3025	3025
60-69.9	65	1	0.3	100	65	4225	4225
total		292			9790		338900

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	9	2.5	2.5	135	225	2025
20-29.9	25	70	19.3	21.2	1650	625	41250
30-39.9	35	243	67.1	89.1	7420	1225	259700
40-49.9	45	38	10.5	99	1395	2025	62775
50-59.9	55	2	0.6	99.3	55	3025	3025
total		362			12210		426450

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	6	1.6	1.6	90	225	1350
20-29.9	25	85	23.2	24.8	2125	625	53125
30-39.9	35	239	65.3	90.1	8365	1225	292795
40-49.9	45	34	9.3	99.4	1530	2025	68850
50-59.9	55	1	0.3	99.7	55	3025	3025
60-69.9	65	1	0.3	100	65	4225	4225
total		366			12230		423350

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	3	0.88	0.88	45	225	675
20-29.9	25	72	21.05	21.93	1800	625	45000
30-39.9	35	237	69.30	91.23	8295	1225	290325
40-49.9	45	29	8.48	99.71	1305	2025	58725
50-59.9	55	0	0.00	99.71	0	3025	0
60-69.9	65	1	0.29	100	65	4225	4225
total		342			11510		398950

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	0	0	0	0	225	0
20-29.9	25	66	21.2	21.2	1650	625	41250
30-39.9	35	212	67.9	89.1	7420	1225	259700
40-49.9	45	31	9.9	99	1395	2025	62775
50-59.9	55	1	0.3	99.3	55	3025	3025
60-69.9	65	1	0.3	99.6	65	4225	4225
70-79.9	75	1	0.3	99.9	75	5625	5625
	total	312			10660		376600

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	0	0	0	0	225	0
20-29.9	25	61	18.71	18.71	1525	625	38125
30-39.9	35	232	71.17	89.88	8120	1225	284200
40-49.9	45	29	8.9	98.78	1305	2025	58725
50-59.9	55	1	0.3	99.08	55	3025	3025
60-69.9	65	2	0.61	99.69	130	4225	8450
70-79.9	75	1	0.3	99.99	75	5625	5625
	total	326			11210		398150

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	5	1.74	1.74	75	225	1125
20-29.9	25	59	20.49	22.23	1475	625	36875
30-39.9	35	200	69.44	91.67	7000	1225	245000
40-49.9	45	21	7.29	98.96	945	2025	42525
50-59.9	55	2	0.69	99.65	110	3025	6050
60-69.9	65	1	0.35	100	65	4225	4225
total		288			9670	11350	335800

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	7	2.31	2.31	105	225	1575
20-29.9	25	45	14.85	17.16	1125	625	28125
30-39.9	35	219	72.28	89.44	7665	1225	268275
40-49.9	45	29	9.57	99.01	1305	2025	58725
50-59.9	55	1	0.33	99.34	55	3025	3025
60-69.9	65	2	0.66	100	130	4225	8450
total		303	100		10385	11350	368175

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	23	5.57	5.57	345	225	5175
20-29.9	25	51	12.35	17.92	1275	625	31875
30-39.9	35	297	71.91	89.83	10395	1225	363825
40-49.9	45	34	8.23	98.06	1530	2025	68850
50-59.9	55	5	1.21	99.27	275	3025	15125
60-69.9	65	2	0.48	99.75	130	4225	8450
70-79.9	75	1	0.24	99.99	75	5625	5625
	total	413			14025	16975	498925

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	17	3.79	3.79	255	225	3825
20-29.9	25	80	17.82	21.61	2000	625	50000
30-39.9	35	311	69.27	90.87	10885	1225	380975
40-49.9	45	27	6.01	96.89	1215	2025	54675
50-59.9	55	11	2.45	99.34	605	3025	33275
60-69.9	65	2	0.45	99.78	130	4225	8450
70-79.9	75	1	0.22	100.00	75	5625	5625
	total	449			15165	16975	536825

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	10	2.77	2.77	150	225	2250
20-29.9	25	67	18.56	21.33	1675	625	41875
30-39.9	35	238	65.93	87.26	8330	1225	291550
40-49.9	45	36	9.97	97.23	1620	2025	72900
50-59.9	55	5	1.39	98.61	275	3025	15125
60-69.9	65	5	1.39	100.00	325	4225	21125
	total	361			12375		444825

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	10	2.75	2.75	150	225	2250
20-29.9	25	71	19.56	22.31	1775	625	44375
30-39.9	35	242	66.67	88.98	8470	1225	296450
40-49.9	45	36	9.92	98.89	1620	2025	72900
50-59.9	55	3	0.83	99.72	165	3025	9075
60-69.9	65	1	0.28	100.00	65	4225	4225
	total	363			12245		429275

Peak hours : Afternoon (12-2 PM)

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	7	1.08	1.08	105	225	1575
20-29.9	25	91	14	15.08	2275	625	56875
30-39.9	35	493	76.1	91.18	17255	1225	603925
40-49.9	45	55	8.5	99.68	2475	2025	111375
50-59.9	55	2	0.3	99.9	110	3025	6050
	total	648			22220		779800

