



ADDIS ABABA UNIVERSITY
ADDIS ABABA INSTITUTE OF TECHNOLOGY
SCHOOL OF GRADUATE STUDIES
SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

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A Thesis Submitted to the School of Graduate Studies in Partial Fulfillment of The
Requirements for the Degree of
Master of Science

In

Road and Transport Engineering Stream

Advisor: Bikila Teklu Wodajo (Ph.D.)

June, 2022

Addis Ababa, Ethiopia

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Assessing the Effect of Speed Humps -on traffic flow at Selected Segments in Addis Ababa

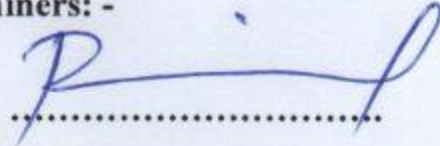
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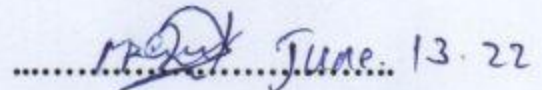
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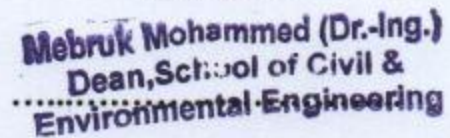
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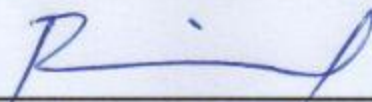


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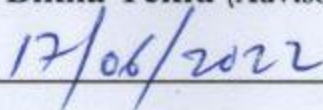
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Certification

The undersigned certify that he has read the thesis entitled: **Assessing the Effect of Traffic Calming Measures (Speed Hump) on traffic flow at Selected Segments in Addis Ababa City** and hereby recommend for acceptance by the Addis Ababa University in partial fulfillment of the requirements for the degree of Master of Science in Road and Transport Engineering Stream.



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Date

Declaration and Copy Right

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Acknowledgment

First and for highest degree indebted thank goes to Almighty God who gave me health and era to reach this time with glory and happiness.

Secondly, I cannot fully express my highest gratitude to my advisor Dr.Bikila Teklu Wodajo,for his generosity and superb guidance beginning from proposal writing to the completion of this thesis work. Without his support, valuable comments and suggestions, it could not be simple to shape this study at this current format.

Thirdly, I would like to give my deepest thank you for Messay Shemsu who gave continuous support and encouragement.

Fourthly, my thank goes to Ethiopian roads Administration (ERA) that provided a learning sponsorship.

Fifthly, I would like to extend my heartfelt acknowledgment to the staff members of my office (Addis Ababa City Road Authority, Design Department members) and fellow friends for their cooperation and assistance during my study.

Lastly, I would like to thank my family for their love prayer and my friends' moral support.

Abstract

In Addis Ababa the speed calming devices are installed on all road hierarchies with a posted speed limit of 30km/hr for LS, CS&SAS and RR 50km/hr. respectively. Due to the lack of clear and uniform design standards and guidelines for the installation of speed humps in Addis Ababa led to their existence on streets with heavy traffic volumes, which caused considerable traffic delay at the locations of speed humps. The speed hump geometry (Length & width), grade of road along speed hump, speed of vehicles, delay and counted vehicle are used for analysis to generate a regression model. The research has been worked with qualitative(questionary) and Quantitative (direct study) which try to associate the two approaches.

In this thesis work, the hump geometry characteristics, geometry of the road, speed of each individual travelling vehicles and delay of vehicles are the main parameters that studied.

As per the analysis model the geometry of speed hump has variable effects on vehicle movement at upstream approaching distance of the vehicles. Up to 25-meter upstream distance is used which a car locates at the spot speed of cars approaching the humps with free flow speed taken as first point that 25m before speed hump and can catch up to enough vehicle.

The overall result shows that the average maximum speed reduction of 16.66km/hr,15.2km/hr,13.8 km/hr,11.31km/hr. &9.67 km/hr. for (Car), (Bajaj, cycle & motor cycle), (Pick up, Mini bus Taxi), (Medium Bus Truck) and (Large Bus & TT) respectively. From the delay analysis, the car group has maximum delay value (164.5 Veh. /min) than other vehicle groups. In the model, the speed hump height, length and grade of the road has direct relation with the delay at upstream of the speed hump.

Key words: Hump width, speed, hump length, delay, grade of the road.

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Abbreviations

- A.D Average Delay
- R-sq.Adj R square Adjusted
- A.S Average Speed
- A.SHH Average Speed Hump Height
- A.SHL Average Speed Hump Length
- B, C&M Bajaj, Cycle and Motor cycle
- CS Collector Street
- GPS Global Positioning System
- HCM High Way Capacity Manual
- ITE Institute of Transport Engineers for United States
- M.Bus &T Medium Bus and Truck
- M, P&T Mini Bus, Pickup &Taxi
- PAS Principal Arterial Street
- SAS Sub Arterial Street
- TMC Traffic Calming Measures
- TT &LB Truck Trailer& Large Bus

CHAPTER ONE: Introduction

1.1 Back Ground

Traffic calming is a practice that has been implemented primarily in developed countries. In some countries, this technique has been incorporated in the urban design of public space during the preliminary stage.

Addis Ababa city is the fastest growing cities in Ethiopia and hosts of Africa Union (AU) and the host of Economic Commission for Africa (ECA) which it serves much transport operations. To reduce the high number of fatalities and serious injuries our city is using the traffic calming strategies. Traffic calming has two main objectives: the reduction in the frequency and severity of accidents; and improving the environment for a local area (Sanz, 2008). This implies, in some cases, the decrease in traffic flow, damage of underneath vehicle body, discomfort of passengers, damage of pavement when cut, and, of course, reducing the speed of vehicles traveling through the area.

Essentially, traffic calming strategies designed to reduce vehicle speeds and volumes that drive thought an area. Some of these strategies and devices used are: warning signs vehicle restrictions, median islands, gateways, roundabouts, raised crosswalks, speed tables, channelization islands, speed humps, rumble strips, mini-circles, special pavements and markings, radar clocked traffic speeds displayed to drivers, lane narrowing, horizontal shifts. The reduction of the motor vehicles speeds is one of the key elements to reduce the probability of death of the pedestrians involved in the accident.

Physical measures involving vertical deflections such as speed tables, speed humps and speed bumps are among the elements used in traffic calming highlight. A speed hump is a raised geometry in the roadway pavement surface extending transversely across the travel way. Speed tables are flat-topped speed humps, through a prefabricated or built on site with a trapezoidal, circular and sinusoidal longitudinal profile, designed specifically to maintain a reduced speed and to allow pedestrians to cross on top.

Several researches have been carried out to analyze the effect of TCMs on traffic operation. Operating speed reductions were found about 18% (Ewing, 1999, Hallmark et al., 2002, Zech et al., 2009). Before and after studies were carried out on speed tables and speed humps. Mean speeds were reduced from 6 to 13 km/h on different locations (Hallmark et al., 2002, Hallmark et al., 2008, Zech et al., 2009). Speeding minimization on speed humps was higher than the other devices (Fehr & Peers Transportation Consultants, 2010). Speed bumps were found noneffective (Pau and Angius, 2001). The lack of statistically significant

differences between the speed values detected, in the same street, at the speed bump or quite far from it, suggested that probably a combined effect of poor efficiency of the device and immurement of drivers to vibrations and noise was present.

Therefore, this article analyzes the impact of Traffic calming measures i.e., speed hump in the reduction of the motor vehicles speed or flow condition in the case of delay and comfort for travelers in Addis Ababa.

1.2. Statement of the Problem

The main speed calming device used in Addis Ababa city is speed hump (which is a vertical deflection counter measure). Its primary function which installed on constructed segments is to reduce adverse motor vehicle speed. Contrary it has traffic movement affection near to the speed breakers and result rough surface condition difficult to drive and irregular shape of structures on the road surface. Studies found that traffic calming measures reduced the speed on neighborhood streets and may contribute to negative impact on road users. The primary purpose of those traffic calming measures provided at different road segments in the city is to reduce traffic injury. On day-to-day movement the number of vehicles increase and cause oversaturated of traffic intensity which leads to excessive congestion of traffic on road segments. Those reduce the motor traffic damage which causes life loss. In addition to this, speed humps have their own effect on congestion. And also, this traffic calming measures (speed humps) have negative impacts on:

- Traffic flow delay
- Passenger discomfort,
- Increase travel time
- Rise traffic noise, especially when large goods vehicles pass by
- Traffic congestion by limiting the mobility of the vehicles and increase fuel consumption.

Hence, this research is organized to answer the above research questions which mostly not considered to in advancing and provision of speed calming strategies. The significant effect of speed hump on traffic movement will be investigated in this research work.

1.3 Research questions

1.3.1 Research questions

The major research questions are as follows:

- ❖ How speed humps have effects on vehicles speed for the selected streets in Addis Ababa?
- ❖ How Speed humps placed on selected segments?
- ❖ How they affect vehicle travel time and delay?
- ❖ What are the factors influencing speed, delay and geometry of speed hump?

The significant effect of speed hump on traffic movement and contribution will be analyzed based on the stated methodologies to answer the questions.

1.4 Objective of the Study

The scope of the study research is composed of General objective and specific objective.

1.4.1 General Objective

The principal objective of this study is to evaluate the targeted effect of Speed hump on traffic flow for selected roads in our capital city, Addis Ababa.

1.3.2 Specific Objective

The specific objective incorporates: -

- ❖ To estimate delay of traffic due to speed humps,
- ❖ To evaluate the effect of speed humps on vehicle movement,
- ❖ To assess the geometric characteristics of speed hump,
- ❖ To develop correlation between speed hump geometry, speed & grade of the road.

1.5 Scope, Limitation and Significance of the Research Study

1.5.1. Scope of the Study

The research will study the type of traffic calming measure which is speed hump in Addis Ababa at selected areas. In the study some segments are selected based on the criteria set in the methodology.

1.5.2 Limitation of the Study

The study will not incorporate: -

- ✓ Effect due to Pedestrian intervention
- ✓ Delay due to pavement distress
- ✓ Effect due to U-turns
- ✓ Effect due to on street parking
- ✓ Geometrical nature (curve, camber, width, length etc.) of the study road segment (except grade)
- ✓ Driver behaviors

1.5.3 Significance of the Study

Recently, road traffic accident has become a major problem in cities throughout the world.

The outcome of this research is very significant. The intended outcome of the study; the researcher will have a better understanding of the impact of speed hump and foundation for better traffic calming measures which will be recommended after analysis. Specifically, it is expected that the results of this study will develop a model relationship between the speed hump and traffic flow.

The practical significance of this research will help experts and stakeholder to implement alternatives among the tested traffic calming strategies.

1.6 Challenges During Thesis work

The following challenges were faced during the thesis period;

1. Manual data extraction was very time-consuming since there is no software package to extract field data.
2. Police men prohibit to take video record due to security issues in the city.
3. Due to the data-intensive nature of the research, it was very hard to collect all the required data.

1.7 Organization of the Thesis

This study research is composed from five chapters. The first chapter describes the general background of the thesis work, general and specific objectives, challenges faced during the study, research questions, statement of the problem, scope of the study significance and limitation of the study.

Chapter two deals with literature review which includes the history of speed calming, geometry of speed humps, positive and negative impact of speed calming measures. In the literature review different articles are referred which support the objective of the thesis work.

Chapter three describes research methods and materials including the description of the study area, data analysis methodology, sample size determination, study design, data collection methodology, data extraction methodology, data analysis and study procedure.

Chapter four deals with qualitative and field results and discussion, a detail of data analysis, and also the results are presented in this chapter as well.

Finally, chapter five consists of the conclusion, recommendation, reference and appendices based on the findings of the study.

CHAPTER TWO: Literature Review

2.1 History and Definition of Traffic Calming Measures

2.1.1 History of Traffic Calming

The idea of traffic calming initiated in the Netherlands, Europe. In the 1960s, traffic volumes in the Netherlands increased as the automobile became more popular. By the late 1960s, Dutch transportation officials began receiving public complaints about speeding traffic through residential neighborhoods (Schlabach, 1997). Early attempts at traffic calming were in response to these complaints. In 1970, the Dutch town of Delft installed the first traffic calming device, a 3-inch speed bump constructed at the end of an alleyway to slow traffic. Similar road bumps were also installed at about the same time in the Dutch towns of Rotterdam and Utrecht, along with other speed inhibiting devices like road narrowing's (Schlabach, 1997).

The concept of traffic calming also spread to other countries of the world including Australia, Canada, and the United States. Berkeley, California, and Seattle, Washington, were the first regions and cities in the United States to attempt traffic calming. The first jurisdiction is Berkeley being using calming in the United States to implement a citywide traffic calming plan, which occurred in 1975 (Ewing, 1999). As stated by St. Louis, Missouri (ITE Traffic Engineering Council, 1997; Smith and Appleyard, 1981), the United States began using speed humps in 1979 when the United States Federal Highway Administration (FHWA) began testing speed humps on a closed site.

2.1.2 Definition

“Traffic calming is a word which appeared in Europe to describe a full range of approaches to slow cars, but not necessarily ban them, as they travel through marketable and inhabited areas. The word traffic slowing (calming) is the conversion of the German word “*verkehrsberuhigung*” and found by the technical literature of Germany around 1974 to define the speed control measures that applied to local roads (traffic calming in Australia, 1991). It is a composite word composed from “*verkehr* (traffic)” and “*beruhigung* (relief, comfort, ease of mind, mitigate). A *verkehrsberuhigung* word known in English language edition, it was given various meanings, Mostly ‘traffic reconciliation, traffic alleviating, traffic limitation (Berlin Conference held in 1988 and 2000).

The benefit of calming is driving of the car in lower speed for the safety of cyclists and pedestrians.

Traffic calming is the combination of mainly physical counters that reduce the drastic effects of motoric vehicles use, vary driver behavior, and upgrade driving conditions for non-motorized road users. (Lockwood, 1997).

Traffic calming is a traffic controlling mechanism that involved in Europe and is now being implemented in numerous world cities. Calming devices for traffic are used to reduce excessive speed and/or volumes along residential streets and may be classified as either volume control or speed control devices (Ewing, 1999).

Vertical speed control measures are physical devices designed to vertically displace the frame of a vehicle. Drivers must reduce speed to comfortably traverse this type of obstacle. Examples of vertical speed control measures include raised intersections, speed humps, and speed tables (Ewing, 1999). Speed humps, not to be confused with the speed bump (vertical undulations three to six inches in height and one to three feet in the direction of travel) are typically parabolic in shape, three to four inches in height, 12 feet in length, and span the entire width of the roadway (Ewing, 1999; ITE Traffic Engineering Council, 1997).

Speed humps are designed to create shaking motion that increases driver uneasiness since of increasing speeds. There are many references and guidelines related to the placement of speed humps according to ITE (ITE Traffic Engineering Council, 1997). Horizontal and vertical sight distance should be considered when determining the installation location in the guidelines These guidelines are also related to the cross section, existing alignment and intersection design of the road. A speed hump/table should be placed in a location where vehicles will not unexpectedly encounter it at a high rate of speed but cannot accelerate to an undesirable speed prior to encountering the speed hump. ITE guidelines recommend that the prior speed hump in a series be placed a distance of 200 feet or less after a stop sign or a short horizontal curve (ITE Traffic Engineering Council, 1997). Though, it is also suggested that speed hump not be located within 250 feet of a traffic signal. The guidelines also state that if a significant downgrade exists, the first speed hump in a series should be located near to the summit. Additionally, sight distances need to be considered. When sight distance may be a matter, especially during dark time hours, the placement of speed humps should be compared to the existing or planned lighting of the street (ITE Traffic Engineering Council, 1997). The layout, arrangement, number, and spacing of speed humps/tables often depend on the executing jurisdiction and tend to be site and project specific.

The ideal design shape for a speed hump was parabolic, 12 feet wide in the direction of travel, and four inches high (Clement, 1983) in 1975 by the Transport and Road Research Board of Great Britain. It was determined that at or below the design speed of this type of speed humps, a driver would get problem of no discomfort, but above the design speed drivers would experience increasing stages of discomfort as speed increases (Clement, 1983). However, drivers purposely traversing the hump at excessive speeds would still can maintain control of their vehicle (Clement, 1983). On average, these speed humps were revealed to lower the prevailing maximum speed by thirty (30%) percent (Clement, 1983).

2.2 Source and Impact of Traffic Calming Measures

2.2.1 Source

Many manuals have been developed to provide engineers guidance on traffic calming measures (TCM) (Ewing and Brown, 2009; ITE, 2007; Ministerio de Fomento, 2008; Dirección General de ObrasPúblicas de la ComunidadValenciana, 2004, CERTU, 2010). Most appropriate location of TCM and Geometry were provided, as well as recommended traffic flow range to implement TCMs. According to the Spain guidelines, no vertical TCMs were suggested on cross-town roads with annual average daily traffic (AADT) higher than 5000 vehicles/day (veh/d). The rate is higher on other guidelines where AADT is limited to 10000veh/d (CERTU, 2010; FHWA, 2009).

Many findings have been carried out to analyze the effect of TCMs on traffic operation. Operating speed reductions were found about 18% (Ewing, 1999, Hallmark et al., 2002, Zech et al., 2009). Earlier and afterwards studies were carried out on speed tables and speed humps. Mean speeds were reduced from 6 to 13 km/h at different locations (Hallmark et al., 2002, Hallmark et al., 2008, Zech et al., 2009).

2.2.2 Effect of speed humps and bumps on Noise, safety and speed

Many researchers (Ahn and Rakha, 2009; Atkins and Coleman, 1997; Chang et al., 2007) have addressed the possible positive and negative impacts of calming devices and speed humps. Thomsen and Engel tried a speed reducing effect of 1 km/hr. reduction in driving speed at every centimeter increase in height of the hump (Engel and Thomsen, 1992). Examples of previous studies that observed the effect of speed humps/bumps of diverse characteristics on the reduction of vehicle speed, including: Antic et al. (2013), Pauand Angius (2001) and Mahdy (2012). Antic et al. (2013) studied the effect of speed humps of different heights (3, 5 and 7 cm) to the decrease of vehicle speed. Speed measurements of 1 day and 1 month after the installation and before speed bumps were constructed had been done. Comparison between different

speed quantification was done by using ANOVA analysis and post hoc analysis. Median speed (V50th) percentile and operating speed (V85th) percentile were used in the comparison before and after speed bumps setting. Compared to the period before setting (Pau and Angius(2001) proposed a speed analysis of 23 speed bump installations in the city of Cagliari ,results showed that there was a significant reduction in speed on the places where speed bumps were set. Final result indicates that, in almost a third of the installations, speed limits are violated and, in another third, the 85th percentile of speed lies in the limit of speeding. Mahdy (2012) ratified the same outcomes that showed that there was a significant discount in speed on the streets where speed humps were installed. Such studies brought that traffic reducing materials reduce the speed on neighborhood streets and may contribute to road safety. On the other hand, they may increase the vehicle fuel consumption and emission rates as well as increasing the response times of emergency vehicles et al. (2006) conducted research to assess the preference and acceptability of various traffic calming measures using a visual preference survey. In this study, many road users, including motorists, pedestrians and bicyclists, were participated. For example, Al-Omari and Al-Massaeid (2002) developed a model to assess the impact of speed hump characteristics on delay times in Jordan. The model indicated that speed humps caused significant delays at their locations. Also, Hashim et al. (2012) presented a practical study to collect and analyze GPS-based travel time data for the case of evaluating the effect of speed humps on travel time and delay for roads in Egypt City. The results proved that the volumes of travel delay over different times of the day were greatly influenced by the presence of speed humps. Rosli and Kadar Hamsa (2013) investigated the effects of road hump on traffic volume and noise level in a residential area in Kuala Lumpur. Also, other studies showed the damaging effects of speed humps which were specially reflected in the noise increasing, vibration increasing (Behzad et al., 2007; Kokowski and Makarewicz, 2006; Lee and Kim, 2008; Rylander and Bjorkman, 2002). Mewuded Sifer (2020) studied the effectiveness of speed braker to reduce traffic crash and performance of them. She also studied the 85th speed of the speed humps but the work did not cover how much speed humps bring significant delay and speed reduction on different vehicle groups.

2.2.2.1 Positive Impact of Speed Humps

Speed humps play an important advantage in traffic reduction and increasing knowing roads characteristics. Speed is the first factor in most vehicle accident which increase both risk and severity. As drivers move quicker, they have low time to respond to road conditions and any resulting crash causes and more damage. Pasanen (1991) studied that when a car travelling away from 14m to a pedestrian at a speed of 48km/hr. and brakes, it will have enough distance to stop safely. But when the vehicle travelled

at a speed of 56km/hr. and it brakes at the same point of 48km/hr. it will travel a speed of 30km/hr. when it hits the pedestrian and can seriously damage or kill the pedestrian as investigated by Masvingo City entitled with Effectiveness of speed Calming Measures (Volume 3,2012).

Bristol (2012) and Burden et al. (2011) claim that traffic calming measures minimize the existence of automobile crash, improve pedestrian safety, create a better connected community, and provide best air quality. Moreover, Tester (2004) and Knapp (2000) claim that speed humps are long term safety solutions, because they are a physical reminder for motorists to drive with cautiousness. This is specifically significant in residential neighborhoods where young children play in the street.

Highway Safety Manual 2010, issued by American Association of State Highway and Transportation Officials', implementation of engineering traffic calming measures reduces accidents on roads by thirty percent.

2.2.2.2 Undesirable Impact of Speed Humps

As speed calming measures have their own pros, they do have cons on traffic movement. When a speed hump is constructed on a street where fully occupied by dwellers, motorists may choose to avoid that street and travel on an adjacent street without the speed deterrent. This can increase the existence of more speeding on adjacent streets (Kotsopoulos, 2000;).

If Speed Humps installed with negligence and without using prior guidelines, can impose serious threats on vehicles. Speed humps are being underestimated in two ways: Firstly, they are being installed improperly without approved design usage. Secondly, they are being constructed at unsuitable places repeatedly. Motor Vehicles considered by previous researchers were all types like cars, trucks, buses, tractors, bikes and rickshaws. These waves on the roads cause extreme Whole-Body Vibration (WBV) with vehicle injury. A vehicle is deteriorated either by wear and tear of brakes and tires or by harm of internal suspension components with more fuel intaking. Local Environment is also affected either due to releases of emission or increase in noise levels. If the design is not good and there is no space for drainage system then rain water may become permanent at various points, which may cause the germination of bacteria and mosquitoes. These in turn affect residents and environment with low aesthetics. At a time of Vehicle body contacted with speed breakers then friction is created which cause demolition of shoulders and hump itself.

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Consequently, while deceleration and acceleration of motor vehicles carbon oxides (CO₂, CO) and nitrogen oxides (NO_x) are emitted in excess, which cause breathing problems for locals and users, Impacts of speed hump on vehicle (Ahmed Hussain and Jahanzaib,2016). When the tires hit a hump or sink into a pothole, a shock occurs. If this shock is high enough, it causes severe spinal injury (Bowrey, Tomas, Evans, & Richmond, 2006) and other harm (Ji, Eger, & Dickey, 2017; Patel Vasudevan, 2016).

Based on the Lithuanian standard, the LST ISO 2631-1:2004 evaluated imposes no strict requirements for the valid vibration limit. It provides reference values for commonly weighted accelerations, affecting road passengers and causing comfort or discomfort during the trip in m/s²:

Table 2.1 Speed hump vibration rate

S.No	Weighted Acceleration(meter/s ²)	Comfort Type
1	<0.315	No discomfort
2	0.315---0.63	A bit uncomfortable
3	0.5----1	Quite uncomfortable
4	0.8----1.6	Uncomfortable
5	1.25---2.5	Very Uncomfortable
6	More than 2	Especially Uncomfortable

2.2.6 Geometry of Speed Humps

Speed humps are vertical deflection traffic calming devices. They are usually installed using asphalt and cement concrete. Speed humps can also made from recycled plastic, metal and volcanized rubber. Pre-shaped rubber speed humps are also available in the market that can be fixed on pavements by bolts. The mobility of road users impacted by the different geometrical natures of speed humps. The type of speed hump geometries is shown in the figure below. Speed humps are usually used to improve safety of pedestrians at high pedestrian activity areas such as residential areas, school areas and religious areas. They are not recommended on major roads as its speed calming effect doesn't agree with their functional objective. Addis Ababa Road Traffic Management Agency adopted the speed hump design recommended by WRI in the guideline Cities Safer by Design. Designs are specified for 30km/hr, 40 km/hr and 50km/hr as follows.

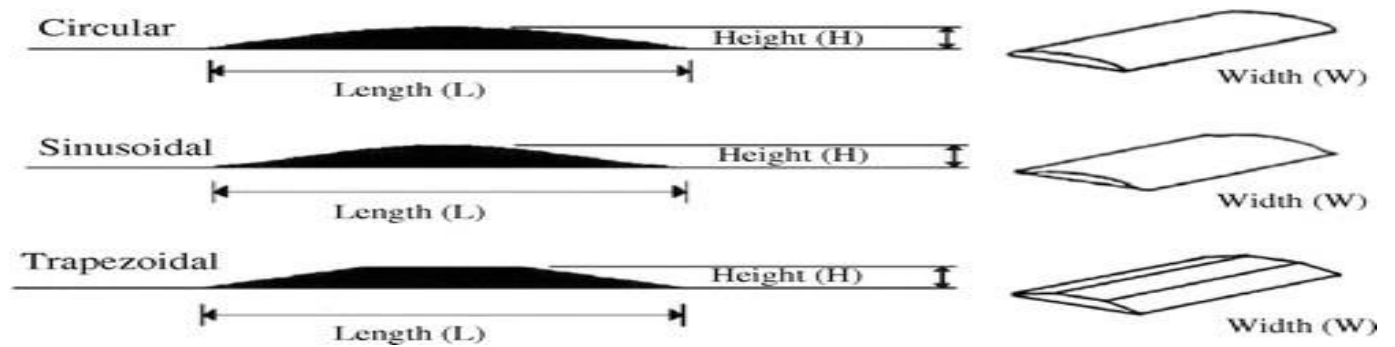


Fig 2.1 Geometry of speed hump

2.3 Noise Levels at Residential Areas

Noise is an undesirable and an unwanted sound created by human activities i.e., detrimental to the quality of life of individuals (Nadaraja et.al,2010). Many researches have been done regarding to noise and its effect on human health. Physiological, psychological, annoyance, high blood pressure, stress related illness, sleep disruption, hearing loss, and productivity loss (Ohrstrom et.al,2006, Nadaraja et.al,2010) are caused by noise. Journal of the Eastern Asia Society for Transportation studies (vol.10,2013) measured the noise-by-noise level meter which is located beside road side when the vehicle approaching and passing over the speed hump. The analysis showed that the maximum fluctuation of sound is 10 decibels and the average noise level along the road was 75.6 decibels which exceeds the recommended noise level of the city which is 60 decibels. Traffic noise sources/traffic flow) produces sound energy that, in turn, translates into tiny fluctuations in atmospheric pressure as the sources move and vibrate to the receiver. Those sound pressure variations are most commonly stated as sound pressure and measured in units of micro-Newton's per square meter $\mu\text{N}/\text{m}^2$, or micro-Pascal (μPa).

Representative sound pressure amplitudes can range from 20 to 200 million μPa . Because of this wide range, sound pressure is measured on a logarithmic scale known as the decibel (**dB**) scale. In the placement of speed humps, the average speed of flowing car is decrease this in turn increases the noise of traffic.

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

The intensity of noise of different sound sources are shown below

Table :2.2 Noise intensity

S.no	Sound Source	Level of Noise (Sound Intensity) (dB)
1	Breathing (Almost Quite)	10
2	Tickling Clock, Rustling Leaves,whisper,Quite Rural Area)	20-30
3	Normal Conversation @3ft, QuiteLibrary, Bird Calls, Moderate RF)	35-60
4	Office Noise, vacuum cleaner	60-80
5	Traffic Noise, diesel truck, alarm clocks	50-90
6	Motor Cycle, concerts,	105
7	Jet Fly, Thunder	130

Source AAiT Safety Course

Table 2.3 Sound Intensity

Area Code	Category of Area	Limit of Sound Noise in dB(A)	
		Day Time (6:00am-9:00pm)	Night Time (9:00pm-6:00pm)
1	Industrial Area	75dB(A)	70dB(A)
2	Commercial Area	65dB(A)	55dB(A)
3	Residential Area	55dB(A)	45dB(A)

Source: (AAEPaGDC), Directive Number 1, 2011

2.4 Levels of Traffic Calming

Scale is a very determined character between the various interpretations of traffic calming. It is essential to introduce at this point a terminology which includes this variable, based on three stages of traffic calming actions that found in practice (Australia Traffic Calming Guideline, 1991 and Noise regulation of Great Britain, April 2006).

2.4.1 Level 1 Traffic Calming

The level incorporates actions that restrain traffic speed and lessen traffic impacts at the local level where network capacity, level of service and traffic volumes are not an issue. This type of actions includes minimizing width of road ways, making zigzag traffic lanes, narrow points and partial repaving (Monheim, 1990). Level 1 traffic calming is called local area traffic management or residential Street traffic management.

2.4.2 Level 2 Traffic Calming

This type of traffic claiming level includes actions which restrain traffic speed and lessen traffic impacts at the local level where level of service, traffic volumes and network capacity are an issue. This action mostly applied in activity areas like Shopping centers, Country towns etc.

2.4.3 Level 3 Traffic Calming

The third level includes actions which taken at the macro level that lessen and weakening traffic speeds and used in city wide. The actions include: -

- ✚ Upgrading and priority for public transport modes, walking and cycling.
- ✚ Restriction on car usage (road pricing, parking policies)
- ✚ Rearrangement of cities and other land use policies to minimize travel demand.
- ✚ Construction of pedestrian facility (pedestrianizations) of town centers.
- ✚ Other techniques of travel demand management.

Most of the world countries have their own traffic calming guide line. For instance, USA, Germany, Ghana, Kenya, Egypt, Jordan, and Australia etc.

2.5. Concept of Level of Service (LOS)

Level of service is defined as a term which represents a range of operating conditions which occur on a transportation facility when it is accommodating a range of traffic volumes. Highway capacity manual (HCM,2000) developed by the transportation research board of USA provides some procedure to determine level of service.

Level of service is defined based on the measure of effectiveness (MOE). Typically, three parameters are used under this and they are speed, travel time and delay. One of the important measures of service quality is the amount of time spent in travel. Therefore, speed and travel time are considered to be more effective

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

in defining LOS of a road. Delay is a term that describes excess or unexpected time spent in travel. Many specific delay measures are defined and used as MOE's in the highway capacity manual. Generally, the LOS criteria on the HCM are given in the form of average travel speed in Kilometer per hour for road way sections.

Table 2.4: Urban Street Levels of Service by Class

Class	I	II	III	IV
Range of free flow	90 to 70km	70 to 55 km/h	55 to 50km/h	50 to 40km/h
Typical free flow	80km	65km/h	55km/h	45km/h
Level of service (Seconds)				
A	>72	>59	>50	>41
B	>56-72	>46-59	>39-50	>32-41
C	>40-46	>33-46	>28-39	>23-32
D	>32-40	>26-33	>22-28	>18-23
E	>26-32	>21-26	>17-22	>14-18
F	≤26	≤21	≤17	≤14

Source HCM 2000

Chapter 3: Research Methodology

3.1 Methods and Materials

The research methodology of this thesis work includes both onsite investigation and office works. Different research techniques and methodologies are used for the data collection and analysis purpose. The methodology of this research work required many preliminary data materials to meet the objective.

As a result, this part of the research runs to discuss the methods used in the thesis work followed by selection criteria to address the research problem that were identified.

3.2 Research Approach

To answer the key questions in the research problem, the research is designed in such a manner in the research methodology. The researcher used categorical questionnaire and qualitative research approaches to evaluate the research question parameters. The direct field measurements of useful parameters are used in each selected segment which is basic to quantitative data approach. The categorical approach is originated from personal perception by classified questionnaire. The qualitative data are emanated from the questionnaire which was distributed to the road users to get degree of comfort while travelling on roads with speed humps. The researcher categorized the vehicle types into five groups-based on vehicle size and configuration (ERA classification). Such as (Cycle, Motor Cycle & Bajaj), (Light Vehicle/car), (Mini Bus (Taxi) & Pick Up), (Medium Bus & Track) & (Large Bus & Track Trailer) for advantage of changing into PCU.

3.3 Description of the Study area

Addis Ababa is the primary capital city of Ethiopia and “the political capital center of the African continent “for its diplomatic, political and historical centrality. The city lies a few miles west of the East Africa Rift Valley which splits Ethiopia in to two. Addis Ababa lies at average elevation of 2,200 meters and located at 9°1’48” N and 38°44’24” E (Zone 37). It is divided in to 11 sub cities/boroughs/. The eleventh sub city is added in 2013/2020.

Addis Ababa city has total road network coverage of 7613.59km from which 3105.46 km Asphalt 961.94km Gravel, 2665.75 km Coble stone, 144.9 km care stone and 735.53 km (AACRA 2012E.C, Data Base Data).

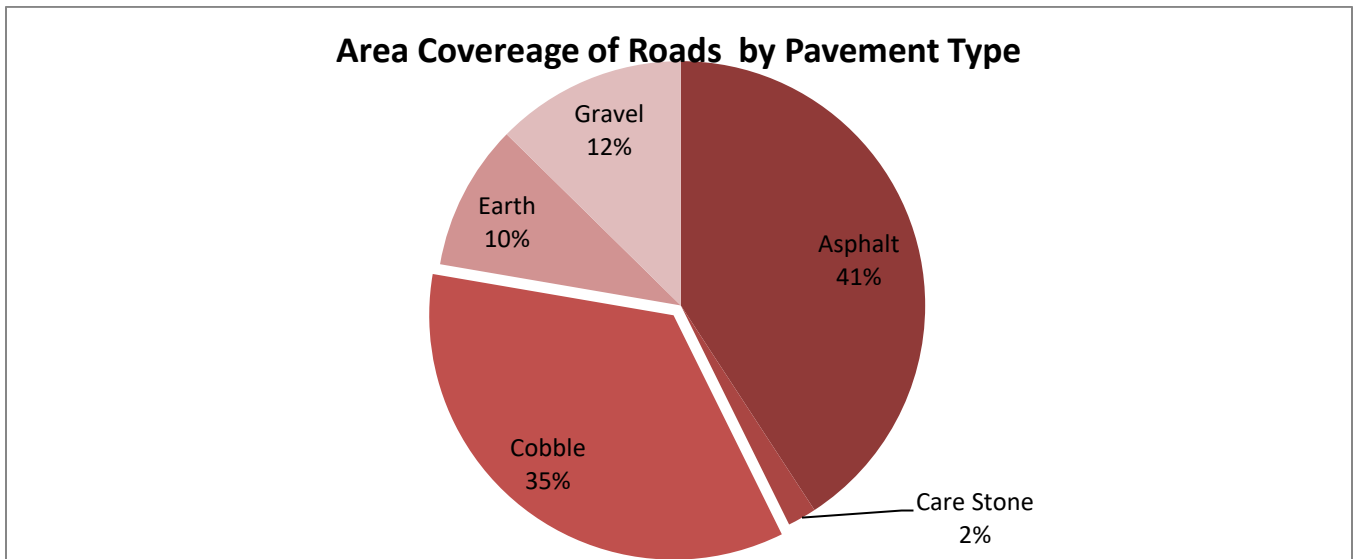


Figure 3.1 Road Pavement Coverage

The seven meter (7th meter) equivalent length of Addis Ababa City Roads Authority 2012 data is presented in the graph below.

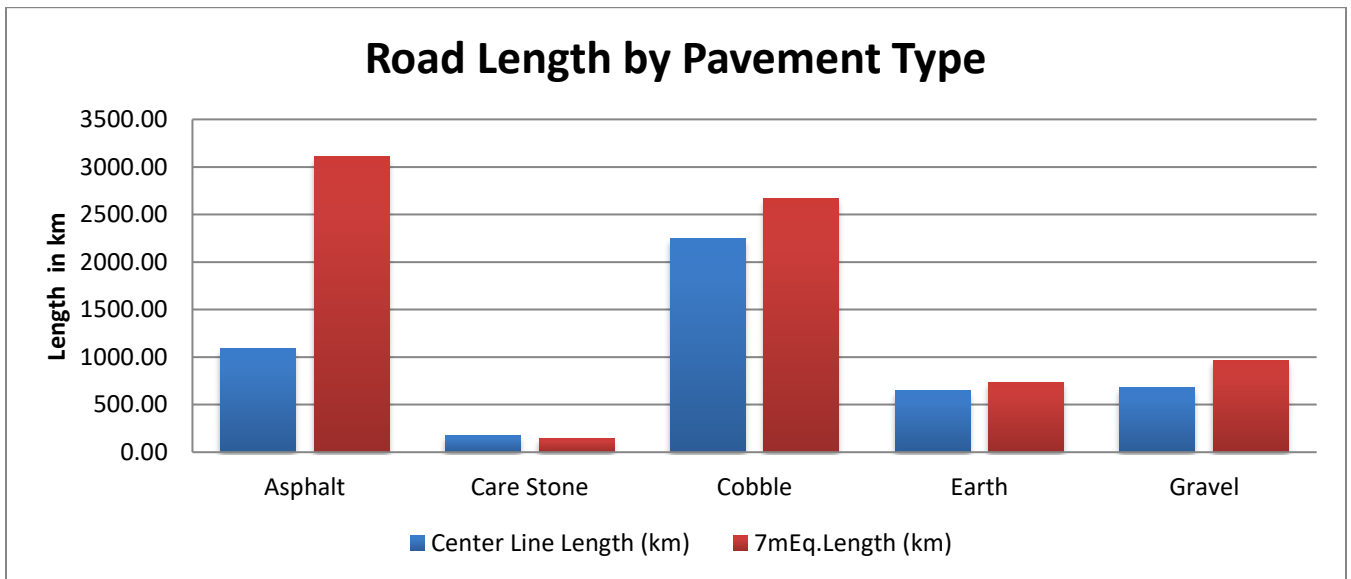


Figure 3.2 Source Addis Ababa City Roads Authority Road Data Base Directorate

In general, this city reaches above 20% road network up to June, 2012 E.C. There are many provisions of speed reduction in the city to reduce the severity of crash impact of speeding. Among those calming strategies speed hump is the one device which reduces speeding.

3.3.1 Traffic Accident Summary of Addis Ababa (July 2011 to June 2012E.C)

An accident is occurrence of risk for human being and property damage by motor vehicle at any time and place. In other word an accident is the outcome of risk, hazardous, loss, consequence or unwanted event.

The causes of accident and risk are: -

- ❖ In appropriate speed
- ❖ Taking of Drugs
- ❖ Being Young/Male
- ❖ In appropriate design of road and Defect
- ❖ Travelling in Darkness
- ❖ Being a vulnerable road user
- ❖ Problem of eye sight
- ❖ Because of bad environment, inadequate visibility

The Addis Ababa Traffic Management Agency reported the accident data of 2012 in the table below. The data is taken from Addis Ababa Traffic Management Agency and the source is taken as they recorded in their sheet catalogue.

Table 3.1 Traffic Severity

S.no	Type of Damage/Accident	Number of Accident	Amount in Birr/Damage
1	Death	448	-----
2	Highly Body Damage	1873	-----
3	Slight Body Damage	938	-----
4	Property Damage	26078	8,269,546,802
Summary		29337	8,269,546,802

Source Addis Ababa Traffic Management Agency (2012 E.C).

3.3.2. Summary of Selected Study Segments

In the city there are many interconnected and networked road segments which give transportation service as per their intended function and road classification. Every activity of the city is facilitated by the

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

constructed segments in the town. The categorical description of the selected segments along with traffic calming types summarized in the table below.

Table3.2 Road class and type of speed calming measure provision

Road Name	Width	Hierarchy	Pavement Quality	Number of lanes	Type of Speed calming Measure	No of Speed Hump
Minarol to Kotebe kidanmihret	20	SAS	Good	4	Speed Hump	10
Ferensay to Kagnev RA	25	SAS	Good	6	Speed Hump	5
Jakros to Goro	30	SAS	Good	6	Speed Hump	6
Summit Medianailem to Goro RA	60	PAS	Good	6	Speed Hump	8
Kara YekaAbado	30	PAS	Medium	6	Speed Hump	9
Figa to Summit	30	SAS	Good	6	Speed Hump	9
Abeyem to Wossen	30	PAS	Good	6	Speed Hump	5
Hill Side School to 02	20	CS	Medium	4	Speed Hump	5
Torhailoch to Noc	40	RR/PAS/	Good	8(4 interior & 4 exterior	Speed Hump	6

Source AACRA and AATMA

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

The researcher used the above selected segments based on the following criteria for further analysis.

Stratified random sampling is used for the selection of studied segment based on the following grouping criteria:

- The intensity of traffic volume,
- Number of lanes greater than or equal to Four
- Street classification/hierarchy/ as Collector up to arterial and
- Streets which have enough and available speed humps with posted speed limits
- sections which have no other calming mechanisms

The criteria are set for enough consideration of speed hump to assess their effect on vehicle volume, to get enough data and take care of get genuine data sources. Nine segments are selected for study.

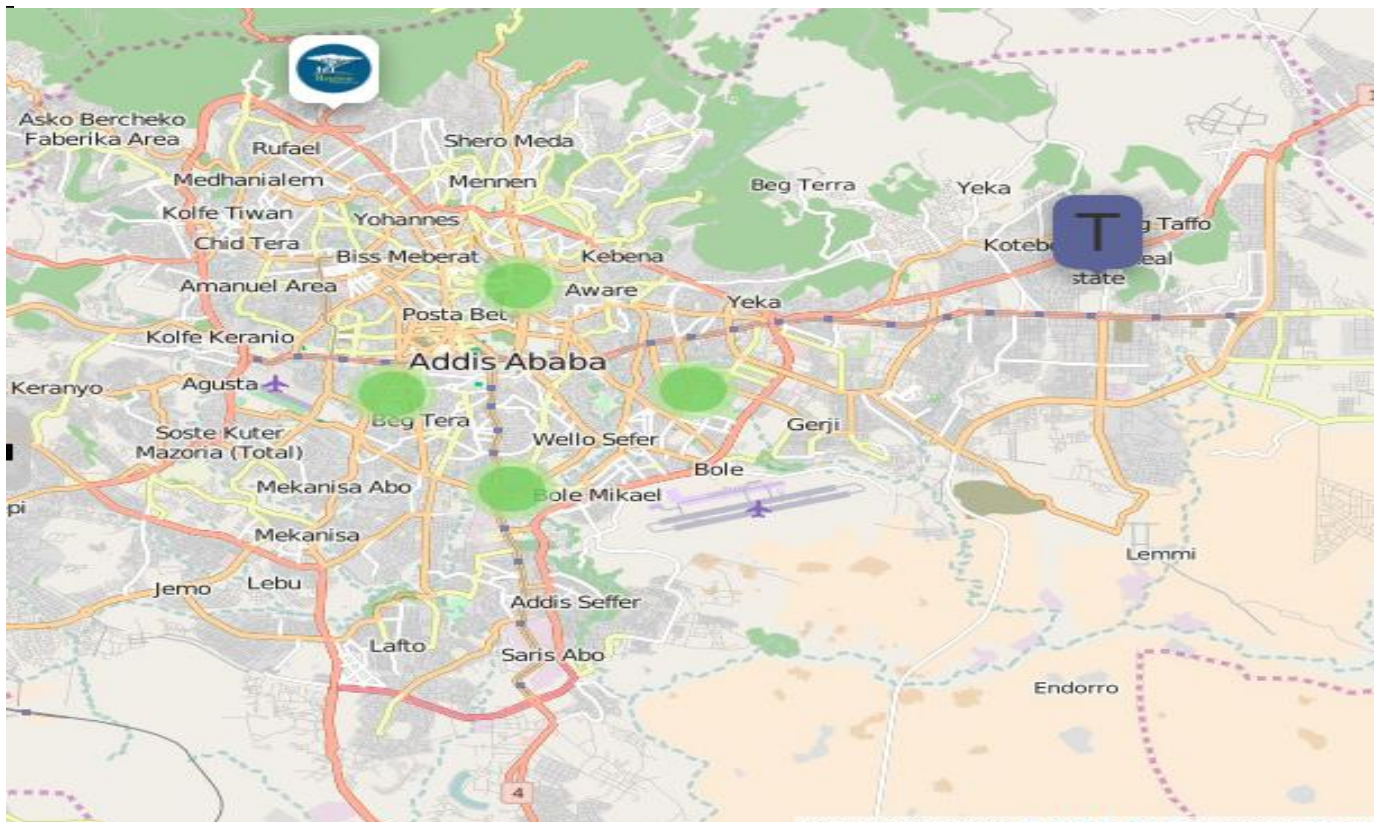


Figure 3.3: Location map of Addis Ababa

Source: - Addis Ababa mapping Agency (2018)

In addition to analysis of the selected segments, the researcher distributed a structured questionnaire to the community and road users as a participant in the research work.

The reason why the population participated in the thesis work by questionnaire is to grasp their understanding and point of view for the installed speed humps. In consideration of the perception of the community, the researcher tried to comprehend ideas about speed hump which tends to examine the qualitative approach of the thesis work. Especially the comfort of speed humps is determined from the perception of the questionnaire respondents.

The questionnaire is composed of four parts: -

- ✚ The first is the general back ground of respondents
- ✚ The second held Optional criteria to evaluate the speed hump effects
- ✚ The third contains ways of traffic calming measures and other effects
- ✚ And the last describes the effect of speed humps for different personnel on transport of motor vehicles

3.3.3 Specific Description of Each Selected Segment

1. Minarol to Kotebekidanmihret

This segment is located in the northern part of the city which connects England Embassy-Megenagna (PAS) with 02 –Andinet (SAS) and lam beret –Kotebre main road. The road gives an alternative access of mobility for the Megenagna wossen stretch. The segment has a total width of 20m (14m traffic lane and 6m walk way) and classified as SAS road as per the Addis Ababa Road classification hierarchy. Every type of traffic is accessing it and speed hump is provided there for safety.