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	17	2.91	2.91	255	225	3825
20-29.9	25	87	14.87	17.78	2175	625	54375
30-39.9	35	445	76.07	93.85	15575	1225	545125
40-49.9	45	21	3.59	97.44	945	2025	42525
50-59.9	55	9	1.54	98.98	495	3025	27225
60-69.9	65	3	0.51	99.49	195	4225	12675
70-79.9	75	3	0.51	100	225	5625	16875
total		585			19865		702625

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	4	0.28	0.28	60	225	900
20-29.9	25	263	18.47	18.75	6575	625	164375
30-39.9	35	1084	76.12	94.87	37940	1225	1327900
40-49.9	45	61	4.28	99.15	2745	2025	123525
50-59.9	55	11	0.77	99.92	605	3025	33275
60-69.9	65	1	0.07	100	65	4225	4225
total		1424			47990		1654200

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	1	0.13	0.13	15	225	225
20-29.9	25	110	14.19	14.32	2750	625	68750
30-39.9	35	659	85.03	99.35	23065	1225	807275
40-49.9	45	0	0	99.35	0	2025	0
50-59.9	55	4	0.52	99.87	220	3025	12100
60-69.9	65	1	0.13	100	65	4225	4225
total		775			26115		892575

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	5	0.47	0.47	75	225	1125
20-29.9	25	197	18.36	18.83	4925	625	123125
30-39.9	35	819	76.3	95.13	28665	1225	1003275
40-49.9	45	47	4.38	99.51	2115	2025	95175
50-59.9	55	4	0.37	99.88	220	3025	12100
60-69.9	65	0	0	99.88	0	4225	0
70-79.9	75	1	0.09	100	75	5625	5625
	total	1073					1240425

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	11	0.95	0.95	165	225	2475
20-29.9	25	183	15.74	16.69	4575	625	114375
30-39.9	35	913	78.50	95.19	31955	1225	1118425
40-49.9	45	47	4.04	99.23	2115	2025	95175
50-59.9	55	5	0.43	99.66	275	3025	15125
60-69.9	65	3	0.26	99.92	195	4225	12675
70-79.9	75	1	0.09	100.00	75	5625	5625
	total	1163			39355		1363875

Peak hours : Evening (4-6 PM)

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	15	1.9	1.9	225	225	3375
20-29.9	25	160	19.9	21.8	4000	625	100000
30-39.9	35	572	71.2	93	20020	1225	700700
40-49.9	45	52	6.5	99.5	2340	2025	105300
50-59.9	55	4	0.5	100	220	3025	12100
total		803			26805		921475

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	4	0.6	0.6	60	225	900
20-29.9	25	127	18.4	19	3175	625	79375
30-39.9	35	516	74.9	93.9	18060	1225	632100
40-49.9	45	40	5.8	99.7	1800	2025	81000
50-59.9	55	2	0.3	100	110	3025	6050
total		689			23205		799425

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	3	0.45	0.45	45	225	675
20-29.9	25	98	14.8	15.25	2450	625	61250
30-39.9	35	513	77.4	92.65	17955	1225	628425
40-49.9	45	48	7.2	99.85	2160	2025	97200
50-59.9	55	1	0.15	100	55	3025	3025
total		663			22665		790575

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	3	0.44	0.44	45	225	675
20-29.9	25	201	29.43	29.87	5025	625	125625
30-39.9	35	421	61.64	91.51	14735	1225	515725
40-49.9	45	49	7.17	98.68	2205	2025	99225
50-59.9	55	4	0.59	99.27	220	3025	12100
60-69.9	65	5	0.73	100	325	4225	21125
total		683			22555		774475

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	5	0.59	0.59	75	225	1125
20-29.9	25	138	16.33	16.92	3450	625	86250
30-39.9	35	635	75.15	92.07	22225	1225	777875
40-49.9	45	59	6.98	99.05	2655	2025	119475
50-59.9	55	6	0.71	99.76	330	3025	18150
60-69.9	65	2	0.24	100	130	4225	8450
	total	845	100		28865		1011325

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	8	0.81	0.81	120	225	1800
20-29.9	25	227	22.91	23.72	5675	625	141875
30-39.9	35	677	68.31	92.03	23695	1225	829325
40-49.9	45	72	7.27	99.3	3240	2025	145800
50-59.9	55	7	0.71	100	385	3025	21175
total		991		100	33115		1139975

SG	v	f	% f	cumu % f	fv	v^2	fv^2
10-19.9	15	15	2.45	2.45	225	225	3375
20-29.9	25	141	23.08	25.53	3525	625	88125
30-39.9	35	389	63.67	89.2	13615	1225	476525
40-49.9	45	61	9.98	99.18	2745	2025	123525
50-59.9	55	5	0.82	100	275	3025	15125
total		611			20385	7125	706675