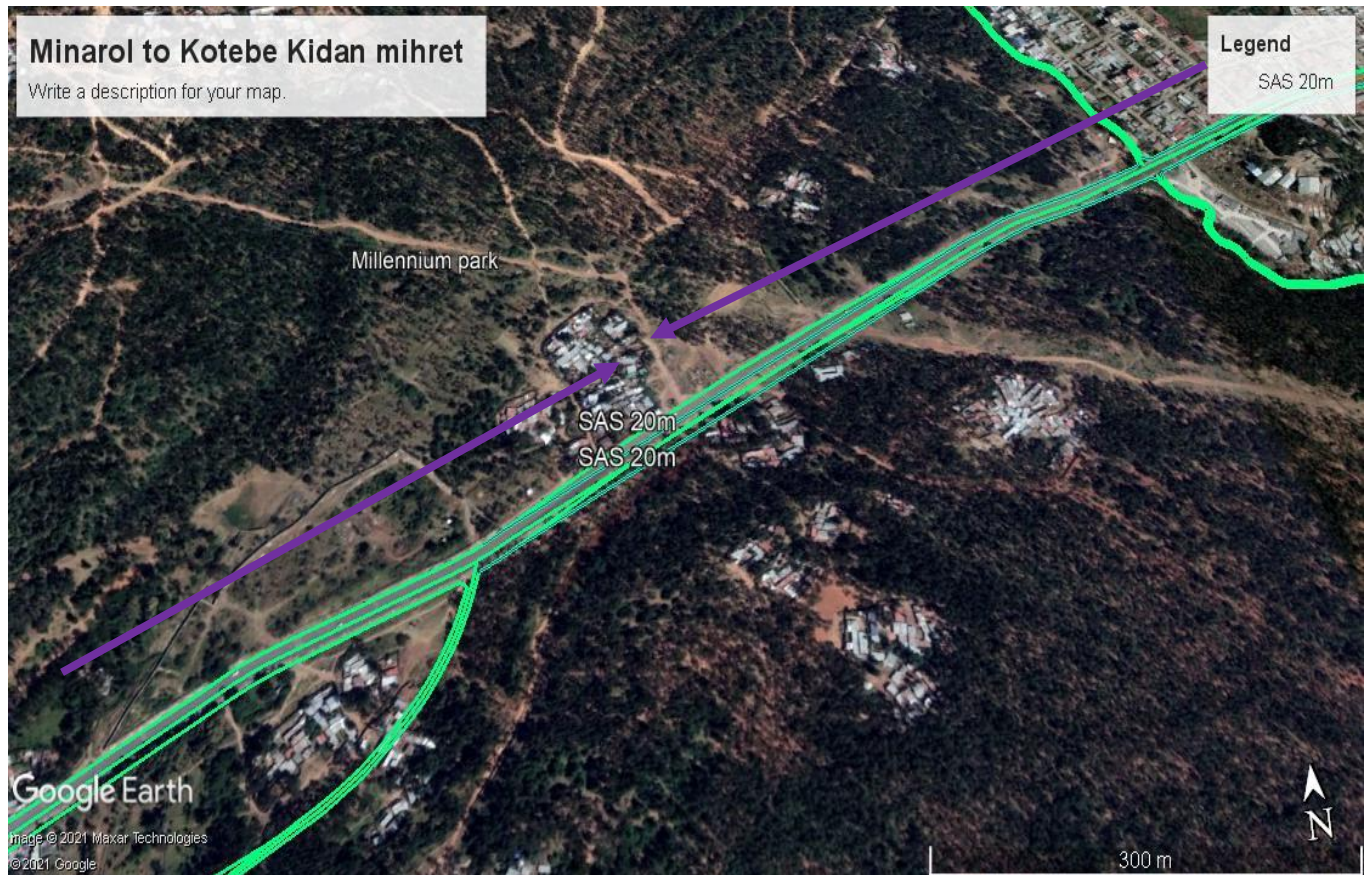


Fig.3.4 Minarol to Kotebekidanmihret

2. Ferensay to Kagnev RA

This road is classified as SAS which act as Principal Street for the adjacent collector and local roads. It has a total width of 25m and connects with 6 kilo main road to function as central divider of different directions. Different motor vehicles are using it as I collected and analyzed.

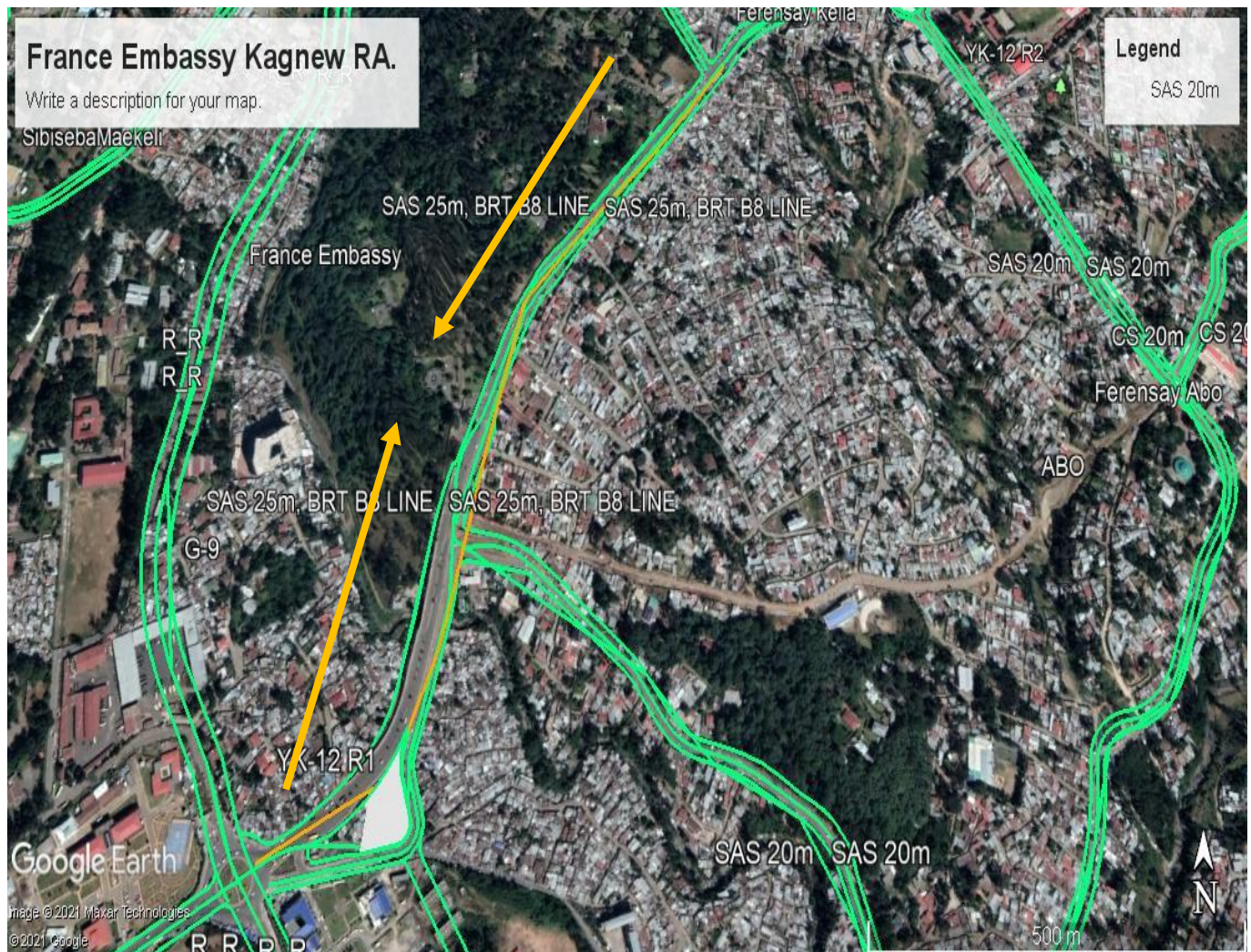


Fig.3.5 Ferensay to Kagnew RA

3. Jakros Junction to Goro RA

This intercity road has a total width of 30m which classified as SAS hierarchy. The traffic intensity is very high and all type of vehicle is using it. It is a main traffic feeder to the Addis –Adama highway road the surrounding community. Speed humps are provided at some stations to reduce the excessive speed of motor vehicles due to difficult slope.



Fig.3.6Jakros Junction to Goro RA

4. Summit Medianalem to Goro RA

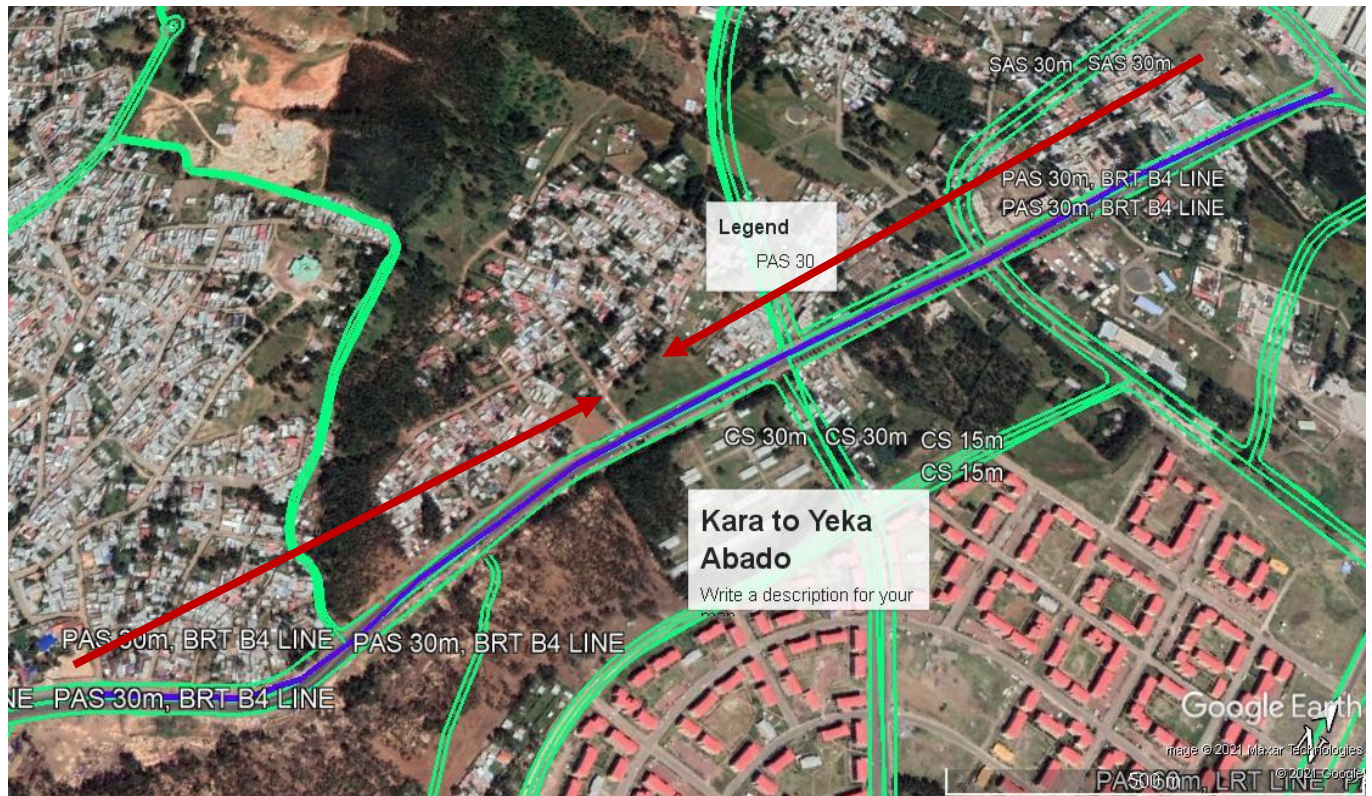
The segment is highly exposed to heavy traffic since it is the right leg extension of the Addis Adama Express way. The road has a total width of 60m as per the master plan network of Addis Ababa (2018). Only 20m part of the segment is serving for traffic and the rest is left as a median. It gives a traffic access to the surrounding community and connected with Summit, Arabsa & Ayat Road segments for branched mobility. This segment is classified as PAS as per the city road network hierarchy. The posted speed limit is 30km/hr for the segment around the speed Hump



Fig.3.7 Summit Medanialem to Goro RA

5. Kara Yeka Abado Road

This segment is the exit corridor of the northern eastern part of the country from the center of Addis Ababa. It hosts the high traffic flow and composition to the city every day. There are many people accessing the road to execute their daily activity through and beyond the stretch. The segment has 6 traffic lanes and 2*3m walkway and it is classified as PAS as per the road network. There are some speed humps installed along the road to treat the excessive motor speed. The speed limit is 30km/hr. around the speed hump.



F.g.3.8 Kara to Yeka Abado Road

6. Figa to Summit

This intercity road has a total width of 30m which classified as SAS hierarchy. The traffic intensity is very high and all type of vehicle is using it. It is a main traffic source meri-Summit and Salitemihret –Jakros road and the surrounding community. Around the speed hump the speed limit is 30km/hr. Speed control is provided at some stations to reduce the excessive speed of motor vehicles due to difficult slope.



Fig. 3.9 Figa to Summit
7. Abeyem to Wossen

This principal segment is the main road which is located in the yeka sub city, Addis Ababa. The segment is part of the megenagna –Lamberet-Kara corridor which gives a traffic access and mobility to the locality residential. It has six traffic lanes and 6m walk way width. Speed hump is provided Abeyem to Wossen side to control the negative traffic effect of motor vehicle. It is the source of highly traffic intensity for the city. The posted speed limit is 30km/hr at the vicinity the speed hump.



F.g.3.10 Abeyem to Wossen

8.Hill Side School to 02

This segment has 4 traffic lanes and 4m walk way width for both sides. It is also a collector street which connects the megenagna-kara and Lamberet Kotebe main principal streets. It gives unlimited access and mobility to the surrounding community. The segment has some road humps which control the excessive speed of vehicles due to the sloped nature of the road. It has no speed limit strategy.



Fig.3.11 Hill Side School to 02

9. Tor Hayloch to NOC

This road is the main segment of the city which collects all networked roads. It has a width of 40m and overall circulates the city to facilitate movement and accessibility. It is we call it ring road. In the new road network in the city, the B6 corridor passes through it. The stretch has inner and outer lane traffic lanes with different speed limit. The inner has a speed limit of 70km/hr. and the outer has 50km/hr. The highlighted shows the segment.



Fig.3.12 Tor Hayloch NOC

3.4 Data Collection Techniques and Methods

The study used intercity roads that connected in the city as a case study. The study area is composed of flat, Rolling and mountainous topography of road networks. The selection of the study road was determined taking into consideration of the availability of considerable speed humps having diversity in their characteristics. In this section, regression analysis is used to model the relationship between speed and speed hump characteristics (width and height), grade of the road, speed of each vehicle group and delay of vehicles. The effect of humps on vehicle's speed can be traced by GPS and direct field study.

The research work will be executed by Manual traffic volume counts and video recording, Field survey, Questionnaire and model is developed by Minitab software. The data collection system is done by the following data sources.

3.4.1. Primary Data

To be genuine, the primary data will be collected on site. Primary data will be collected at the selected road segments in Addis Ababa with videotaping at vantage stretches to record traffic movement by using camera. The video field will be mounted on nearby building. The location of stop speed hump and distance upstream of it will mark to determine the exact distance of the vehicle from the speed calming. By the video, the number of traffic vehicles will be recorded up to 25 m upstream of the speed hump. The reason

why up to 25m distance chosen is that to avoid obstructions and the speed of study vehicle fully attain its maximum speed at the mid-way of two consecutive speed humps. The duration of study will select as to capture as many speed humps as possible along the selected area.

The data items that will be analyzed in the study area are delay, approach speed, geometry of speed hump and their convenient for road users.

The primary data includes the following but not limited: -

- ✓ The number of speed humps
- ✓ The width of the road
- ✓ Proposed speed limit
- ✓ Height of speed humps
- ✓ Length of individual speed humps
- ✓ Number of vehicles
- ✓ Type of vehicle

i. Delay

Those parameters are the systematic representation of congestion of traffic in flow channel. Delay and queue develop when the road capacity is less than traffic volume or any obstruction and incident occur. The average delay is a critical operational performance measure on interrupted-flow facilities, which reflects a greater discomfort caused to drivers than travel time (Zhou *et al* 2002)

In this project, the parameters will study due to the provision of speed hump at the road segments transversely which affect flow performance. I will select appropriate place for video recording at the field and set the video recorder instrument then count vehicles at the selected segments. And count the number of vehicles that pass through the studied segment to investigate the delay and queue. Finally model a relationship between TCM and upstream delay of vehicles.

ii. Geometry of Speed Humps

The geometric nature of installed humps may have effect on traffic flow and pavement failure. In this study, the length, width and height of the speed hump will be studied on site how they are appropriate for vehicle operation and convenient. The geometry of the speed hump i.e., Length, width and height measured on the field to check with the accepted guide lines and standards. And correlate the geometry

with vehicle speed and assess their effect on movement by using Minitab. Formulate regression analysis to evaluate their effect

Geometry = f(H, W) Where,,H=Height of hump,W=Width of Hump of the studied segments.

iii. Speed

Speed is the rate of vehicle movement on a given time. In this study the approaching speed examined on marked distance on the approach of installed speed hump. Cottrell et al. (2006) used before and after studies to identify speed profiles, interviews with residents to identify the perceived impact of the speed humps.

iv. Comfort for users

This analyzes the convenient of speed humps for road users due to mobility and safety. Cottrell et al. (2006) used before and after studies to identify speed profiles, interviews with residents to identify the perceived impact of the speed humps, and case studies to conclude that complete streets promote walk able communities. Cottrell et al. (2006) used before and after studies to interviews with residents to identify the perceived impact of the speed humps.

3.4.2 Secondary Data

Different studies like dissertations, articles, journals, books, different authority's standard manuals similar to the study are going to be used as secondary data.

The data sources for secondary or derivative are Addis Ababa Transport Bureau, Addis Abba City Roads Authority, Addis Ababa Traffic Management Agency.

3.4.3 Determination of Sample Size

The sample data will be selected from different road users which considers those can access the selected routes which have speed humps and experience different characteristics.

By 2020 the population size of Addis Ababa city is estimated to be 7.2 million (*Laura 2018*). Sample size for TCMs of the driver attitude and comfort for passengers among the total population, $N = \left(\frac{Z \cdot \sigma}{\epsilon}\right)^2 = (1.96 \cdot 0.5 / 0.05)^2 = 384$ Respondents (driver, community and Passenger) as a minimum sample size. The 0.5 is proportion of people expected (50%) .1.96 is the reliability coefficient for confidence interval of 95% and 5% is marginal Error.

3.4.4 Data Analysis

The following parameters will be analyzed:

i. Delay

After video recording and count of traffic data a mathematical model will be developed to compare the mobility whether it is mandatory to install speed hump or not. This is the case to delay the vehicles excessively due to the provision of speed hump beyond the low capacity of roads. The previous traffic data and transport pattern collected from traffic management agency and Addis Ababa Transport bureau to compare the performance of the speed hump. Delay equations were developed in this study for the traffic flow as stated in the following data analysis manner.

In the performance evaluation of modern transportation systems, deterministic service time queuing models are frequently applied for system modeling. There are several deterministic service time models in the system. Several methods are available for the field measurement of delay and number of stops (Cohen and Reilly, 1998; ITE, 1996). These methods can be categorized into three basic approaches, namely the point sample, the input-output and the path-trace methods. The point sample method is based on the direct measurement of queue lengths at the location of stop sections. The researcher used this method on site in consideration of the following mathematical formula. The delay of each vehicle category is calculated by changing into passenger car Equivalent (PCE). The cumulative approaching and flowing delay are calculated from the field measurements of travel time and speed for each vehicle category. The service time and delay are calculated in the excel sheet (see appendix B).

The researcher used the model that used Service times and deterministic time D (serving at rate $\mu = 1/D$).

$$L = [2\rho - \rho^2] / [2(1 - \rho)] \quad (1)$$

Where, L = average queue length (veh), ρ = traffic intensity ($VHs/3600$)

A relationship can be established between average hump delay and the average queue length= $D=L/\lambda$ (2)

Where D = average hump delay (s/veh) L = average queue length (veh), (λ = arrival rate (veh/s), $\lambda = V/3600$ and V = traffic volume (veh/h/lane)

By combining *Equations (1)* and *(2)*, the following

Hump delay model can be obtained: $D = [2\rho - \rho^2] / [2\lambda(1 - \rho)]$

ii. Geometry of Speed Hump

Correlate the geometry with vehicle speed and assess their effect on movement by using Minitab. Formulate regression analysis to evaluate their effect on vehicle moment by assessing its geometry.

Delay = f(G, H, W, Ua) Where, H=Height of hump, W=Width of Hump and Ua=Approaching speed of the vehicles.

iii. Speed Analysis

The speed of the vehicles at the approach of the speed hump will be analyzed by setting a distance mark of 25m at the upstream of the installed hump by taking a stopwatch timing count. The average travel time of each vehicle group is measured on field and the average speed of each vehicle group is calculated at 25,20,15,10 &5m upstream distance of the provided speed hump at the selected segments. The speed of approaching vehicles is analyzed in the following manner.

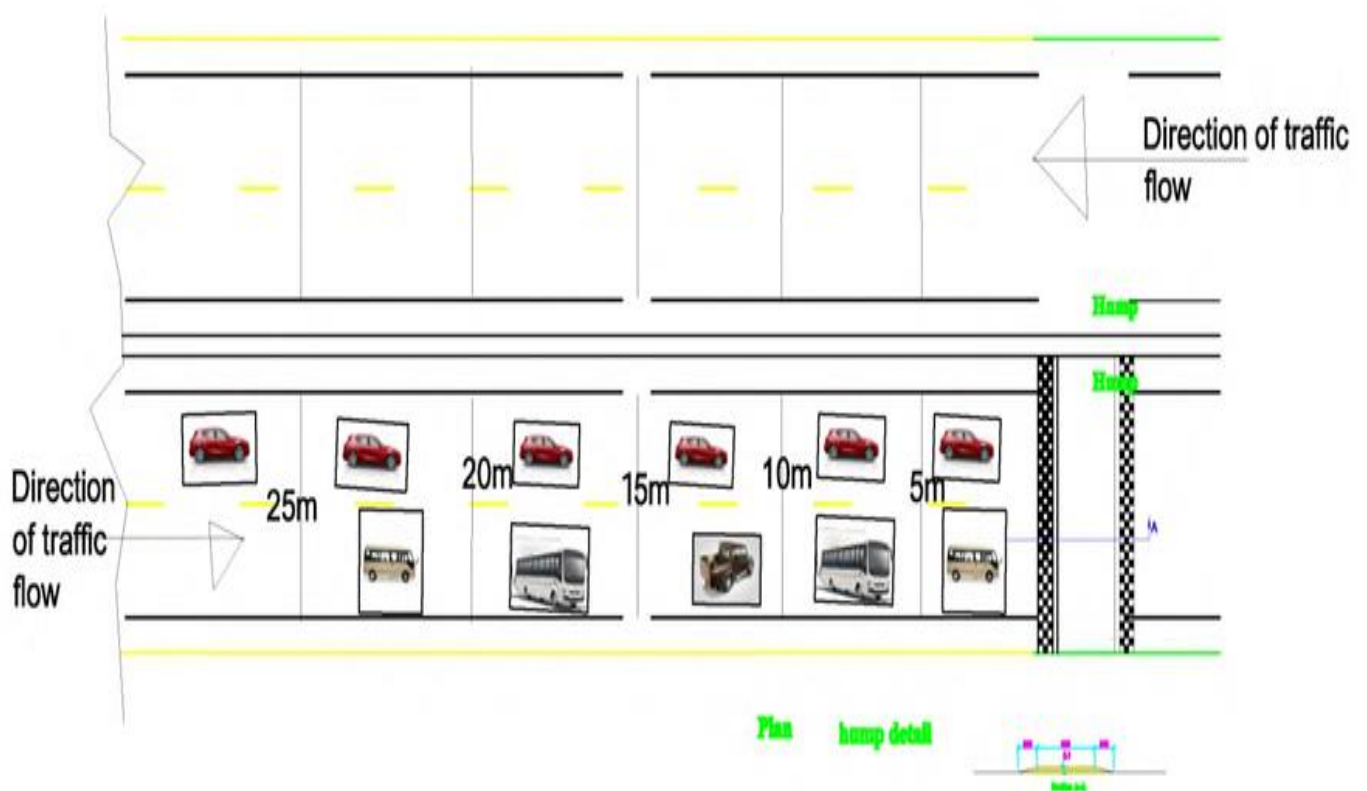


Fig 3.13 speed hump and approach distances

Since vehicles decelerate gradually, this assumption is believed to be reasonable and should result in a fairly accurate estimation of the vehicle delay time. With a speed hump, the approaching speed (V_a) of a vehicle over a section of length (s) at the travel time (t) is:

$$\text{Approach speed } (V_a) = \frac{\text{The Distance the car travelled}}{\text{Travel time of the car}} \dots\dots\dots (\text{km/hr.})$$

The travel time can be determined by different method in traffic engineering. Accordingly, the pen and paper technique require a recorder, one or two stopwatches, data collection forms and a test vehicle. The test vehicles are the vehicles which cross the speed humps through the study segment. To record the travel time of each vehicle it is conducted carefully and recorded by stopwatch.

An average speed of each vehicle category is analyzed for the research by using the travel time of the travel vehicle in the analyzed road segment.

iv. Comfort for users

This analyzes the convenient of speed humps for road users. This study will be supported by respondent perception especially those who experienced the effect frequently (road users). This qualitative effect is analyzed by the attitude of adjacent live hoods and road users.

The model will be developed by Minitab software which is multiple linear regression to determine the overall integrations of speed, speed hump geometry, grade of road and delay of each vehicle group. The model specifies that how the speed hump height & length, speed of each vehicle group and geometry of the road correlate with the delay of the vehicles.

Generally, the analysis includes:

- ❖ Conduct speed measurements and calculations for the installed speed humps and compare with the posted speed limit and speed before installation.
- ❖ Make regression analysis by using Minitab.
- ❖ Model a relationship between delay and Speed Hump Height, length, grade of road and speed

Chapter 4: Result and Discussion

Data analysis was done based on the selected segments using the stated methods and the result is presented by the discussion. The upper distance of the speed hump measured, the respective vehicles are counted for 7 consecutive days starting from Monday to Sunday for each segment at interval of 15minute for 12Hrs (starting from early morning to late afternoon), the average speed is calculated and delay is determined from the data. The Qualitative data is distributed for the respondents as discussed in section 3.2 to understand the perception of speed calming measures for the selected segments.

4.1 Questionnaire Response Summary

As discussed in section 3.2, questionnaire is distributed to selected experts as a pilot start. They gave good feedback and filled the questionnaire properly. And then the questionnaire was distributed to the respondents randomly to assess their perception towards speed hump effect on traffic movement. The number of respondents participated in the questionnaire were 396 which was above the minimum number (384, sampled in the methodology). The following table shows the respondents profile for the distributed questionnaire and some parts of the questionnaire responses.

Table 4.1 Perception of respondents

<i>S.No</i>	<i>Parameter</i>	<i>Number</i>	<i>%tage</i>	
1	Sex	Male	229	57.83
		Female	167	42.17
2	Education Back Ground	Msc&Above	75	18.94
		Bsc	268	67.68
		Diploma	33	8.33
		Certificate Below	19	4.80
3	Questionnaire Distributed	Distributed	396	100.00
		Returned	396	100.00
		Improper Geometry	330	83.33
4	Effect of SH on Speed	Largely Decrease	192	48.48
		Slightly Decrease	198	50.00
		No Effect	6	1.52
5	Sign Description of SH	Clearly Informed	42	10.61
		Information Sign Lacked	324	81.82
		Described in Wrong Way	24	6.06

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

6	Spacing of SH on road segments	Uniform Interval	30	7.58
		Non-Uniform Interval	228	57.58
		Variable as the geometry	138	34.85
7	Effect of SH on nearby People/dwellers	Noisy	30	7.58
		Restlessness	36	9.09
		Shocking	24	6.06
		All	312	78.79
8	Do speed hump effective for reduction of crush, damage and loss of life	They reduce the accident	162	40.9
		Slightly reduce the accident	147	37.1
		No, they do not reduce the accident	69	17.42
		No correlation	18	4.58
9	Effect on Passenger Cross Over SH	Shivering	48	12.12
		Vertical Deflection	96	24.24
		Horizontal Deflection	12	3.03
		All	234	59.09

4.1.1 The Degree of Comfort SH for Road Users

The comfort ability of speed humps for road users at different settlement is rated by respondents' perception and experience. These conditions are used to evaluate the degree of comfort speed humps. As per the respondent's perception, the degree of uncomfortable is greater for different passengers. Even though the effect is different from one vehicle to another, the respondent's selection of perception is presented here under in the table.

Table 4.2 Comfort Degree for SH at different situation of people

Comfort Zones of Speed Hump on Different Situations/Road Users/	Degree of Comfort Zones				
	Very Uncomfortable	Uncomfortable	Slightly Comfortable	Comfortable	Very comfortable
	0	1	2	3	4
1. Disables with wheel chairs on the car	132	162	72	30	0
2. For pregnant passengers	180	180	36	12	0

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

3. Elder passengers on any type of car	72	210	102	6	0
4. Passengers which sit at the rear	66	192	102	24	0
5. Effect on erected passengers	48	180	144	24	0

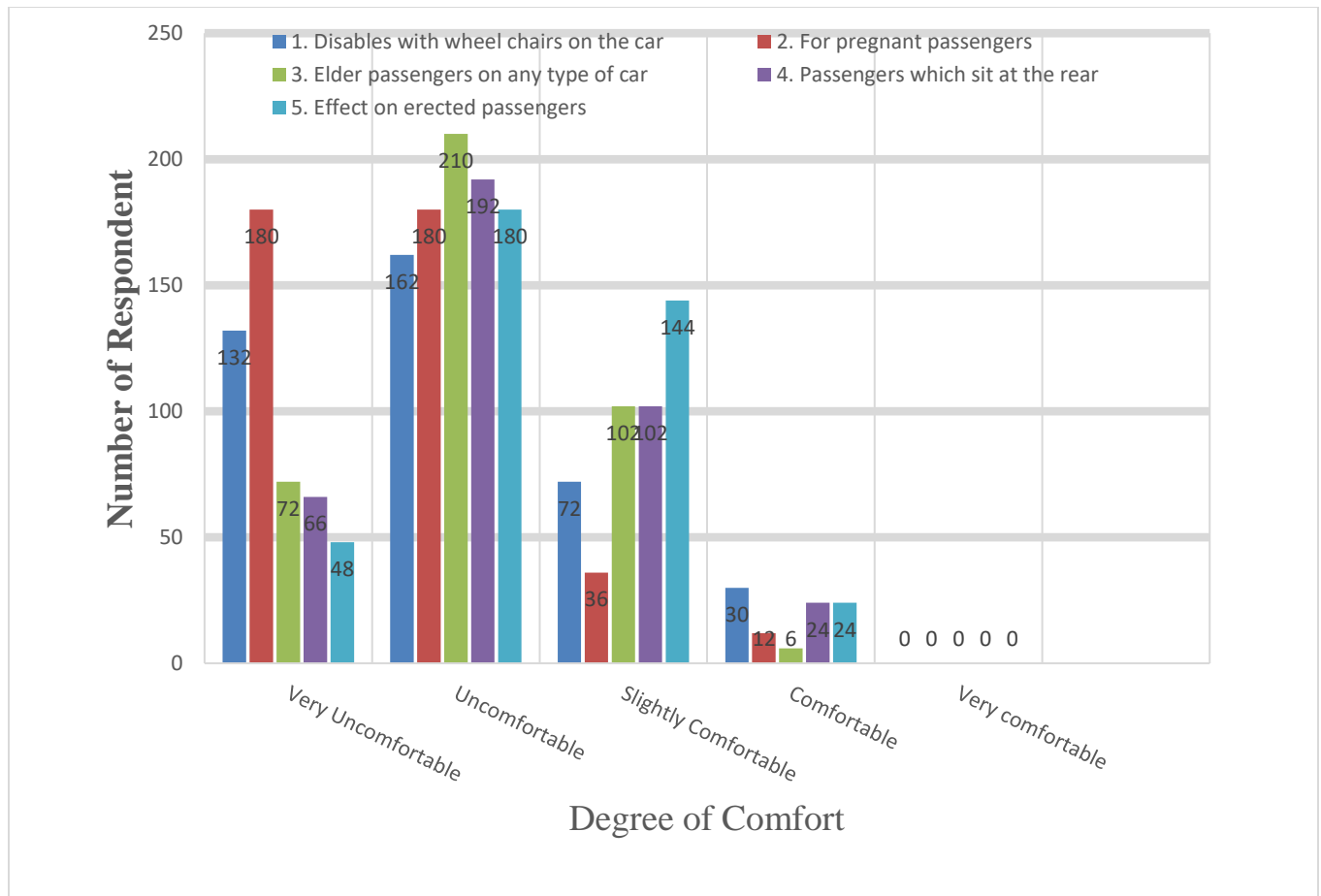


Figure 4.1 Qualitative data summary from respondents

4.2 Speed Analysis of Vehicle Group

The speed of each vehicle group is analyzed 25m upstream of each segment which it attempted to catch up enough vehicle movement. The speed is calculated by dividing 5m distance to the time taken to cover this gap distance through respective intervals. The speed of the moving vehicle is calculated in the following manner as shown in the table

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Table 4.3 sample of speed calculation (Abium Hotel to Wossen)

Vehicle	Upstream Distance(M)@					Time Taken(Travel) in Seconds @					Average Speed(Km/Hr)				
	25	20	15	10	5	25	20	15	10	5	25	20	15	10	5
Cycle,motor & Bajaj	25	20	15	10	5	0.95	0.95	1.1	1.12	1.12	18.9	18.9	16.4	16.1	16.1
Light Vehicle	25	20	15	10	5	0.9	1.05	1.04	1.07	1.12	20.0	17.1	17.3	16.8	16.1
Mini Bus,pick up&Ta	25	20	15	10	5	0.95	1.025	1.1	1.025	1.04	18.9	17.6	16.4	17.6	17.3
Bus	25	20	15	10	5	0.95	1.035	1.085	1.085	1.12	18.9	17.4	16.6	16.6	16.1
Track & Track Train	25	20	15	10	5	1	1.05	1.09	1.11	1.12	18.00	17.1	16.5	16	16.1
											94.8	88.2	83.1	83.3	81.6
											19.0	17.6	16.6	16.7	16.3

As compared to the posted speed limit(30km/hr.), the calculated average speed (analyzed on field) is less than the installed one (posted speed limit).

4.2.1 Speed of vehicle at different Distances

The average speed of each study vehicle at the distance of 5m,10m,15m,20m&25m from upstream side of the speed hump is stipulated in the graph below.

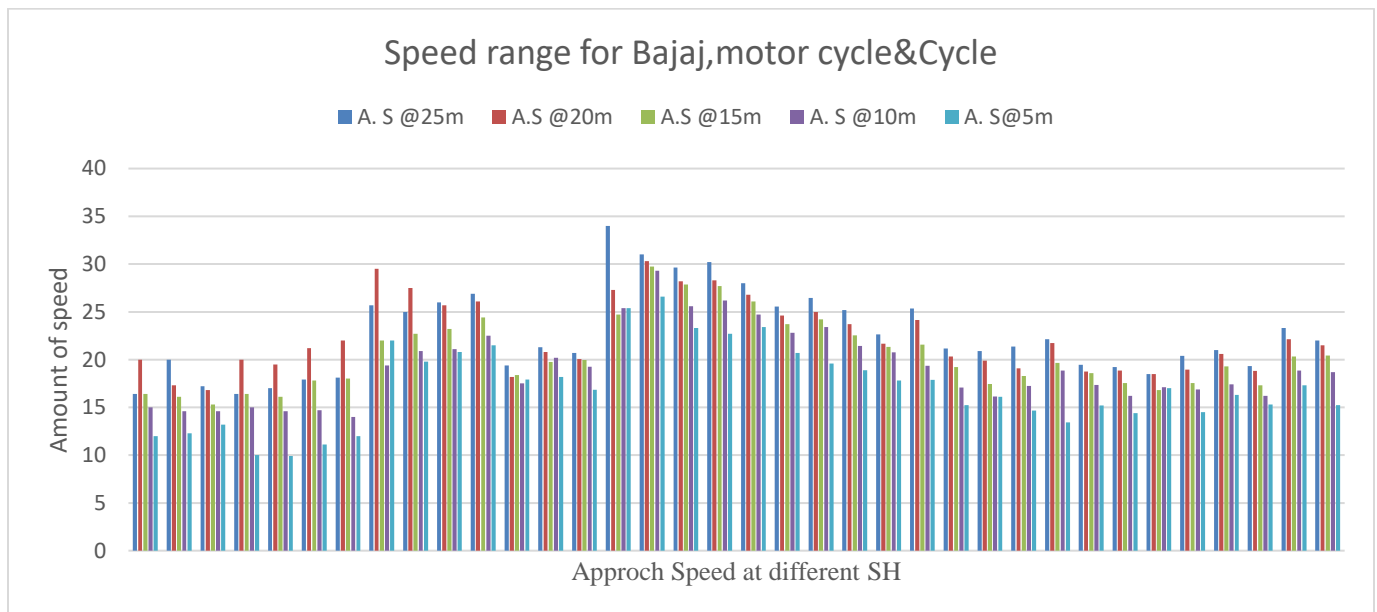


Figure 4.2 The speed of Bajaj, Cycle & motor

As indicated in the graph the average speed of vehicle groups is decreased as the vehicle moves from 25m to 5m towards the speed hump. The speed of the car at 5m distance is very declined.

Figure 4.3 The speed of Car

The speed of the car group at 20m&25m are almost the same. The speed of car is gradually decreased as the vehicle is approached to the speed hump.

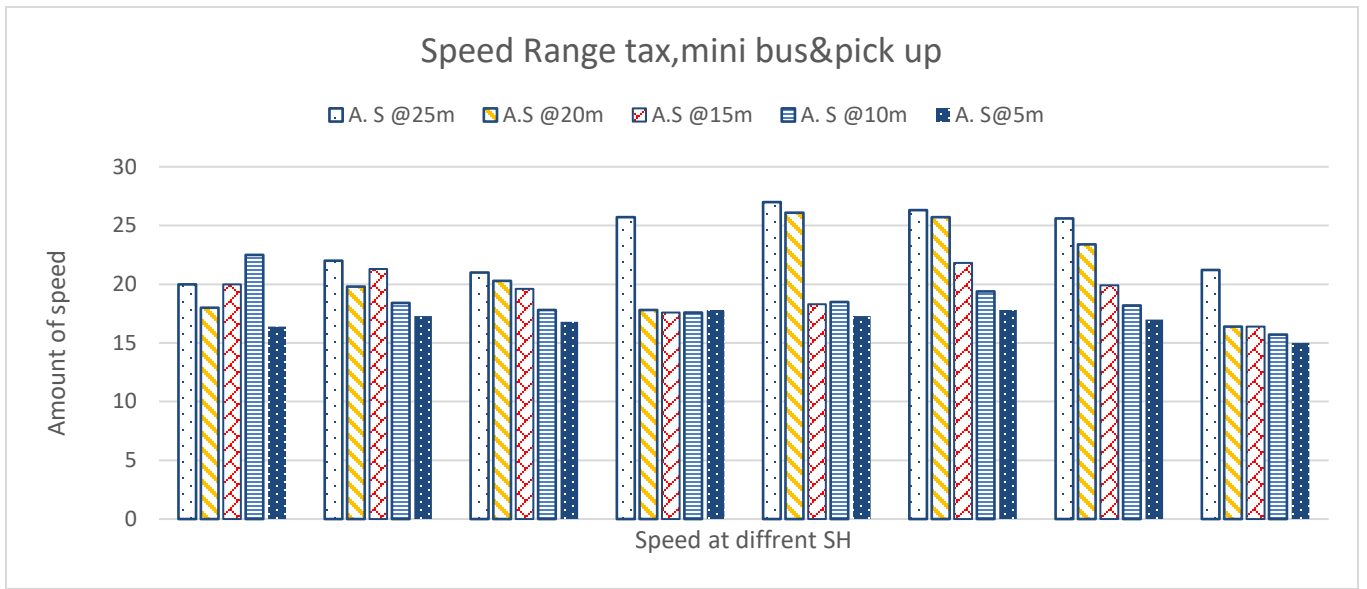


Figure 4.4 The speed of Taxi,Mini bus &pick up

The average speed of the above vehicle group at 25m and 20 are large. The speed at 25m is greater than the speed at 20m. And the speed of taxi,pick up and minibus is gradually decrease as they approach to the speed hump. The average speeds at 15m ,10m, and 5m are almost similar as the graph and field study.

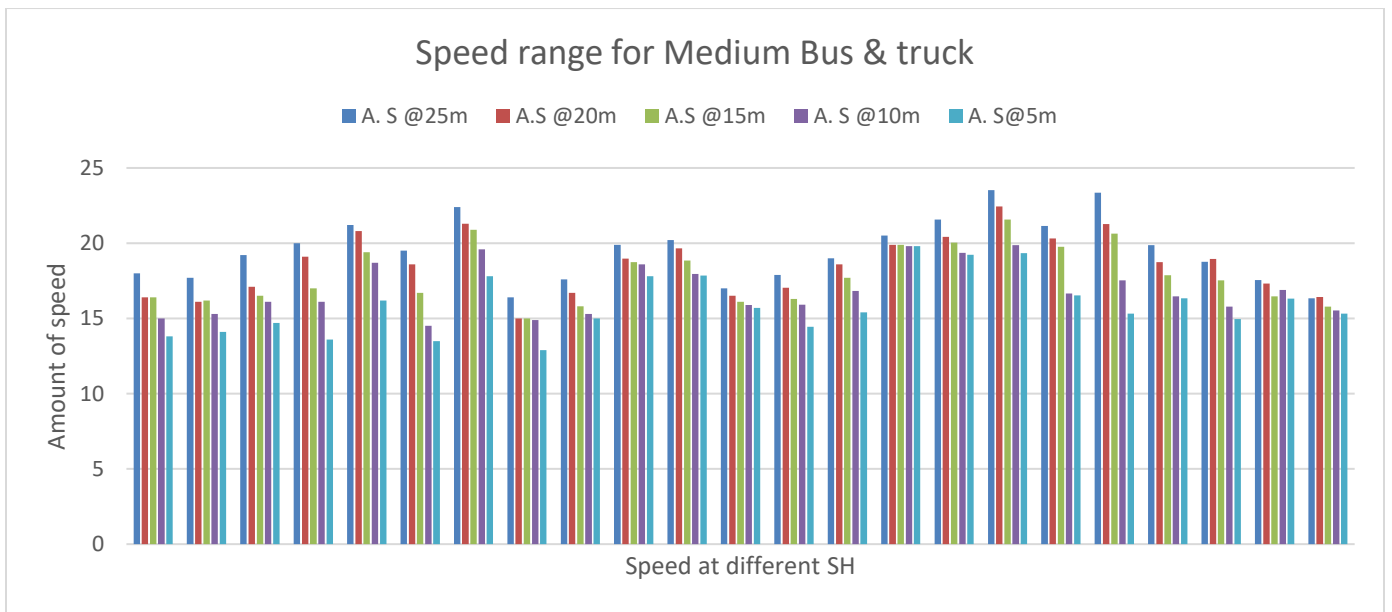


Figure 4.5 The speed of Medium Bus &Truck

The speed of the vehicle group is gradually decrease from 25m to5m as the car approached to the speed hump location. The calculated field data is attached in the appendix. (B).

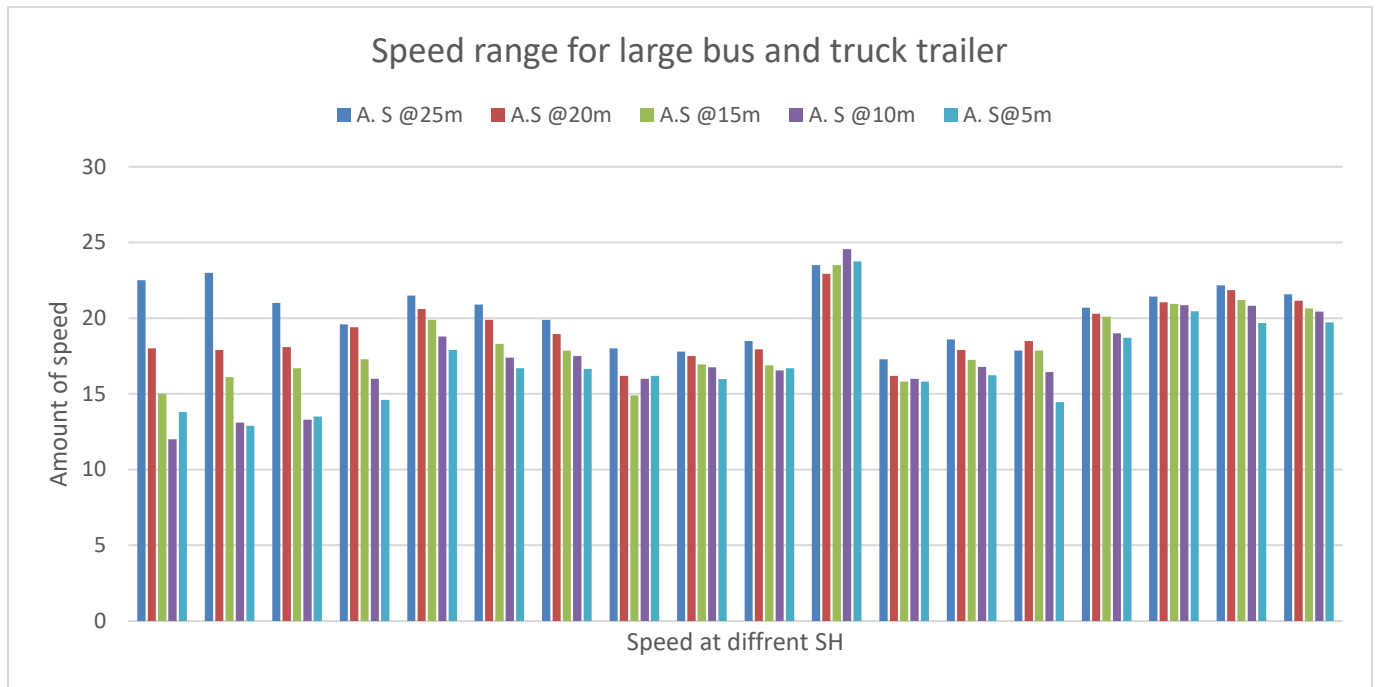


Figure 4.6 The speed of Large Bus & Truck Trailer

The study shows that the speed of large bus and truck trailer are reduced as the vehicles are approached to the speed hump.

In general, the speed of taxi, minibus and pick up speeds are greater than other vehicles speed in approaching of the toward the speed hump.

4.3 Geometrical and Corresponding Traffic Condition Investigations

As mentioned in the research methodology, the geometrical analysis of speed hump, speed calculation and delay analysis are conducted. The geometrical part of the speed hump is measured by tape meter for analysis purpose. The delay of each vehicle group is calculated based on the travel time, grade of road, PCE and number of vehicles. The analysis and traffic count are shown in the table and figure respectively. The rest will be shown in the appendix.

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Table 4.4 SH geometry, grade of road, speed and delay

Salite Mihret to Summit(Both Sides)(8 speed Humps)										
SHL(cm)	Height	Grade	B,M&MC			V10	V5	Delay(veh-min)		
			V25	V20	V15					
755.6	9.83	-2.6	18.5	18.5	16.8	17.1	17	30.56		
756	8	-5.4	20.4	18.95	17.54	16.89	14.5	31.49		
756.3	7.33	-5.1	21	20.6	19.3	17.4	16.3	32.88		
755.3	8.17	-3.2	19.32	18.83	17.3	16.21	15.3	34.64		
757	7	-6.8	23.3	22.13	20.34	18.87	17.3	36.12		
755.8	7.5	-7.4	22	21.5	20.43	18.67	15.23	31.49		
754.9	6.63	-10.7	24.45	23.45	22.3	20.34	18.2	33.81		
754	7.43	-2.8	20.54	19.33	18.21	17.43	15.65	37.97		
755.61	7.74	-5.50	21.19	20.41	19.03	17.86	16.19	33.62		
Car										
755.6	9.83	-2.6	20.8	20.2	18.3	18.1	17.1	179.13		
756	8	-5.4	21.76	20.33	17.78	15.89	15.5	185.76		
756.3	7.33	-5.1	21.45	19.65	18.32	17.11	15.87	185.76		
755.3	8.17	-3.2	20.32	19.1	18.8	16.79	14.36	165.86		
757	7	-6.8	23.45	22.1	20.78	19.45	17.33	208.98		
755.8	7.5	-7.4	22	19.7	18.6	17.31	15.66	195.71		
754.9	6.63	-10.7	21.76	20.27	18.97	16.85	15.33	189.74		
754	7.43	-2.8	20.32	19.67	18.63	16.84	14.74	202.35		
			21.48	20.13	18.77	17.29	15.74	189.16		
M,P&T										
755.6	9.83	-2.6	19.1	19.6	18.4	18.2	17.6	96.51		
756	8	-5.4	24.2	22.86	20.89	19.88	17.35	98.42		
756.3	7.33	-5.1	26.33	24.22	22.78	20.38	14.78	92.07		
755.3	8.17	-3.2	23.56	21.87	20.55	18.33	16	101.59		
757	7	-6.8	26.45	24.67	22.88	20.98	18	90.48		
755.8	7.5	-7.4	24	22.45	20.65	18.57	16.87	106.36		
754.9	6.63	-10.7	26.5	24.37	22.78	20.69	16.87	108.58		
754	7.43	-2.8	22.35	20.76	18.65	16.29	14.53	105.40		
			24.06	22.60	20.95	19.17	16.50	99.93		
Bus										
755.6	9.83	-2.6	19.5	19.3	19.2	18.8	16.89	10.62		
756	8	-5.4	18.86	17.47	16.22	14.66	13.22	9.65		
756.3	7.33	-5.1	20.33	19.78	17.55	16.05	15.11	11.58		
755.3	8.17	-3.2	19.34	17.88	16.78	14.89	12.56	12.22		
757	7	-6.8	19.24	17	16.23	15.55	13.67	12.55		
755.8	7.5	-7.4	19.15	19.15	17.45	15.88	13.99	10.94		
754.9	6.63	-10.7	20.3	18.98	16.77	15.66	14.25	11.26		
754	7.43	-2.8	20.2	19.65	18.85	17.96	17.85	12.55		
			19.62	18.65	17.38	16.18	14.69	11.42		
T&TT										
755.6	9.83	-2.6	18.56	16.4	15.9	15.8	14.8	88.04		
756	8	-5.4	19.65	18.93	17.77	16.44	14.32	93.72		
756.3	7.33	-5.1	20.32	19.44	17.96	16.87	14.4	85.2		
755.3	8.17	-3.2	18.45	17.76	16.46	13.53	9.67	99.4		
757	7	-6.8	19.88	17	15.65	13	11.11	107.92		
755.8	7.5	-7.4	19.22	17.66	15.35	14.77	13.33	99.4		
754.9	6.63	-10.7	21.57	19.99	17.47	15.36	13.54	116.44		
754	7.43	-2.8	19.05	17.22	15.88	13.44	9.66	102.24		
			19.59	18.05	16.56	14.90	12.60	99.05		

Table 4.5 Average speed length, height, Grade and Speed @25,20,15,10&5m

Name of Segment	A.SHL	A. SHH	G	A. S @25m	A.S @20m	A.S @15m	A. S @10m	A. S@5m	A.D
02 to Hill Side	756	9.67	-7.4	15	13.8	13.6	13.6	12	56.00
	755	9	-5.6	17	14.2	14	13.8	13.2	52.26
	755	8.17	-3.8	16.6	16.3	15.2	14.3	13.6	31.73
Minarol to kotebeKidanimhret	755	8.33	-4.3	20	15.9	17	17.1	16.5	72.51
	754	8.67	-8.3	19.2	18.8	16.9	16.4	15	78.55
	756	7.67	10.5	18.3	17.6	18.1	15.6	14.7	64.45
	754	8.4	-7.8	19.5	19.1	18.8	15.2	13.3	88.62
	755	8.23	-2.3	20	16.1	14.3	14.4	14.4	94.67
	756	8.86	-0.3	21	17	15.2	13.9	14.8	106.75

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	755	8.54	11.3	19.8	17.9	14.9	15.1	14.3	62.44
	754	8.93	-6.4	23	21.7	20.3	19.7	15.6	86.61
Ferensay to Kagnew RA	756	9.67	-2.4	18.5	19.4	17.2	16.4	16.2	63.06
	755	9	10.6	19.3	18.9	18.2	16.6	16.15	68.27
	755	8.17	13.4	18.2	18.17	18.1	15.9	16	73.66
Kara to Abado	730	8.83	-4.7	24.7	23.8	23.5	20.6	19.3	42.52
	740	7.5	-2.9	26.7	25.4	25.105	24.2	23.3	52.19
	1090	6.17	-1.5	27.56	25.75	24.68	23.8	22.65	61.85
	734	7.33	-1.7	25.6	24.86	24.42	23.87	22.45	63.79
	1010	6.67	-3.6	24	22.9	22.75	22.56	20.67	56.05
	1074	7.83	-4	25.54	23.44	23.56	22.99	21.95	54.12
	1011	8.7	-5.1	23.8	22.67	21.56	21.05	19.96	69.59
	1070	8.23	-4.5	22.96	21.65	21.51	22.05	18.91	71.52
	1095	8.5	-4.8	22.25	22.08	21.65	18.76	16.95	57.99
	1093	7.2	-3.7	24.55	24.13	21.56	19.34	17.89	50.26
	1081	6.4	-4.5	23.34	22.64	21.27	19.86	17.73	83.12
AbeyemWossen	755	7.67	-6.7	22.67	20.1	17.3	16.8	16.2	119.44
	755	7.17	-7.6	23.2	21.54	20.2	18.95	16.45	127.40
	754	7	-5.4	23.5	21.75	20.1	18.54	15.65	125.41
	755	8.67	-6.8	20.45	18.43	16.75	15.9	15.35	117.45
	756	8.5	-3.1	19.22	18.54	17.89	16.7	15.78	133.37
SaliteMihret to Summit	756	9.83	-2.6	20.8	20.2	18.3	18.1	17.1	179.13
	756	8	-5.4	21.76	20.33	17.78	15.89	15.5	185.76
	756	7.33	-5.1	21.45	19.65	18.32	17.11	15.87	185.76
	755	8.17	-3.2	20.32	19.1	18.8	16.79	14.36	165.86
	757	7	-6.8	23.45	22.1	20.78	19.45	17.33	208.98
	756	7.5	-7.4	22	19.7	18.6	17.31	15.66	195.71
	755	6.63	10.7	21.76	20.27	18.97	16.85	15.33	189.74
	754	7.43	-2.8	20.32	19.67	18.63	16.84	14.74	202.35
Summit Medianialem to GA	754	6.33	-2.7	18.7	17.6	17.1	16.5	16.5	316.25
	755	7.67	-3.2	21.67	20.89	18.09	17.1	13.3	327.96
	754	7.33	-3.9	18	17.05	15.67	14.8	11.5	299.85
	757	8.29	-3.4	18.5	17.35	14.33	12.52	8.66	257.68
	750	6.11	-5.6	19.24	16.88	14.39	12.99	11.76	333.82
	750	7.16	-6.4	17.32	16.87	17.43	16.54	13.07	297.51
	756	7.44	-5.7	17.36	16.66	14.9	13.53	13.43	351.39
	757	6.73	-3.7	17	17	16.32	14.54	13.37	333.82
Goro RA to jakros Junction	755	6.83	-4.3	18.1	16.18	16.2	15.9	15.8	428.12
	755	5.83	-5.4	24.54	22.76	20.87	17.55	15.55	460.35

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	757	7.5	-4.5	21.54	20.33	19.54	16.87	14.65	475.69
	755	8.33	-9.9	19.91	19	18.2	17.32	16.6	460.35
	755	5.33	11.2	23.99	22.32	20.58	18.68	16.66	491.03
	754	7.13	-7.4	18.65	18.2	17.45	16.58	14.76	498.71
	756	7.4	-7.9	18.78	17.56	16.89	16	13.33	514.05
	756	6.67	-7.3	19.96	18.64	17.22	13.4	14.11	454.21
Ayer tena to Wingate	1104	8.64	-3.2	47.5	45.9	44.68	43.25	40.76	765.39
	1105	9.83	-6.8	49.34	46.44	43.45	41.65	35.89	751.96
	1120	7.67	-5.7	40	36	34	33.3	32.1	671.39
	1102	7.84	-3.3	46.57	43.43	40.24	36.89	36.5	822.46
	1121	9.42	-5.6	45.77	44.45	42.24	40.14	38.16	822.46
	1118	8.17	-6.3	49.86	46.78	43.78	41.67	39.2	788.89
	1118	7.79	-3.8	46.86	42.89	42.67	36.66	30.2	738.53
	1104	7.12	-2.8	46.43	42.75	38.63	35.98	29.89	671.39

The length and width of the installed speed humps are different with the WRI standards which the Addis Ababa traffic management Agency uses.

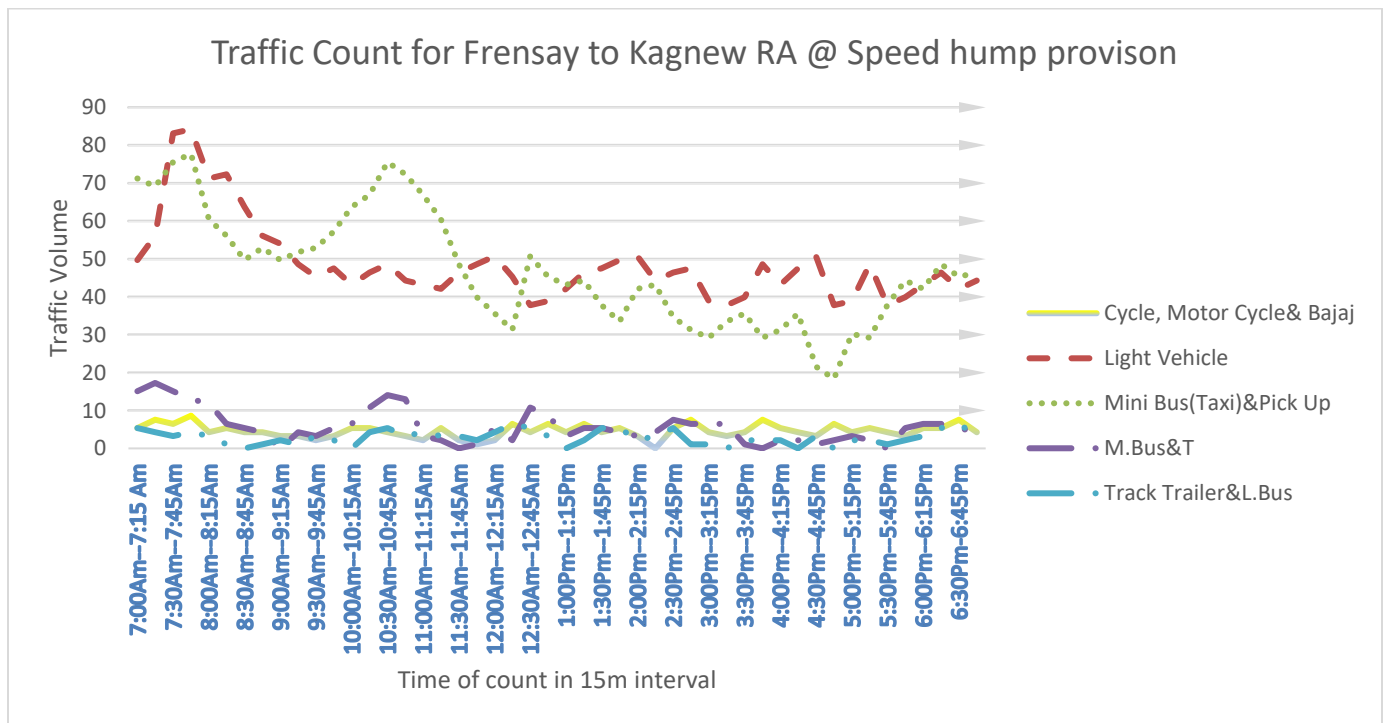


Figure 4.7 Traffic Volume for Ferensay to Kagnew RA.

As indicated in the graph the amount of minibus, taxi, pickup and light vehicle are larger than the rest of the vehicle count.

4.3.1 Statistical Analysis of SH geometry, Speed, Grade and Delay (Modeling)

The speed hump geometry, speed for each speed hump, the time taken to cross the speed hump, grade of road at each section are recorded on field study. The delay is analyzed based on the field data and traffic count. In this section, a statistical model is developed for the above parameters.

The Dependent Variable is

- Delay

The Independent Variables are

- Speed hump Height
- Speed @ 5,10,15,20&25 meters up stream distance
- Grade at each location of Speed hump

4.3.1.1 Regression Analysis for Vehicle Types @ 25 Meter

A. Delay versus A. SHL, A. SHH, G, A. S @25m for Car

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S @25m

Regression Equation

$$A. D = 136 - 0.450 A.SHL - 34.0 A. SHH - 12.90 G + 27.74 A. S @25m, R\text{-}sq=0.72 \text{ and } R\text{-}sq.\text{Adj.}=0.7$$

this means the variables used in the model have decent correlations and the model fits with the observations.

The speed hump length, height, grade has negative correlation but speed has direct relation at 25m of upstream distance.

The model indicates that the speed hump length, width and grade of the road have negative impact on car delay.

$$A. S@25m = -15.31 + 0.047 A.SHL - 0.062 G, R\text{-}Sq.\text{Adj.}=0.68$$

The speed at 25m has a positive relationship with SHL and negative relation with grade of the road. And the R-Sq.Adj=0.68 indicates that more or less good correlation of dependent and independent variable. This means not that all independent variables are good for the model.

$$S@25m = 19.25 + 1.03 A.SHH + 0.55 G, R\text{-}Sq.\text{Adj.}=0.81$$

The adjusted R-squared =0.81 considered as a strong or high effect size of independent variable on dependent variables.

B. Delay versus A. SHL, A. SHH, G, A. S @ 25m For TT&L.Bus

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S @25m

Regression Equation

$$A. D = 209.7 - 0.1373 A.SHL - 27.28 A. SHH - 4.07 G + 8.07 A. S @25m$$

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The speed hump length, height and grade have indirect relationship with delay and speed at 25m upstream distance has direct relationship with delay. R-square adjusted is 0.46 which indicate low effect of variables.

C. Delay versus A. SHL, A. SHH, G, A. S @25m for B, C&M

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S @25m

Regression Equation

$$A. D = 43.9 - 0.0158 A.SHL - 0.19 A. SHH + 1.113 G - 0.085 A. S @25m$$

The speed hump length, width and speed @ 25m up stream distance has indirect relationship with delay and the longitudinal grade of the road has direct relation with delay of vehicles.

As indicated in the model speed hump length. Width and speed have negative impact on delay of cycle, motor cycle and Bajaj at 25m upstream distance of speed hump. But the grade of the road toward the direction flow helps to intensification speed for cycle, motor cycle and Bajaj. The adjusted R-sq=0.59 indicate medium effect /correlation of value/ for modeled variables.

D. Delay versus A. SHL, A. SHH, G, A. S @25m for P, M&T

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S @25m

Regression Equation

$$A. D = 250 - 0.031 A.SHL - 34.5 A. SHH - 7.59 G + 6.19 A. S @25m$$

The speed of the vehicles at 25m upstream distance has direct relation with delay and grade of road, speed hump length and height have indirect relationship with delay. R-sq. adjusted is 0.27 which indicates weak correlation of variables.

E. Delay versus A. SHL, A. SHH, G, A. S @25m For M.Bus&T

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S @25m

Regression Equation

$$A. D = 104.0 + 0.0497 A.SHL - 19.51 A. SHH - 1.62 G + 3.16 A. S @25m$$

The delay has direct relation with speed hump length and speed at 25m. And speed hump height and grade have indirect relationship with delay. The adjusted R-sq=0.36 indicates that the low effect size of variables.

Discussion of the Result

- ❖ The speed hump length has direct correlation with average delay at 25m for medium bus and track.
- ❖ The Speed hump height has indirect relationship with the delay of the all-vehicle groups. The effect is very high on pick up, minibus and taxi.
- ❖ The average speed has high correlation with delay for car as the developed model shows.

4.3.1.2 Regression Analysis for Vehicle Types @ 20 Meter

A. Delay versus A. SHL, A. SHH, G, A. S @20m for B, C&M

Regression Analysis: A.D versus A.SHL, A. SHH, G, A.S @20m

Regression Equation

$$A. D = 43.1 - 0.0147 A.SHL - 0.12 A. SHH + 1.114 G - 0.116 A. S @20m$$

The grade of the road has direct relation with the delay and indirect relation with speed hump height and length. But the delay has subsidiary correlation with speed hump height & Length and speed @20m of upstream distance. R-sq. adj= 0.03 indicate that a very weak relation of dependent and independent variables.

B. Delay versus A. SHL, A. SHH, G, A. S @20m for car

Regression Analysis: A.D versus A.SHL, A. SHH, G, A.S @20m

Regression Equation

$$A. D = 199 - 0.472 A.SHL - 37.4 A. SHH - 10.99 G + 29.35 A. S @20m$$

The speed hump length, height and grade of road have negative relationship with delay. And speed at 20m upstream distance has positive impact for delay. The 0.65 value of R-sq adj. indicate that the variables have medium relations.

(See appendix B).

$$A. S@20m = 17.12 + 1.06 A.SHH + 0.485 G, R-Sq.Adj=0.67$$

The R-sq.Adj=0.67 seems to be ideal which it describes good correlations.

The speed at 20m upstream distance has a positive relationship with the speed hump height and grade of the road.

A. S@20m = -15.82 + 0.045A.SHL - 0.045 G, R-Sq.Adj=0.61, the model indicates that a weak correlation of variables (dependent and independent at 20m).

The speed at 20m upstream distance has negative relation with the field grade and positive relation with speed hump length.

C. Delay versus A. SHL, A. SHH, G, A. S @20m for P, M&T

Regression Analysis: A.D versus A.SHL, A. SHH, G, A.S @20m

Regression Equation

$$A. D = 265 - 0.052 A.SHL - 33.5 A. SHH - 6.74 G + 6.67 A. S @20m$$

The speed at 20m upstream distance has positive relationship with delay and the speed hump height, length and grade of road have negative relationship.

D. Delay versus A. SHL, A. SHH, G, A. S @ 20m For TT&L.Bus

Regression Analysis: A.D versus A.SHL, A. SHH, G, A.S @20m

Regression Equation

$$A. D = 227.0 - 0.1471 A.SHL - 27.71 A. SHH - 4.09 G + 8.34 A. S @20m$$

The speed at 20m upstream distance has direct relationship with delay and speed hump length, height and grade of the road have indirect correlation with delay.

E. Delay versus A. SHL, A. SHH, G, A. S @20m For M.Bus&T

Regression Analysis: A.D versus A.SHL, A. SHH, G, A.S @20m

Regression Equation

$$A. D = 112.1 + 0.0398 A.SHL - 19.99 A. SHH - 1.52 G + 3.53 A. S @20m$$

Discussion of the Result

- ❖ The grade of the road has high influence for average delay for car group at 20m upstream distance.
- ❖ The average speed of the car has high effect on the delay compared with other vehicle groups.
- ❖ The speed hump length has negative impact on delay for truck trailer and large bus. And it has positive relation with other vehicle groups.

4.3.1.3 Regression Analysis for Vehicle Types @ 15 Meter

A. Delay versus A. SHL, A. SHH, G, A. S @15m for P, M&T

Regression Analysis: A.D versus A.SHL, A. SHH, G, A.S @15m

Regression Equation

$$A. D = 271 - 0.037 A.SHL - 35.1 A. SHH - 7.50 G + 6.63 A. S @15m$$

The delay speed at 15m upstream distance has direct relationship but the speed hump length, height and grade of the road have indirect relationship with delay. The value of R-sq. adjusted is 0.27 which indicates low correlation of independent and dependent variables.

B. Delay versus A. SHL, A. SHH, G, A. S @15m for Car

Regression Analysis: A.D versus A.SHL, A. SHH, G, A.S @15m

Regression Equation

$$A. D = 206 - 0.474 A.SHL - 37.5 A. SHH - 11.24 G + 30.68 A. S @15m$$

The speed at 15m upstream distance has positive impact on the delay and height and length of speed humps have negative impact. And grade of road has also negative relation.

$R^2=0.66$ and $R^2=0.63$ indicate that the dependent and independent variables have decent correlation at 95% confidence level which is significant.

A. S@15m= $-15.82+0.044A.SHL-0.114 G$, R-Sq.Adj=0.6 indicate medium relation of variables.

The speed hump length has a positive relationship with speed at upstream distance of 15m and the grade of the road has negative impact.

A. S@15m= $15.96+1.02 A.SHH+0.455 G$, R-Sq.Adj=0.06, the value indicate that the weak correlation of variables.

At 15m upstream distance the speed hump height has positive impact on speed and the grade has also positive impact.

C. Delay versus A. SHL, A. SHH, G, A. S @15m for B, C&M

Regression Analysis: A.D versus A.SHL, A. SHH, G, A.S @15m

Regression Equation

$$A. D = 44.9 - 0.0200 A.SHL - 0.19 A. SHH + 1.114 G + 0.007 A. S @15m$$

The recorded speed of the vehicle group at 15m upstream distance and grade of road has positive relationship with delay and height and length of speed hump have negative relationship with delay of vehicles.

D. Delay versus A. SHL, A. SHH, G, A. S @15m For M.Bus&T

Regression Analysis: A.D versus A.SHL, A. SHH, G, A.S @15m

Regression Equation

$$A. D = 116.2 + 0.0527 A.SHL - 20.87 A. SHH - 1.93 G + 3.23 A. S @15m$$

The speed hump length and speed have direct relation with delay. And speed hump height and grade have indirect relation.

E. Delay versus A. SHL, A. SHH, G, A. S @ 15m For TT &L. Bus

Regression Analysis: A.D versus A.SHL, A. SHH, G, A.S @15m

Regression Equation

$$A. D = 244.1 - 0.1389 A.SHL - 29.66 A. SHH - 3.97 G + 8.54 A. S @15m$$

The speed hump length, height and grade of the road have indirect relation with delay and speed at 15m upstream distance has direct relationship with delay.

Discussion of the Result

- ❖ The speed hump height has high negative impact on delay for car group and less impact on Bajaj, Cycle and Motor Cycle at 15m upstream distance.
- ❖ The average speed at 15m upstream distance has positive relation with average delay. The delay of car has strong relationship with speed at 15m.
- ❖ The grade of the road has less positive relation with delay for Bajaj, cycle and motor cycle and negative relationship with other vehicle groups.

4.3.1.4 Regression Analysis (Multinomial Vehicle Types @ 10 Meter

A. Delay versus A. SHL, A. SHH, G, A. S @10m For M.Bus&T

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S @10m

Regression Equation

$$A. D = 127.1 + 0.0574 A.SHL - 22.26 A. SHH - 1.97 G + 3.23 A. S @10m$$

The delay of the vehicle has a positive relationship with speed hump length and speed at 10m upstream distance. 0.33 R-sq. adjusted indicates that weak correlation of dependent and independent variables at 10m upstream distance for medium bus and track.

B. Delay versus A. SHL, A. SHH, G, A. S @10m for Car

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S @10m

Regression Equation

$$A. D = 281 - 0.473 A.SHL - 46.5 A. SHH - 12.85 G + 32.12 A. S @10m$$

The collected speed at 10m upstream distance has a positive correlation with delay and grade of road, speed hump height and length have negative relation on the delay.

R^2 adj=0.6 indicate a good correlation of dependent and independent variables.

A. S@10m= $-15.32+0.041A.SHL-0.057 G$, R-Sq.Adj=0.62this indicates that medium correlation of dependent and independent variables.

The speed at the 10m upstream distance has positive relationship with speed hump length and negative relationship with the longitudinal grade of the road.

A. S@10m= $13.19+1.28 A.SHH+0.47 G$, R-Sq.Adj=0.2 indicates that weak or low relation of dependent and independent variables.

The speed of 10m upstream distance has both positive relationship with speed hump height and grade.

C. Delay versus A. SHL, A. SHH, G, A. S @ 10m For TT&L.Bus

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S @10m

Regression Equation

$$A. D = 213.9 - 0.0905 A.SHL - 28.13 A. SHH - 4.39 G + 7.81 A. S @10m$$

The delay has indirect relationship with speed hump length, height and grade but direct relationship with speed at 10m upstream distance.

D. Delay versus A. SHL, A. SHH, G, A. S @10m for P, M&T

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S @10m

Regression Equation

$$A. D = 311 - 0.058 A.SHL - 37.5 A. SHH - 7.00 G + 7.08 A. S @10m$$

The delay has indirect relationship with speed hump length, height and grade of the road. And speed at 10m upstream distance has direct relationship with delay

E. Delay versus A. SHL, A. SHH, G, A. S @10m for B, C&M

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S @10m

Regression Equation

$$A. D = 44.5 - 0.0189 A.SHL - 0.17 A. SHH + 1.113 G - 0.017 A. S @10m$$

Discussion of the Result

- ❖ The speed hump length has less positive and negative impacts for medium bus and other vehicle groups respectively.
- ❖ The speed hump height has high negative impact on the group of cars at 10m upstream distance than other vehicles.

- ❖ The average speed of Bajaj, Cycle and motor cycle has negative impact on delay over other vehicle groups.

4.3.1.5 Regression Analysis for Vehicle Types @ 5 Meter

A. Delay versus A. SHL, A. SHH, G, A. S @ 5m For TT &L. Bus

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S@5m

Regression Equation

$$A. D = 218 - 0.0301 A.SHL - 31.58 A. SHH - 4.87 G + 6.86 A. S@5m$$

The speed at 5m upstream distance has direct relationship with delay and the speed hump length, height and grade have indirect relationship with delay. The 0.3 value of R-sq. adj indicates that the low size effect of independent variables on dependent variables at 5m upstream distance for track trailer and large bus.

B. Delay versus A. SHL, A. SHH, G, A. S @5m for Car

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S@5m

Regression Equation

$$A. D = 256 - 0.391 A.SHL - 50.1 A. SHH - 14.08 G + 33.66 A. S@5m$$

The speed hump length, height and grade of road has negative correlation on delay but the speed at 5m upstream distance has positive impact.

A. S@5m= $-13.9+0.038A.SHL-0.05 G$, R-Sq.Adj=0.59 indicates medium relation of variables.

Speed has a negative relation with grade and positive relation with length of speed hump.

A. S@5m= $11.12+1.24 A.SHH+0.445 G$, R-Sq.Adj=0.26 indicate low relation of dependent and independent variables.

Both grade of road and height has positive relationship with speed at upstream distance of 5m for car group.

C. Delay versus A. SHL, A. SHH, G, A. S @5m for B, C&M

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S@5m

Regression Equation

$$A. D = 44.1 - 0.0183 A.SHL - 0.16 A. SHH + 1.116 G - 0.030 A. S@5m$$

The average delay has a direct relationship with grade of the road and a negative correlation with speed, speed hump height and length. The speed hump height has high positive correlation with delay and length of speed hump less positive impact. The grade has high positive impact.

D. Delay versus A. SHL, A. SHH, G, A. S @5m for P, M&T

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S@5m

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Regression Equation

$$A. D = 302 - 0.030 A.SHL - 39.3 A. SHH - 11.35 G + 6.77 A. S@5m$$

The speed hump length, height and grade have in direct relationship with delay and speed at 5m of upstream distance has direct relation with delay.

E. Delay versus A. SHL, A. SHH, G, A. S @5m For M.Bus&T

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S@5m

Regression Equation

$$A. D = 127.1 + 0.0659 A.SHL - 22.30 A. SHH - 2.19 G + 3.05 A. S@5m$$

The speed hump length and speed at 5m distance of the road has direct relationship with delay and height of hump and grade has indirect relationship.

Discussion of the Result

- ❖ The grade of the road has high negative correlation with delay for car and positive relation with delay only for Bajaj, cycle and motor cycle.
- ❖ The speed at 5m upstream distance has high positive impact on delay for car and less negative impact on Bajaj, cycle and motor cycle.
- ❖ The speed hump height for car has high negative impact on delay despite of other vehicle groups.
- ❖ Generally, the R.squ.adj value for car group is greater than other vehicular groups which indicates that the model is stronger than others.

4.3.2 Vehicular Composition of Segments

As indicated in the methodology and studied in the field measurement, the roads used as a base movement for all vehicle types. The field data collection of vehicle count is conducted for seven consecutive days. The number of the cumulative vehicle groups and road segments are summarized in the table and graph.

Table 4.30 Number of cumulative vehicles with respective segments

Name of Segment	Type of Vehicle				
	Cycle, Motor Cycle& Bajaj	Light Vehicle	Mini Bus (Taxi)&Pick Up	M.Bus& Track	Large Bus &Track Trailer
02 to Hill Side	12500	11199	7162	1228	857
Minarol to kotebeKidanmihret	2145	12085	12215	1000	402
Ferensay to Kagnev RA	1030	10780	10420	1270	640
Kara to Abado	2595	23195	14830	4630	1685
AbeyemWossen	3745	23888	25256	4177	2937
SaliteMihret to Summit	11114.24	39805.76	19048.64	772.16	6815.68
Summit Medianialem to GA	18167	70277	34340	5502	4262
Goro RA to Jakros Junction	3411	92069	40955	8767	7126
Ayer tena to Wingate	8196	201418	71939	12680	19096

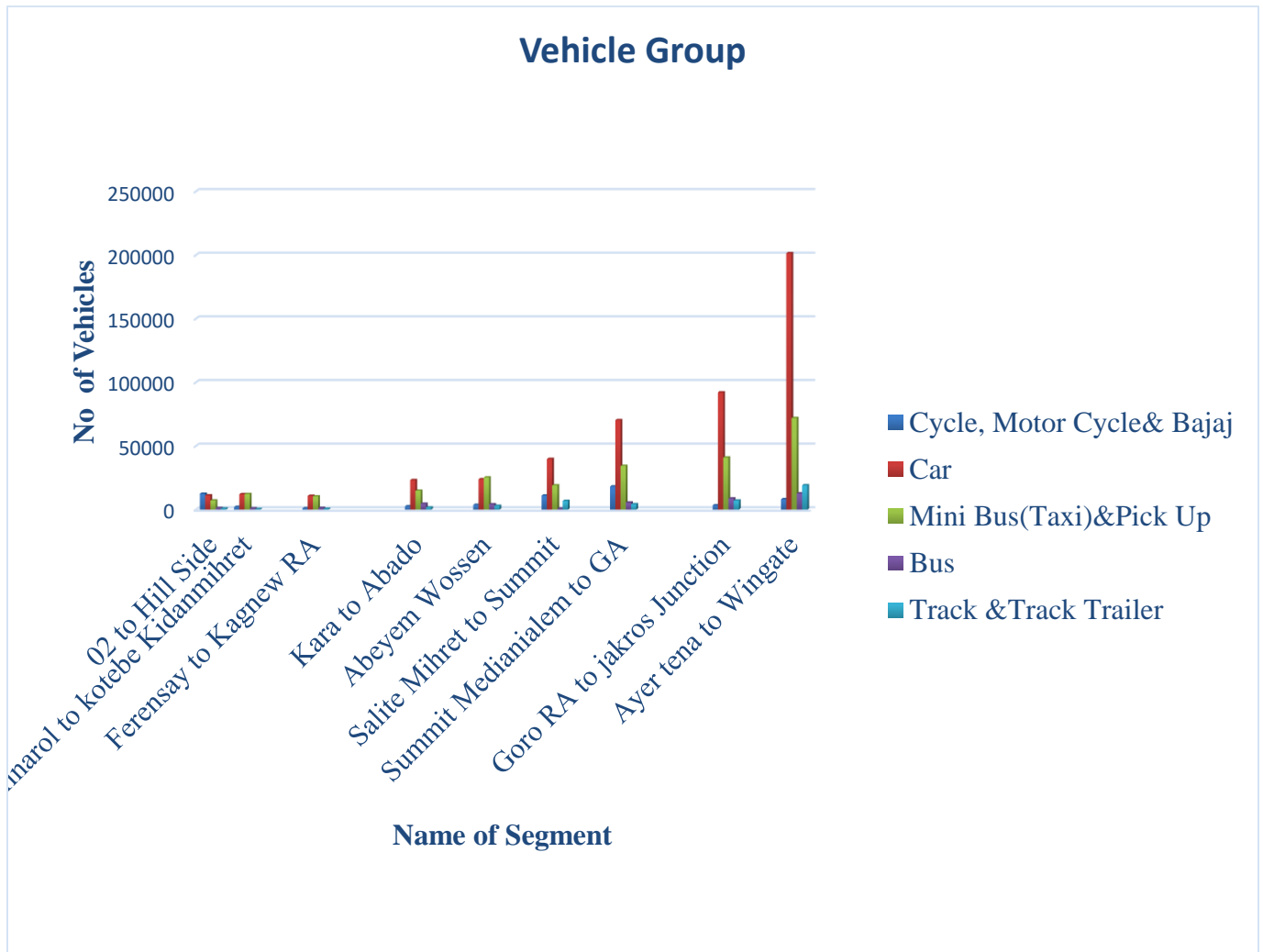


Fig.4.8 segment vs No.of Vehicle

As per the data collection, the composition of light vehicle is greater than other vehicle groups. The number of cycles, Bajaj and motor cycle seized the minimum volume in the vehicle composition. The total vehicle composition of Cycle, motorcycle & Bajaj, Light Vehicle, Minibus, Bus and Truck & Truck Trailer are 7.25, 55.87, 27.22, 4.61 & 5.05 respectively.

4.4 Summary of Regression Analysis of all Vehicle Groups

In section 4.3 Modeling and regression analysis of individual vehicle was developed at upstream side of each of existing speed hump structure. A regression relation was developed for 25m upstream distance which divided in to 5 gaps. To recognize the combined effect of variables, it is necessary to model the whole data in one single modeling. It is as such presented in the following manner.

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S @25m, A.S @20m, A.S @15m, A. S @10m, A. S@5m

Regression Equation

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$$A. = -33.7 - 0.0076 A.SHL - 10.12 A. SHH - 4.84 G + 16.73 A. S @25m + 2.07 A. S @20m \\ D - 1.25 A. S @15m - 2.35 A. S @10m - 9.48 A. S@5m$$

The equation shows that the delay of the vehicles has a direct relationship with speed at 25m, 20 and indirect relationship with speed hump height & width, grade of road, speed at 15m, 10m&5m.

The negative T-value indicates that the values are laid on the left of the mean.

$$R\text{-sq}=0.31$$

$$R\text{-sq(adj)}=0.29$$

R-square 0.31 and R-sq adj. 0.29 indicates that it is not laid in a good range which indicates the weakness of variance of the dependent variable with the independent variable collectively.

Regression Analysis: A. S @25m versus A.SHL, G

$$A. S @25m = -14.20 + 0.04557 A.SHL - 0.123 G$$

Regression Analysis: A. S @25m versus A. SHH, G

Regression Equation

$$A. S @25m = 21.86 + 0.701 A. SHH + 0.470 G$$

The speed hump and grade have positive relationship with the speed at 25m upstream distance.

Regression Analysis: A.S @20m versus A. SHH, G

Regression Equation

$$A.S @20m = 19.30 + 0.820 A. SHH + 0.422 G$$

The speed hump height and grade of the road has direct relationship with speed at 20m upstream distance.

Regression Analysis: A.S @20m versus A.SHL, G

Regression Equation

$$A.S @20m = -14.65 + 0.04427 A.SHL - 0.153 G$$

The speed hump length has positive impact on the speed at 20m upstream distance and the negative correlation.

Regression Analysis: A.S @15m versus A.SHL, G

Regression Equation

$$A.S @15m = -15.60 + 0.04394 A.SHL - 0.127 G$$

The speed hump length of has positive relationship with speed and grade of road has negative correlation with speed and speed hump length.

Regression Analysis: A.S @15m versus A. SHH, G

Regression Equation

$$A.S @15m = 17.06 + 0.944 A. SHH + 0.443 G$$

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The speed at 15m upstream distance has positive relationship with speed hump height and also with grade of the road.

Regression Analysis: A. S @10m versus A. SHH, G

Regression Equation

$$A. S @10m = 14.29 + 1.118 A. SHH + 0.444 G$$

The speed at upstream distance of 10m has apposite relationship with speed hump height and grade of road.

Regression Analysis: A. S @10m versus A.SHL, G

Regression Equation

$$A. S @10m = -15.87 + 0.04269 A.SHL - 0.109 G$$

The speed hump length has positive impact and the grade of the road has negative correlation with at 10m upstream distance.

Regression Analysis: A. S@5m versus A.SHL, G

Regression Equation

$$A. S@5m = -15.62 + 0.04075 A.SHL - 0.018 G$$

The speed hump length and grade of the road have positive and negative impact on the speed at 5m upstream distance.

Regression Analysis: A. S@5m versus A. SHH, G

Regression Equation

$$A. S@5m = 10.77 + 1.375 A. SHH + 0.508 G$$

The speed at 5m upstream distance has positive relationship with both speed hump height and grade.

4.5 Discussion on Findings

4.5.1 Speed

The average speed of the vehicle group is calculated and summarized in the following charts.

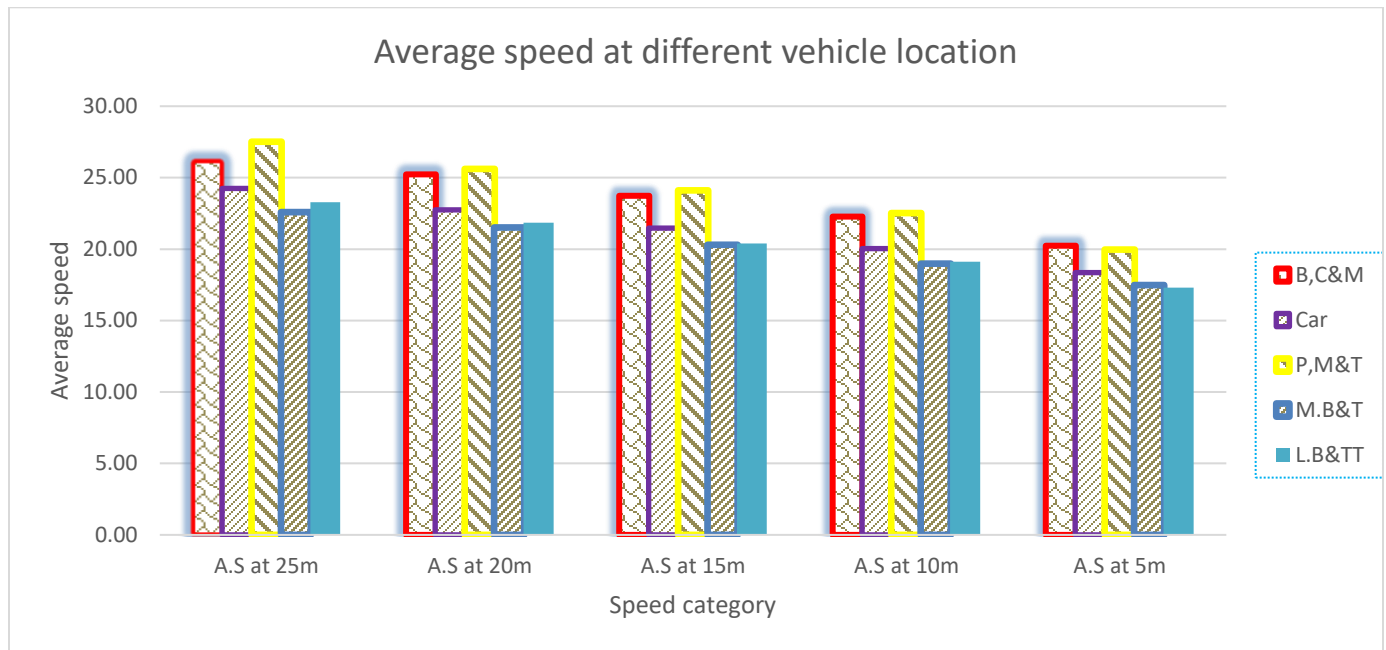


Fig. 4.9 Chart for average speed

The speed of the vehicle group is calculated at 25m ,20m,15m ,10m and 5m upstream distance of the installed speed humps. In the chart, the speed of pick up, minibus and taxi are higher than other vehicle groups. Which this indicates that the driver reacts with speed hump in driving of the car. The speed of the medium bus & track and large bus & Track Trailer is almost equal at respective locations. Thus, the impact is the same.

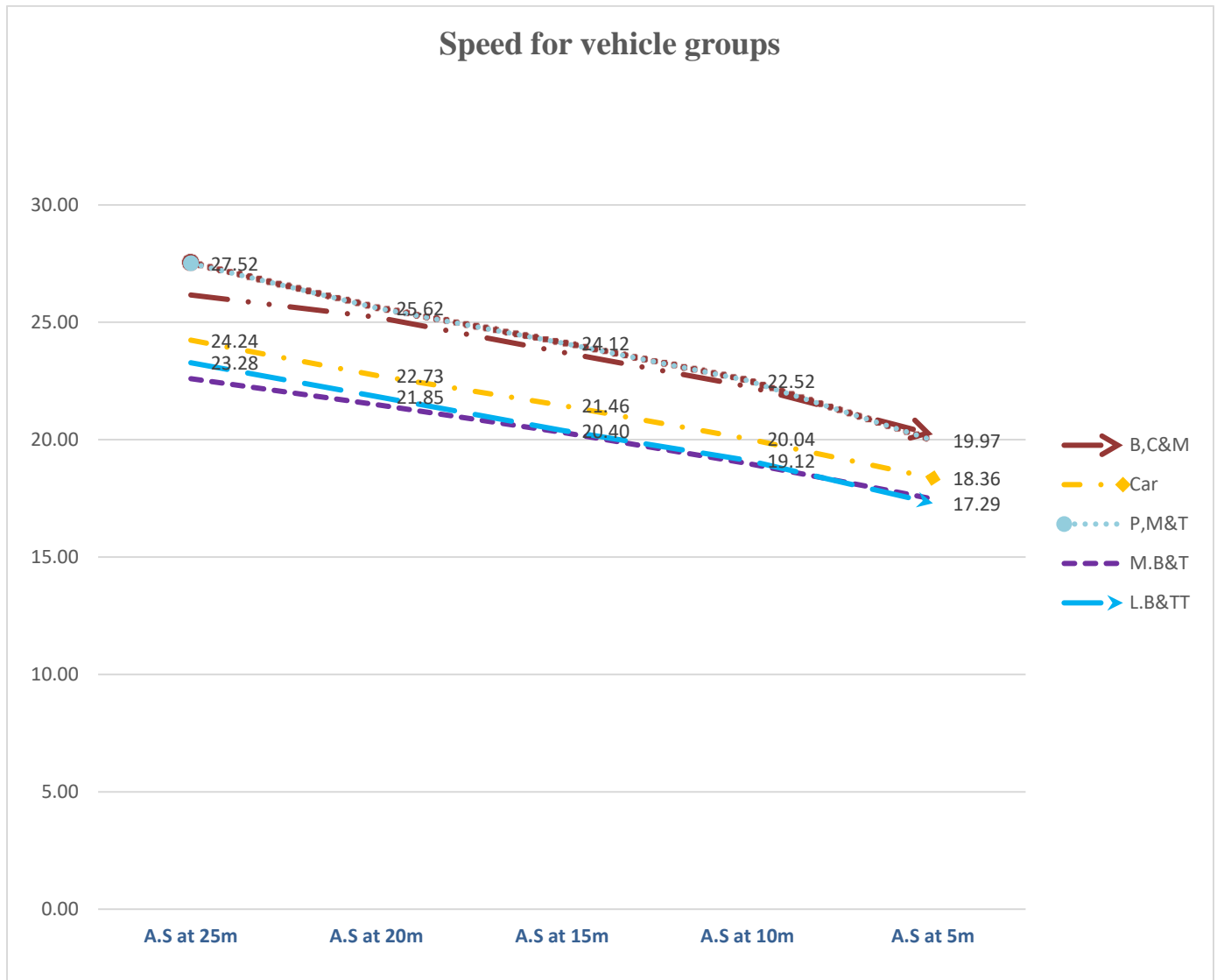


Fig 4. 10 Graph line for speed

The graph indicates that the speed of each vehicle group is gradually decline as the vehicles move from 25m to 5m. The speed of Bajaj, cycle and motor cycle is reduced by 29.7% from 25m to 5m. The rapid speed reduction is experienced on pick up, minibus and taxi which is 37.77%. The change of average speed for medium bus and track is less than other vehicle groups that is 28.2%. The indicated values on the graph are average values of each vehicle group. In the study, the researcher found below 5km/hr. speed values.

4.5.2 Delay

The delay of each vehicle group is summarized in the below chart.

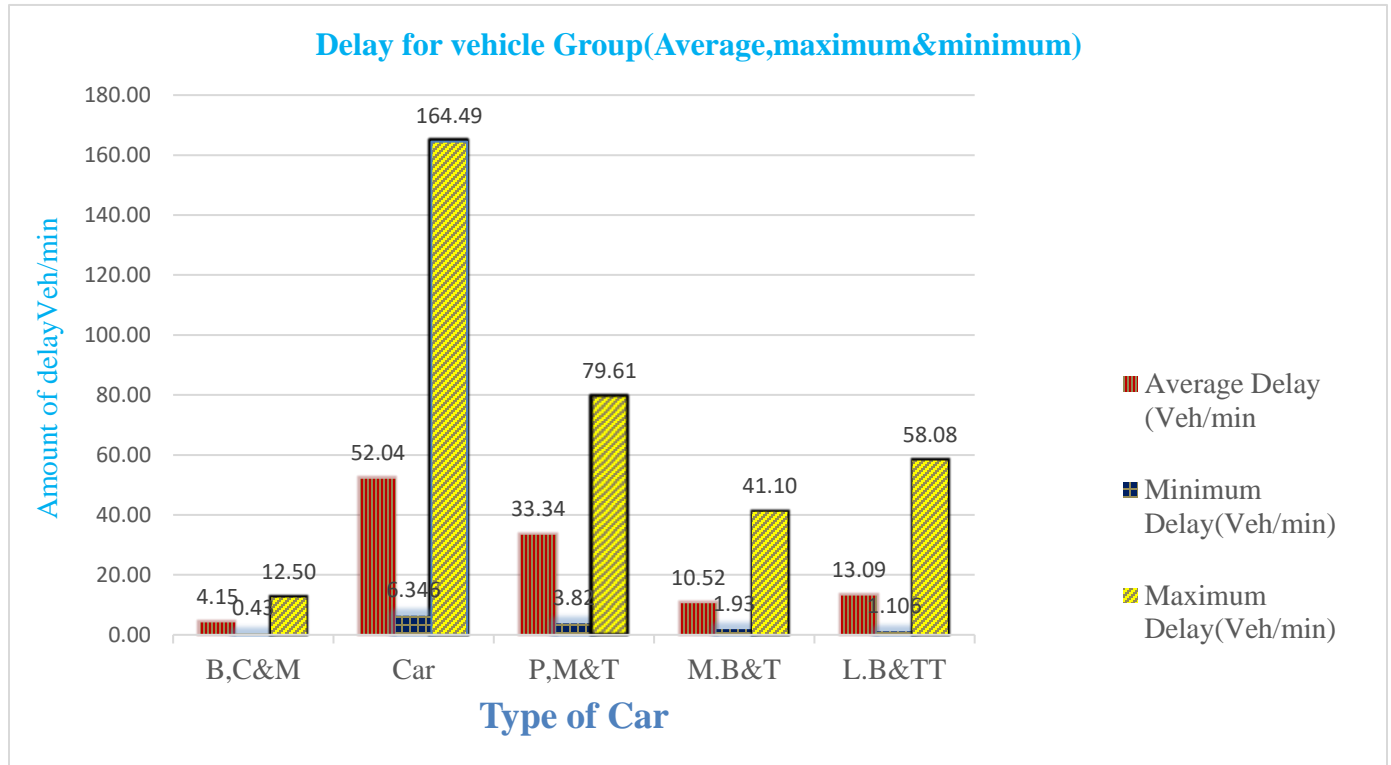


Fig.4.11 delay chart

In the graph, the average delay of car group is larger than other vehicle groups since the frequency and quantity of passing vehicles increased on the selected segments. The average delay value of Bajaj, cycle and motor cycle is less than other vehicle groups. As indicated in the chart, the maximum and minimum delay value are recorded for car and Bajaj, cycle and motor cycle respectively.

Chapter 5: Conclusions and Recommendations

5.1 Conclusions

The following conclusions are drawn from the research work.

- As a general objective, speed humps have merit on speed reduction but this research shows that how much the provision of speed humps significantly reduce the speed of each categorized vehicle groups as shown in the study result.
- The speed hump length, height and grade of the road in the direction of flow have direct proportional with delay at upstream distance of 5,10,15,20 &25m respectively for Car, (Bajaj, cycle, motor cycle), (pick up, taxi & Mini bus) and (large bus & truck trailer).
- From the qualitative approach (respondents' perception), the installation of speed humps has high dynamic effect on the car and road users when crossing over them. Those effects are shivering, vertical and horizontal deflections.
- The analysis result indicates that 32.61% average speed reduction of all vehicle groups from 25m to 5m.
- From the qualitative approach of study, the speed humps have uncomfortable status on road users while the vehicle crossing over the speed humps.
- In the speed, speed hump height and grade relation, the speed has direct relationship with the speed hump height and grade of the road at 25,20,15,10&5m respectively. On the other hand, the speed has direct relationship with speed hump length and indirect correlation with grade of the road at 25,20,15,10&5m upstream distance away from the speed hump's location in speed, speed hump length and grade relation.

5.2 Recommendations

- ❖ The researcher recommends that the effect of concrete speed humps for nearby dwellers shall be further studied while the vehicles passing over the speed humps have high vibration and noisy voices. This research will provoke further study on their social impact.
- ❖ Third world countries like Ethiopia do not have clear guide lines for the construction and installation of speed humps. They simply constructed without calibration with our land use, culture, driver behavior and topography. Most of the studied roads hierarchy laid on arterial roads which accommodate large volume of traffic and those speed humps are constructed ignoring of their effect on traffic delay.
- ❖ Instead of constructing rigid concrete speed humps, the researcher recommends to adopt rubber type speed humps. Since it has flexible nature, cheap and ease of installation.
- ❖ Most speed humps are constructed on existing roads which in turn bring lack of combination with the native asphalt, create distress at the joint, traffic congestion during construction and installed by poor work man ship. It is better to design and construct the speed hump together with the road section at the beginning to enhance its homogeneity with the asphalt material.
- ❖ Speed humps are not the only option to reduce speed. The Addis Ababa Traffic Management Agency shall use Provision of Radar, Proper use of traffic sign. Speed limiter device, legal restriction, GPS, awareness, and campaign.
- ❖ A guide line of speed restriction shall be developed which will cognate with our topography, land use, behavior etc. And also, audit is mandatory. And AACRTMA adopts WRI speed hump characteristics; however, it is very difficult to construct the shape of hump by asphalt concrete. Most of the speed humps constructed in Addis Ababa force vehicle to decelerate up to zero speed than decrease the speed when the vehicle passes speed limit.
- ❖ To enhance the comfort of passengers especially for disables, pregnancies and emergency vehicles like ambulance, it is better use flexible material like rubber instead of asphalt concrete speed calming. Or if there anything which makes more flexible pavement.
- ❖ Further study of deflections, distresses, effect on vehicle body shall be conducted.

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Appendix A
Traffic Count

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

02 to Hill Side School (Right Hand Side)						Posted Speed Limit=30km/hr(Invisible to Drivers)						
Date 11/12/12(Monday)						Date 12/12/12(Tuesday)						
Time 15m interval	Vehicle Classification					Time 15m interval	Vehicle Classification					
	Cycle, Motor Cycle & Bajaj	Light Vehicle	Mini Bus(Taxi) & Pick Up	M. Bus & T	L. Bus & Track Trailer		Cycle, Motor Cycle & Bajaj	Light Vehicle	Mini Bus(Taxi) & Pick Up	M. Bus & T	L. Bus & Track Trailer	
7:00Am-7:15	84	62	57	12	13	7:00Am	86	63	58	12	13	
7:15Am-7:30	82	59	62	15	9	7:15Am	84	61	63	15	9	
7:30Am-7:45	89	65	60	8	8	7:30Am	90	66	62	8	8	
7:45Am-8:00	77	66	64	14	10	7:45Am	78	67	65	14	10	
8:00Am-8:15	84	68	70	12	11	8:00Am	86	69	72	12	11	
8:15Am-8:30	90	82	67	13	12	8:15Am	91	84	68	13	12	
8:30Am-8:45	79	75	55	12	9	8:30Am	80	76	56	12	9	
8:45Am-9:00	64	69	49	8	5	8:45Am	65	70	50	8	6	
9:00Am-9:15	67	63	42	10	8	9:00Am	68	64	43	10	8	
9:15Am-9:30	65	64	33	8	2	9:15Am	66	65	34	8	2	
9:30Am-9:45	67	59	29	6	5	9:30Am	68	61	30	7	6	
9:45Am-10:00	65	56	24	4	5	9:45Am	66	57	24	4	6	
10:00Am-10:15	57	45	26	3	8	10:00Ar	58	46	26	3	8	
10:15Am-10:30	54	38	16	5	11	10:15Ar	55	39	17	6	11	
10:30Am-10:45	45	29	13	6	3	10:30Ar	46	30	13	7	3	
10:45Am-11:00	40	30	14	4	2	10:45Ar	41	31	14	4	2	
11:00Am-11:15	30	30	13	3	3	11:00Ar	31	31	13	3	3	
11:15Am-11:30	32	29	12	2	2	11:15Ar	33	30	12	2	2	
11:30Am-11:45	30	29	8	1	3	11:30Ar	31	30	8	1	3	
11:45Am-12:00	25	35	9	3	4	11:45Ar	25	35	9	3	4	
12:00Am-12:15	29	45	6	2	3	12:00Ar	30	46	7	2	3	
12:15Am-12:30	26	39	5	2	0	12:15Ar	26	40	6	2	0	
12:30Am-12:45	24	35	19	1	0	12:30Ar	24	35	20	1	0	
12:45Am-1:00	25	26	17	0	0	12:45Ar	25	26	18	0	0	
1:00Pm-1:15	16	27	14	2	1	1:00Pm	17	28	14	2	1	
1:15Pm-1:30	21	30	8	1	0	1:15Pm	21	31	8	1	0	
1:30Pm-1:45	18	22	9	0	0	1:30Pm	19	22	9	0	0	
1:45Pm-2:00	18	24	5	2	1	1:45Pm	19	24	6	2	1	
2:00Pm-2:15	24	14	8	1	1	2:00Pm	24	14	8	1	1	
2:15Pm-2:30	27	19	6	2	0	2:15Pm	28	20	7	2	0	
2:30Pm-2:45	29	31	8	1	0	2:30Pm	30	32	8	1	0	
2:45Pm-3:00	24	21	6	0	0	2:45Pm	24	21	7	0	0	
3:00Pm-3:15	27	18	10	1	0	3:00Pm	28	19	10	1	0	
3:15Pm-3:30	29	21	8	2	3	3:15Pm	30	21	8	2	3	
3:30Pm-3:45	33	19	6	1	1	3:30Pm	34	20	7	1	1	
3:45Pm-4:00	27	25	12	3	0	3:45Pm	28	25	12	3	0	
4:00Pm-4:15	29	29	17	1	2	4:00Pm	30	30	18	1	2	
4:15Pm-4:30	36	24	18	2	0	4:15Pm	36	24	19	2	0	
4:30Pm-4:45	39	31	16	1	0	4:30Pm	40	32	17	1	0	
4:45Pm-5:00	43	35	29	3	1	4:45Pm	44	35	30	3	1	
5:00Pm-5:15	48	40	26	2	1	5:00Pm	48	41	26	2	1	
5:15Pm-5:30	42	49	25	1	0	5:15Pm	43	50	25	1	0	
5:30Pm-5:45	51	54	29	2	1	5:30Pm	52	55	30	2	1	
5:45Pm-6:00	56	49	38	2	1	5:45Pm	57	50	39	2	1	
6:00Pm-6:15	62	50	44	8	1	6:00Pm	63	51	45	8	1	
6:15Pm-6:30	66	55	51	10	0	6:15Pm	67	56	52	10	0	
6:30Pm-6:45	70	60	57	8	1	6:30Pm	72	62	58	8	1	
6:45Pm-7:00	56	45	51	5	0	6:45Pm	57	46	52	6	0	
	2220	1989	1272	218	152		2262	2026	1296	222	155	5961

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Traffic Count @ Each Segment with Speed Hump												
Min Park To Kotebe Kidanmihret (Right Hand)						Posted Speed Limit=30km/hr						
Date 11/12/12(Monday)						Date 12/12/12(Tuesday)						
Time 15m interval	Vehicle Classification					Time 15m interval	Vehicle Classification					
	Cycle, Motor Cycle & Bajaj	Light Vehicle	Mini Bus (Taxi) & Pick Up	M. Bus & Bajaj	L. Bus & Track Trailer		Cycle, Motor Cycle & Bajaj	Light Vehicle	Mini Bus (Taxi) & Pick Up	M. Bus & T	L. Bus & Track Trailer	
7:00Am-7:15 Am	5	21	25	2	1	7:00Am-7:15 Am	6	21	25	2	1	
7:15Am-7:30 Am	2	26	35	4	0	7:15Am-7:30 Am	2	26	35	4	0	
7:30Am-7:45Am	6	31	40	5	2	7:30Am-7:45Am	7	32	41	6	2	
7:45Am-8:00Am	8	28	33	3	1	7:45Am-8:00Am	8	29	34	3	1	
8:00Am-8:15Am	9	30	36	3	0	8:00Am-8:15Am	9	31	36	3	0	
8:15Am-8:30Am	5	26	32	3	1	8:15Am-8:30Am	6	26	33	3	1	
8:30Am-8:45Am	6	35	29	0	0	8:30Am-8:45Am	7	35	30	0	0	
8:45Am-9:00Am	4	23	41	0	1	8:45Am-9:00Am	4	23	42	0	1	
9:00Am-9:15Am	3	21	24	1	0	9:00Am-9:15Am	3	21	24	1	0	
9:15Am-9:30Am	5	24	21	2	1	9:15Am-9:30Am	6	24	21	2	1	
9:30Am-9:45Am	6	16	27	0	1	9:30Am-9:45Am	7	17	28	0	1	
9:45Am-10:00Am	10	30	31	0	0	9:45Am-10:00Am	10	31	32	0	0	
10:00Am-10:15Am	9	35	38	0	1	10:00Am-10:15Ar	9	35	39	0	1	
10:15Am-10:30Am	8	42	36	2	0	10:15Am-10:30Ar	8	43	36	2	0	
10:30Am-10:45Am	6	40	37	1	1	10:30Am-10:45Ar	7	41	37	1	1	
10:45Am-11:00Am	8	42	42	1	0	10:45Am-11:00Ar	8	43	43	1	0	
11:00Am-11:15Am	3	43	37	1	1	11:00Am-11:15Ar	3	44	37	1	1	
11:15Am-11:30Am	11	49	38	11	5	11:15Am-11:30Ar	11	50	39	11	6	
11:30Am-11:45Am	9	40	31	10	0	11:30Am-11:45Ar	9	41	32	10	0	
11:45Am-12:00Am	10	41	24	5	1	11:45Am-12:00Ar	10	42	24	6	1	
12:00Am-12:15Am	13	45	29	6	0	12:00Am-12:15Ar	13	46	30	7	0	
12:15Am-12:30Am	8	43	28	9	1	12:15Am-12:30Ar	8	44	29	9	1	
12:30Am-12:45Am	4	53	36	6	2	12:30Am-12:45Ar	4	54	36	7	2	
12:45Am-1:00Pm	9	46	37	5	0	12:45Am-1:00Pm	9	47	37	6	0	
1:00Pm-1:15Pm	8	35	29	3	1	1:00Pm-1:15Pm	8	35	30	3	1	
1:15Pm-1:30Pm	3	41	25	2	0	1:15Pm-1:30Pm	3	42	25	2	0	
1:30Pm-1:45Pm	5	29	31	1	0	1:30Pm-1:45Pm	6	30	32	1	0	
1:45Pm-2:00Pm	6	38	37	2	2	1:45Pm-2:00Pm	7	39	37	2	2	
2:00Pm-2:15Pm	9	39	43	3	0	2:00Pm-2:15Pm	9	40	44	3	0	
2:15Pm-2:30Pm	8	41	43	2	1	2:15Pm-2:30Pm	8	42	44	2	1	
2:30Pm-2:45Pm	4	30	35	1	0	2:30Pm-2:45Pm	4	31	35	1	0	
2:45Pm-3:00Pm	5	37	31	0	0	2:45Pm-3:00Pm	6	37	32	0	0	
3:00Pm-3:15Pm	10	48	35	0	1	3:00Pm-3:15Pm	10	48	35	0	1	
3:15Pm-3:30Pm	6	38	39	0	0	3:15Pm-3:30Pm	7	39	40	0	0	
3:30Pm-3:45Pm	2	44	29	2	0	3:30Pm-3:45Pm	2	45	30	2	0	
3:45Pm-4:00Pm	3	35	38	1	1	3:45Pm-4:00Pm	3	35	39	1	1	
4:00Pm-4:15Pm	2	49	37	2	1	4:00Pm-4:15Pm	2	50	37	2	1	
4:15Pm-4:30Pm	12	50	42	3	1	4:15Pm-4:30Pm	12	51	43	3	1	
4:30Pm-4:45Pm	15	51	48	4	2	4:30Pm-4:45Pm	15	52	48	4	2	
4:45Pm-5:00Pm	15	50	44	3	3	4:45Pm-5:00Pm	15	51	45	3	3	
5:00Pm-5:15Pm	13	48	46	5	2	5:00Pm-5:15Pm	13	48	47	6	2	
5:15Pm-5:30Pm	11	43	53	1	2	5:15Pm-5:30Pm	11	44	54	1	2	
5:30Pm-5:45Pm	10	53	55	3	1	5:30Pm-5:45Pm	10	54	56	3	1	
5:45Pm-6:00Pm	15	51	50	4	1	5:45Pm-6:00Pm	15	52	51	4	1	
6:00Pm-6:15Pm	8	62	51	3	2	6:00Pm-6:15Pm	8	63	52	3	2	
6:15Pm-6:30Pm	9	67	50	1	1	6:15Pm-6:30Pm	9	68	51	1	1	
6:30Pm-6:45Pm	12	75	56	6	2	6:30Pm-6:45Pm	12	76	57	7	2	
6:45Pm-7:00Am	11	85	51	3	0	6:45Pm-7:00Am	11	87	52	3	0	
	369	1965	1782	143	48		376	2001	1815	145	48	

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Traffic Count @ Each Segment with Speed Hump											
Ferensay to Kagnew RA(Right Hand Side)						Posted Speed Limit=30km/hr					
Date 13/12/12(Wednesday)						Date 14/12/12(Thursday)					
Time 15m interval	Vehicle Classification					Time 15m interval	Vehicle Classification				
	Cycle, Motor Cycle & Bajaj	Light Vehicle	Mini Bus(Taxi) & Pick Up	M.Bus&T	L.Bus & Track Trailer		Cycle, Motor Cycle & Bajaj	Light Vehicle	Mini Bus(Taxi) & Pick Up	M.Bus&T	L.Bus & Track Trailer
7:00Am-7:15 Am	5	48	69	15	5	7:00Am-7:15 Am	5	46	66	14	5
7:15Am-7:30 Am	7	55	67	17	4	7:15Am-7:30 Am	7	52	64	16	4
7:30Am-7:45Am	6	81	74	15	3	7:30Am-7:45Am	6	77	70	14	3
7:45Am-8:00Am	8	82	76	13	4	7:45Am-8:00Am	8	78	72	12	4
8:00Am-8:15Am	4	69	59	12	3	8:00Am-8:15Am	4	66	56	11	3
8:15Am-8:30Am	5	70	55	6	1	8:15Am-8:30Am	5	67	52	6	1
8:30Am-8:45Am	4	62	48	5	0	8:30Am-8:45Am	4	59	46	5	0
8:45Am-9:00Am	4	55	51	4	1	8:45Am-9:00Am	4	52	49	4	1
9:00Am-9:15Am	3	53	48	0	2	9:00Am-9:15Am	3	50	46	0	2
9:15Am-9:30Am	3	47	50	4	1	9:15Am-9:30Am	3	45	48	4	1
9:30Am-9:45Am	2	44	51	3	3	9:30Am-9:45Am	2	42	49	3	3
9:45Am-10:00Am	3	46	56	5	2	9:45Am-10:00Am	3	44	53	5	2
10:00Am-10:15Am	5	42	62	6	0	10:00Am-10:15Am	5	40	59	6	0
10:15Am-10:30Am	5	45	65	11	4	10:15Am-10:30Am	5	43	62	10	4
10:30Am-10:45Am	4	47	74	14	5	10:30Am-10:45Am	4	45	70	13	5
10:45Am-11:00Am	3	43	70	13	3	10:45Am-11:00Am	3	41	67	12	3
11:00Am-11:15Am	2	42	65	3	4	11:00Am-11:15Am	2	40	62	3	4
11:15Am-11:30Am	5	41	59	2	3	11:15Am-11:30Am	5	39	56	2	3
11:30Am-11:45Am	2	45	47	0	3	11:30Am-11:45Am	2	43	45	0	3
11:45Am-12:00Am	1	47	39	1	2	11:45Am-12:00Am	1	45	37	1	2
12:00Am-12:15Am	2	49	35	5	4	12:00Am-12:15Am	2	47	33	5	4
12:15Am-12:30Am	6	44	30	2	6	12:15Am-12:30Am	6	42	29	2	6
12:30Am-12:45Am	4	37	49	11	5	12:30Am-12:45Am	4	35	47	10	5
12:45Am-1:00Pm	6	38	44	8	3	12:45Am-1:00Pm	6	36	42	8	3
1:00Pm-1:15Pm	4	41	42	3	0	1:00Pm-1:15Pm	4	39	40	3	0
1:15Pm-1:30Pm	6	45	43	5	2	1:15Pm-1:30Pm	6	43	41	5	2
1:30Pm-1:45Pm	4	46	37	5	5	1:30Pm-1:45Pm	4	44	35	5	5
1:45Pm-2:00Pm	5	48	33	4	5	1:45Pm-2:00Pm	5	46	31	4	5
2:00Pm-2:15Pm	3	49	41	3	2	2:00Pm-2:15Pm	3	47	39	3	2
2:15Pm-2:30Pm	0	43	42	4	3	2:15Pm-2:30Pm	0	41	40	4	3
2:30Pm-2:45Pm	5	45	34	7	5	2:30Pm-2:45Pm	5	43	32	7	5
2:45Pm-3:00Pm	7	46	30	6	1	2:45Pm-3:00Pm	7	44	29	6	1
3:00Pm-3:15Pm	4	38	28	6	1	3:00Pm-3:15Pm	4	36	27	6	1
3:15Pm-3:30Pm	3	37	33	6	0	3:15Pm-3:30Pm	3	35	31	6	0
3:30Pm-3:45Pm	4	39	35	1	2	3:30Pm-3:45Pm	4	37	33	1	2
3:45Pm-4:00Pm	7	47	28	0	2	3:45Pm-4:00Pm	7	45	27	0	2
4:00Pm-4:15Pm	5	42	30	2	2	4:00Pm-4:15Pm	5	40	29	2	2
4:15Pm-4:30Pm	4	46	35	2	0	4:15Pm-4:30Pm	4	44	33	2	0
4:30Pm-4:45Pm	3	49	21	1	3	4:30Pm-4:45Pm	3	47	20	1	3
4:45Pm-5:00Pm	6	37	18	2	0	4:45Pm-5:00Pm	6	35	17	2	0
5:00Pm-5:15Pm	4	38	29	3	2	5:00Pm-5:15Pm	4	36	28	3	2
5:15Pm-5:30Pm	5	47	28	2	2	5:15Pm-5:30Pm	5	45	27	2	2
5:30Pm-5:45Pm	4	37	37	0	1	5:30Pm-5:45Pm	4	35	35	0	1
5:45Pm-6:00Pm	3	39	43	5	2	5:45Pm-6:00Pm	3	37	41	5	2
6:00Pm-6:15Pm	5	42	41	6	3	6:00Pm-6:15Pm	5	40	39	6	3
6:15Pm-6:30Pm	5	45	47	6	5	6:15Pm-6:30Pm	5	43	45	6	5
6:30Pm-6:45Pm	7	41	44	5	6	6:30Pm-6:45Pm	7	39	42	5	6
6:45Pm-7:00Am	4	43	45	4	3	6:45Pm-7:00Am	4	41	43	4	3
	<u>216</u>	<u>2264</u>	<u>2188</u>	<u>267</u>	<u>134</u>		<u>206</u>	<u>2156</u>	<u>2084</u>	<u>254</u>	<u>128</u>

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Traffic Count @ Each Segment with Speed Hump											
Kra To Gedera(Right Hand Side)						Posted Speed Limit=30km/hr					
Date 14/12/12(Thursday)						Date 15/12/12(Friday)					
Time 15m interval	Vehicle Classification					Time 15m interval	Vehicle Classification				
	Cycle, Motor Cycle & Bajaj	Light Vehicle	Mini Bus(Taxi) & Pick Up	M.Bus	L.Bus & Track Trailer		Cycle, Motor Cycle & Bajaj	Light Vehicle	Mini Bus(Taxi) & Pick Up	M.Bus	L.Bus & Track Trailer
7:00Am-7:15 Am	13	126	36	32	25	7:00Am-7:15 Am	11	107	31	27	21
7:15Am-7:30 Am	9	101	45	29	18	7:15Am-7:30 Am	8	86	38	25	15
7:30Am-7:45Am	12	92	39	26	17	7:30Am-7:45Am	10	78	33	22	14
7:45Am-8:00Am	7	86	44	23	14	7:45Am-8:00Am	6	73	37	20	12
8:00Am-8:15Am	8	79	50	19	11	8:00Am-8:15Am	7	67	43	16	9
8:15Am-8:30Am	9	82	53	17	4	8:15Am-8:30Am	8	70	45	14	3
8:30Am-8:45Am	8	77	47	14	8	8:30Am-8:45Am	7	65	40	12	7
8:45Am-9:00Am	9	87	42	16	6	8:45Am-9:00Am	8	74	36	14	5
9:00Am-9:15Am	7	92	41	15	9	9:00Am-9:15Am	6	78	35	13	8
9:15Am-9:30Am	10	97	37	16	3	9:15Am-9:30Am	9	82	31	14	3
9:30Am-9:45Am	10	120	30	18	15	9:30Am-9:45Am	9	102	26	15	13
9:45Am-10:00Am	9	112	32	17	9	9:45Am-10:00Am	8	95	27	14	8
10:00Am-10:15Am	6	102	37	18	12	10:00Am-10:15Am	5	87	31	15	10
10:15Am-10:30Am	7	93	35	17	10	10:15Am-10:30Am	6	79	30	14	9
10:30Am-10:45Am	8	99	36	15	11	10:30Am-10:45Am	7	84	31	13	9
10:45Am-11:00Am	10	105	33	16	10	10:45Am-11:00Am	9	89	28	14	9
11:00Am-11:15Am	6	98	29	17	8	11:00Am-11:15Am	5	83	25	14	7
11:15Am-11:30Am	7	88	24	16	0	11:15Am-11:30Am	6	75	20	14	0
11:30Am-11:45Am	6	85	35	13	5	11:30Am-11:45Am	5	72	30	11	4
11:45Am-12:00Am	9	95	36	11	4	11:45Am-12:00Am	8	81	31	9	3
12:00Am-12:15Am	4	83	42	16	5	12:00Am-12:15Am	3	71	36	14	4
12:15Am-12:30Am	3	67	45	17	4	12:15Am-12:30Am	3	57	38	14	3
12:30Am-12:45Am	3	77	39	16	3	12:30Am-12:45Am	3	65	33	14	3
12:45Am-1:00Pm	6	81	45	23	4	12:45Am-1:00Pm	5	69	38	20	3
1:00Pm-1:15Pm	5	72	37	30	5	1:00Pm-1:15Pm	4	61	31	26	4
1:15Pm-1:30Pm	7	79	36	22	1	1:15Pm-1:30Pm	6	67	31	19	1
1:30Pm-1:45Pm	8	88	45	16	3	1:30Pm-1:45Pm	7	75	38	14	3
1:45Pm-2:00Pm	9	67	56	13	2	1:45Pm-2:00Pm	8	57	48	11	2
2:00Pm-2:15Pm	8	75	47	10	3	2:00Pm-2:15Pm	7	64	40	9	3
2:15Pm-2:30Pm	7	76	47	9	2	2:15Pm-2:30Pm	6	65	40	8	2
2:30Pm-2:45Pm	5	79	57	5	1	2:30Pm-2:45Pm	4	67	48	4	1
2:45Pm-3:00Pm	10	89	56	7	1	2:45Pm-3:00Pm	9	76	48	6	1
3:00Pm-3:15Pm	11	69	61	8	2	3:00Pm-3:15Pm	9	59	52	7	2
3:15Pm-3:30Pm	12	72	65	6	2	3:15Pm-3:30Pm	10	61	55	5	2
3:30Pm-3:45Pm	13	79	56	9	3	3:30Pm-3:45Pm	11	67	48	8	3
3:45Pm-4:00Pm	15	89	60	10	6	3:45Pm-4:00Pm	13	76	51	9	5
4:00Pm-4:15Pm	17	95	69	15	7	4:00Pm-4:15Pm	14	81	59	13	6
4:15Pm-4:30Pm	18	109	87	12	9	4:15Pm-4:30Pm	15	93	74	10	8
4:30Pm-4:45Pm	19	112	95	17	8	4:30Pm-4:45Pm	16	95	81	14	7
4:45Pm-5:00Pm	23	117	99	18	7	4:45Pm-5:00Pm	20	99	84	15	6
5:00Pm-5:15Pm	25	121	102	19	9	5:00Pm-5:15Pm	21	103	87	16	8
5:15Pm-5:30Pm	22	115	112	20	7	5:15Pm-5:30Pm	19	98	95	17	6
5:30Pm-5:45Pm	15	119	117	26	8	5:30Pm-5:45Pm	13	101	99	22	7
5:45Pm-6:00Pm	17	127	132	34	6	5:45Pm-6:00Pm	14	108	112	29	5
6:00Pm-6:15Pm	16	135	137	40	9	6:00Pm-6:15Pm	14	115	116	34	8
6:15Pm-6:30Pm	19	138	146	45	6	6:15Pm-6:30Pm	16	117	124	38	5
6:30Pm-6:45Pm	17	144	156	47	8	6:30Pm-6:45Pm	14	122	133	40	7
6:45Pm-7:00Am	15	149	159	51	7	6:45Pm-7:00Am	13	127	135	43	6
	<u>519</u>	<u>4639</u>	<u>2966</u>	<u>926</u>	<u>337</u>		<u>441</u>	<u>3943</u>	<u>2521</u>	<u>787</u>	<u>286</u>

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Traffic Count @ Each Segment with Speed Hump											
Yeabium Hotel to Wosen Grocery(Right Hand Side)						Posted Speed Limit=30km/hr					
Date 16/12/12(Saturday)						Date 17/12/12(Sunday)					
Time 15m interval	Vehicle Classification					Time 15m interval	Vehicle Classification				
	Cycle, Motor Cycle & Bajaj	Light Vehicle	Mini Bus(Taxi) & Pick Up	M.Bus&T	L.Bus & Track Trailer		Cycle, Motor Cycle & Bajaj	Light Vehicle	Mini Bus(Taxi) & Pick Up	M.Bu	L.Bus & Track Trailer
7:00Am-7:15 Am	8	60	63	9	14	7:00Am-7:15 Am	6	40	42	6	9
7:15Am-7:30 Am	11	74	70	11	11	7:15Am-7:30 Am	7	50	47	8	8
7:30Am-7:45Am	7	79	67	17	10	7:30Am-7:45Am	5	52	44	12	6
7:45Am-8:00Am	10	83	76	13	8	7:45Am-8:00Am	6	56	51	9	5
8:00Am-8:15Am	7	76	73	10	7	8:00Am-8:15Am	5	50	48	7	5
8:15Am-8:30Am	8	67	74	9	2	8:15Am-8:30Am	6	44	49	6	2
8:30Am-8:45Am	9	62	76	10	4	8:30Am-8:45Am	6	41	50	7	2
8:45Am-9:00Am	3	53	74	8	4	8:45Am-9:00Am	2	35	49	5	2
9:00Am-9:15Am	7	59	69	10	4	9:00Am-9:15Am	5	40	46	7	3
9:15Am-9:30Am	2	50	67	11	3	9:15Am-9:30Am	2	33	45	8	2
9:30Am-9:45Am	5	47	70	10	4	9:30Am-9:45Am	4	32	47	7	2
9:45Am-10:00Am	6	52	68	9	3	9:45Am-10:00Am	4	35	45	6	2
10:00Am-10:15Am	8	56	73	11	8	10:00Am-10:15Am	5	37	48	8	5
10:15Am-10:30Am	7	58	68	10	10	10:15Am-10:30Am	5	39	45	7	7
10:30Am-10:45Am	8	60	63	9	14	10:30Am-10:45Am	6	40	42	6	9
10:45Am-11:00Am	9	61	59	8	13	10:45Am-11:00Am	6	41	40	5	9
11:00Am-11:15Am	8	47	55	7	14	11:00Am-11:15Am	5	31	36	4	9
11:15Am-11:30Am	14	46	52	7	7	11:15Am-11:30Am	10	31	35	5	5
11:30Am-11:45Am	16	51	47	9	10	11:30Am-11:45Am	11	34	32	6	6
11:45Am-12:00Am	14	55	50	8	8	11:45Am-12:00Am	9	36	33	5	5
12:00Am-12:15Am	14	53	51	8	10	12:00Am-12:15Am	10	36	34	6	6
12:15Am-12:30Am	15	59	47	8	8	12:15Am-12:30Am	10	39	31	5	5
12:30Am-12:45Am	14	52	43	8	7	12:30Am-12:45Am	10	35	29	6	5
12:45Am-1:00Pm	10	42	48	7	7	12:45Am-1:00Pm	7	28	32	5	4
1:00Pm-1:15Pm	8	40	46	10	9	1:00Pm-1:15Pm	5	27	30	7	6
1:15Pm-1:30Pm	7	34	35	9	7	1:15Pm-1:30Pm	5	22	23	6	4
1:30Pm-1:45Pm	5	31	37	8	8	1:30Pm-1:45Pm	4	21	25	5	5
1:45Pm-2:00Pm	7	37	40	7	6	1:45Pm-2:00Pm	4	24	27	5	4
2:00Pm-2:15Pm	7	38	43	8	5	2:00Pm-2:15Pm	5	25	28	6	3
2:15Pm-2:30Pm	10	42	43	7	4	2:15Pm-2:30Pm	7	28	29	5	3
2:30Pm-2:45Pm	7	44	46	7	3	2:30Pm-2:45Pm	5	29	30	5	2
2:45Pm-3:00Pm	8	49	48	6	3	2:45Pm-3:00Pm	6	33	32	4	2
3:00Pm-3:15Pm	6	54	53	7	3	3:00Pm-3:15Pm	4	36	35	4	2
3:15Pm-3:30Pm	7	56	53	7	4	3:15Pm-3:30Pm	5	37	36	5	2
3:30Pm-3:45Pm	6	55	56	9	5	3:30Pm-3:45Pm	4	37	37	6	3
3:45Pm-4:00Pm	9	53	53	6	4	3:45Pm-4:00Pm	6	36	35	4	3
4:00Pm-4:15Pm	7	47	55	8	4	4:00Pm-4:15Pm	5	32	37	5	2
4:15Pm-4:30Pm	8	54	59	9	5	4:15Pm-4:30Pm	5	36	40	6	3
4:30Pm-4:45Pm	2	49	44	4	5	4:30Pm-4:45Pm	2	32	29	2	4
4:45Pm-5:00Pm	3	41	38	5	3	4:45Pm-5:00Pm	2	28	25	3	2
5:00Pm-5:15Pm	4	38	34	5	4	5:00Pm-5:15Pm	2	25	23	4	2
5:15Pm-5:30Pm	4	37	33	7	4	5:15Pm-5:30Pm	2	24	22	4	3
5:30Pm-5:45Pm	3	34	31	7	5	5:30Pm-5:45Pm	2	22	21	5	3
5:45Pm-6:00Pm	8	34	35	7	2	5:45Pm-6:00Pm	6	23	23	4	1
6:00Pm-6:15Pm	7	26	28	8	0	6:00Pm-6:15Pm	5	18	18	6	0
6:15Pm-6:30Pm	5	21	28	10	3	6:15Pm-6:30Pm	3	14	19	7	2
6:30Pm-6:45Pm	4	20	25	10	3	6:30Pm-6:45Pm	3	13	17	6	2
6:45Pm-7:00Am	3	22	28	11	5	6:45Pm-7:00Am	2	14	19	8	3
	<u>370</u>	<u>2357</u>	<u>2492</u>	<u>412</u>	<u>290</u>		<u>246</u>	<u>1572</u>	<u>1662</u>	<u>275</u>	<u>193</u>

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Traffic Count @ Each Segment with Speed Hump											
Salite mihret to Summit (Right Hand Side)						Posted Speed Limit=30km/hr(Invisible to Drivers)					
Date 11/12/12(Monday)						Date 12/12/12(Tuesday)					
Time 15m interval	Vehicle Classification					Time 15m interval	Vehicle Classification				
	Cycle, Motor Cycle & Bajaj	Light Vehicle	Mini Bus(Taxi) & Pick Up	M. Bus	L. Bus & Track Trailer		Cycle, Motor Cycle & Bajaj	Light Vehicle	Mini Bus(Taxi) & Pick Up	M. Bus & L. Bus	L. Bus & Track Trailer
7:00Am-7:15 Am	67	167	71	8	55	7:00Am-7:15 Am	68	171	73	8	56
7:15Am-7:30 Am	69	174	75	12	51	7:15Am-7:30 Am	70	177	76	12	52
7:30Am-7:45Am	72	191	79	13	46	7:30Am-7:45Am	74	195	80	13	47
7:45Am-8:00Am	62	175	84	11	40	7:45Am-8:00Am	63	178	86	11	41
8:00Am-8:15Am	49	170	78	6	32	8:00Am-8:15Am	50	173	79	7	33
8:15Am-8:30Am	45	159	71	3	30	8:15Am-8:30Am	46	162	73	3	31
8:30Am-8:45Am	49	146	58	2	24	8:30Am-8:45Am	50	149	59	2	24
8:45Am-9:00Am	37	137	48	1	22	8:45Am-9:00Am	37	140	48	1	22
9:00Am-9:15Am	44	133	44	2	18	9:00Am-9:15Am	45	135	45	2	19
9:15Am-9:30Am	39	125	38	3	19	9:15Am-9:30Am	40	128	39	3	20
9:30Am-9:45Am	30	122	32	2	16	9:30Am-9:45Am	31	124	33	2	17
9:45Am-10:00Am	23	133	29	0	6	9:45Am-10:00Am	23	135	30	0	7
10:00Am-10:15Ar	36	122	24	3	5	10:00Am-10:15Am	36	124	24	3	6
10:15Am-10:30Ar	40	137	29	5	13	10:15Am-10:30Am	41	140	30	6	13
10:30Am-10:45Ar	46	147	42	2	16	10:30Am-10:45Am	47	150	43	2	17
10:45Am-11:00Ar	50	149	49	0	13	10:45Am-11:00Am	51	152	50	0	13
11:00Am-11:15Ar	56	154	62	4	36	11:00Am-11:15Am	57	157	63	4	36
11:15Am-11:30Ar	62	145	56	0	31	11:15Am-11:30Am	63	147	57	0	32
11:30Am-11:45Ar	49	159	68	2	24	11:30Am-11:45Am	50	162	69	2	24
11:45Am-12:00Ar	43	150	67	1	30	11:45Am-12:00Am	44	153	68	1	31
12:00Am-12:15Ar	38	165	76	0	26	12:00Am-12:15Am	39	168	77	0	26
12:15Am-12:30Ar	40	176	75	2	21	12:15Am-12:30Am	41	179	76	2	21
12:30Am-12:45Ar	31	170	94	0	18	12:30Am-12:45Am	32	173	96	0	19
12:45Am-1:00Pm	40	176	99	4	12	12:45Am-1:00Pm	41	179	101	4	12
1:00Pm-1:15Pm	32	162	89	2	15	1:00Pm-1:15Pm	33	165	90	2	15
1:15Pm-1:30Pm	24	143	90	4	13	1:15Pm-1:30Pm	24	145	91	4	13
1:30Pm-1:45Pm	23	146	94	1	12	1:30Pm-1:45Pm	23	149	96	1	12
1:45Pm-2:00Pm	22	140	99	1	10	1:45Pm-2:00Pm	22	143	101	1	10
2:00Pm-2:15Pm	31	144	110	2	10	2:00Pm-2:15Pm	32	146	112	2	10
2:15Pm-2:30Pm	35	157	106	3	31	2:15Pm-2:30Pm	35	160	108	3	32
2:30Pm-2:45Pm	29	145	100	2	29	2:30Pm-2:45Pm	30	147	102	2	30
2:45Pm-3:00Pm	25	157	104	1	28	2:45Pm-3:00Pm	25	160	106	1	29
3:00Pm-3:15Pm	35	143	110	1	23	3:00Pm-3:15Pm	35	145	112	1	23
3:15Pm-3:30Pm	37	140	120	2	31	3:15Pm-3:30Pm	37	143	122	2	32
3:30Pm-3:45Pm	40	137	122	1	35	3:30Pm-3:45Pm	41	140	124	1	35
3:45Pm-4:00Pm	49	131	126	2	36	3:45Pm-4:00Pm	50	133	129	2	36
4:00Pm-4:15Pm	48	143	94	1	28	4:00Pm-4:15Pm	48	145	96	1	29
4:15Pm-4:30Pm	42	144	83	1	24	4:15Pm-4:30Pm	43	146	85	1	24
4:30Pm-4:45Pm	49	143	68	2	18	4:30Pm-4:45Pm	50	145	69	2	19
4:45Pm-5:00Pm	43	140	70	3	31	4:45Pm-5:00Pm	44	143	72	3	32
5:00Pm-5:15Pm	44	152	62	1	24	5:00Pm-5:15Pm	45	155	63	1	24
5:15Pm-5:30Pm	35	139	51	0	29	5:15Pm-5:30Pm	35	142	52	0	30
5:30Pm-5:45Pm	41	132	48	2	21	5:30Pm-5:45Pm	42	134	48	2	21
5:45Pm-6:00Pm	35	137	40	3	28	5:45Pm-6:00Pm	35	140	41	3	29
6:00Pm-6:15Pm	39	131	44	2	23	6:00Pm-6:15Pm	40	133	45	2	23
6:15Pm-6:30Pm	36	139	38	3	31	6:15Pm-6:30Pm	36	142	39	3	32
6:30Pm-6:45Pm	30	126	32	3	35	6:30Pm-6:45Pm	31	129	33	3	35
6:45Pm-7:00Am	38	120	37	2	41	6:45Pm-7:00Am	39	122	37	2	42
	<u>1974</u>	<u>7071</u>	<u>3384</u>	<u>137</u>	<u>1211</u>		<u>2011</u>	<u>7202</u>	<u>3446</u>	<u>140</u>	<u>1233</u>

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Traffic Count @ Each Segment with Speed Hump

Sun Rise Real Estate to GoroRA (Right Hand Side) Posted Speed Limit=30km/hr(Invisible to Drivers)

Date 13/12/12(Wednesday)						Date 14/12/12(Thursday)					
Time 15m interval	Vehicle Classification					Time 15m interval	Vehicle Classification				
	Cycle, Motor Cycle&	Light Vehicle	Mini Bus(Taxi) &Pick Up	M.Bus &T	L.Bus &Track Trailer		Cycle, Motor Cycle&	Light Vehicle	Mini Bus(Taxi) &Pick Up	M.Bu s&T	L.Bus &Track Trailer
7:00Am-7:15 Am	72	106	47	12	16	7:00Am-7:15 Am	69	101	45	11	15
7:15Am-7:30 Am	79	122	54	14	18	7:15Am-7:30 Am	75	116	51	13	17
7:30Am-7:45Am	74	129	60	12	19	7:30Am-7:45Am	70	123	57	11	18
7:45Am-8:00Am	82	134	66	7	14	7:45Am-8:00Am	78	128	63	7	13
8:00Am-8:15Am	74	142	72	3	12	8:00Am-8:15Am	70	135	69	3	11
8:15Am-8:30Am	58	132	80	2	6	8:15Am-8:30Am	55	126	76	2	6
8:30Am-8:45Am	48	134	81	3	7	8:30Am-8:45Am	46	128	77	3	7
8:45Am-9:00Am	54	140	75	0	9	8:45Am-9:00Am	51	133	71	0	9
9:00Am-9:15Am	59	134	70	3	5	9:00Am-9:15Am	56	128	67	3	5
9:15Am-9:30Am	51	128	59	2	4	9:15Am-9:30Am	49	122	56	2	4
9:30Am-9:45Am	41	137	48	3	5	9:30Am-9:45Am	39	130	46	3	5
9:45Am-10:00Am	38	124	42	2	4	9:45Am-10:00Am	36	118	40	2	4
10:00Am-10:15Am	44	119	36	0	5	10:00Am-10:15Am	42	115	34	0	5
10:15Am-10:30Am	40	117	42	2	3	10:15Am-10:30Am	38	111	40	2	3
10:30Am-10:45Am	45	112	37	3	5	10:30Am-10:45Am	43	107	35	3	5
10:45Am-11:00Am	37	103	44	0	4	10:45Am-11:00Am	35	98	42	0	4
11:00Am-11:15Am	47	91	49	3	0	11:00Am-11:15Am	45	87	47	3	0
11:15Am-11:30Am	51	95	59	3	2	11:15Am-11:30Am	49	90	56	3	2
11:30Am-11:45Am	55	97	51	2	2	11:30Am-11:45Am	52	92	49	2	2
11:45Am-12:00Am	64	102	47	4	3	11:45Am-12:00Am	61	97	45	4	3
12:00Am-12:15Am	69	106	45	2	1	12:00Am-12:15Am	66	101	43	2	1
12:15Am-12:30Am	74	109	43	7	12	12:15Am-12:30Am	70	104	41	7	11
12:30Am-12:45Am	79	104	37	6	14	12:30Am-12:45Am	75	99	35	6	13
12:45Am-1:00Pm	77	107	39	2	13	12:45Am-1:00Pm	73	102	37	2	12
1:00Pm-1:15Pm	70	113	35	3	14	1:00Pm-1:15Pm	67	108	33	3	13
1:15Pm-1:30Pm	68	118	39	5	9	1:15Pm-1:30Pm	65	112	37	5	9
1:30Pm-1:45Pm	75	128	33	4	3	1:30Pm-1:45Pm	71	122	31	4	3
1:45Pm-2:00Pm	68	123	27	2	1	1:45Pm-2:00Pm	65	117	26	2	1
2:00Pm-2:15Pm	71	114	28	6	3	2:00Pm-2:15Pm	68	109	27	6	3
2:15Pm-2:30Pm	56	99	30	2	1	2:15Pm-2:30Pm	53	94	29	2	1
2:30Pm-2:45Pm	62	95	24	4	5	2:30Pm-2:45Pm	59	90	23	4	5
2:45Pm-3:00Pm	65	91	17	2	7	2:45Pm-3:00Pm	62	87	16	2	7
3:00Pm-3:15Pm	80	71	22	7	2	3:00Pm-3:15Pm	76	68	21	7	2
3:15Pm-3:30Pm	83	86	24	11	3	3:15Pm-3:30Pm	79	82	23	10	3
3:30Pm-3:45Pm	68	97	28	2	4	3:30Pm-3:45Pm	65	92	27	2	4
3:45Pm-4:00Pm	62	102	21	0	2	3:45Pm-4:00Pm	59	97	20	0	2
4:00Pm-4:15Pm	58	92	18	0	0	4:00Pm-4:15Pm	55	88	17	0	0
4:15Pm-4:30Pm	53	84	22	6	6	4:15Pm-4:30Pm	50	80	21	6	6
4:30Pm-4:45Pm	58	81	27	6	3	4:30Pm-4:45Pm	55	77	26	6	3
4:45Pm-5:00Pm	60	86	30	5	5	4:45Pm-5:00Pm	57	82	29	5	5
5:00Pm-5:15Pm	62	70	35	5	4	5:00Pm-5:15Pm	59	67	33	5	4
5:15Pm-5:30Pm	65	83	47	7	7	5:15Pm-5:30Pm	62	79	45	7	7
5:30Pm-5:45Pm	55	70	36	9	5	5:30Pm-5:45Pm	52	67	34	9	5
5:45Pm-6:00Pm	46	92	39	0	2	5:45Pm-6:00Pm	44	88	37	0	2
6:00Pm-6:15Pm	41	69	44	4	3	6:00Pm-6:15Pm	39	66	42	4	3
6:15Pm-6:30Pm	48	56	39	1	2	6:15Pm-6:30Pm	46	53	37	1	2
6:30Pm-6:45Pm	54	49	36	0	5	6:30Pm-6:45Pm	51	47	34	0	5
6:45Pm-7:00Am	65	37	40	3	8	6:45Pm-7:00Am	62	35	38	3	8
<u>10841</u>	<u>2902</u>	<u>3250</u>	<u>2024</u>	<u>196</u>	<u>292</u>	<u>2764</u>	<u>4698</u>	<u>1928</u>	<u>187</u>	<u>278</u>	

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Traffic Count @ Each Segment with Speed Hump

Jakros Junction to GoroRA (Right Hand Side) Posted Speed Limit=30km/hr(Invisible to Drivers)

Date 11/12/12(Monday)						Date 12/12/12(Tuesday)					
Time 15m interval	Vehicle Classification					Time 15m interval	Vehicle Classification				
	Cycle, Motor Cycle& Bajaj	Light Vehicle	Mini Bus(Taxi) &Pick Up	M.Bus&T &Track Trailer	L.Bus		Cycle, Motor Cycle& Bajaj	Light Vehicle	Mini Bus(Taxi) &Pick Up	M.Bus&T &Track Trailer	L.Bus
7:00Am-7:15 Am	16	206	51	15	16	7:00Am-7:15 Am	17	210	52	15	17
7:15Am-7:30 Am	10	175	55	21	13	7:15Am-7:30 Am	10	178	56	21	13
7:30Am-7:45Am	6	185	46	14	21	7:30Am-7:45Am	7	188	47	14	21
7:45Am-8:00Am	8	179	44	11	26	7:45Am-8:00Am	8	183	45	11	26
8:00Am-8:15Am	12	146	55	14	29	8:00Am-8:15Am	12	149	56	14	30
8:15Am-8:30Am	10	154	64	19	33	8:15Am-8:30Am	10	157	65	20	34
8:30Am-8:45Am	8	156	59	14	38	8:30Am-8:45Am	8	158	61	14	39
8:45Am-9:00Am	5	161	67	18	28	8:45Am-9:00Am	6	164	68	19	29
9:00Am-9:15Am	8	178	62	14	23	9:00Am-9:15Am	8	182	63	14	23
9:15Am-9:30Am	6	170	55	15	26	9:15Am-9:30Am	7	173	56	15	26
9:30Am-9:45Am	4	154	46	13	24	9:30Am-9:45Am	4	157	47	13	24
9:45Am-10:00Am	9	157	35	10	30	9:45Am-10:00Am	9	160	35	10	31
10:00Am-10:15Am	10	143	60	17	35	10:00Am-10:15Am	10	145	62	18	35
10:15Am-10:30Am	2	148	51	16	27	10:15Am-10:30Am	2	151	52	17	28
10:30Am-10:45Am	0	166	42	16	23	10:30Am-10:45Am	0	169	43	17	23
10:45Am-11:00Am	6	157	36	12	24	10:45Am-11:00Am	7	160	36	12	24
11:00Am-11:15Am	5	145	27	10	14	11:00Am-11:15Am	6	147	28	10	14
11:15Am-11:30Am	4	159	56	14	5	11:15Am-11:30Am	4	162	57	14	6
11:30Am-11:45Am	9	137	73	17	16	11:30Am-11:45Am	9	140	75	18	17
11:45Am-12:00Am	9	149	79	12	14	11:45Am-12:00Am	9	152	80	12	14
12:00Am-12:15Am	3	160	75	11	10	12:00Am-12:15Am	3	163	76	11	10
12:15Am-12:30Am	1	166	70	15	10	12:15Am-12:30Am	1	169	72	15	10
12:30Am-12:45Am	4	180	64	18	4	12:30Am-12:45Am	4	184	65	19	4
12:45Am-1:00Pm	8	192	66	17	2	12:45Am-1:00Pm	8	196	67	18	2
1:00Pm-1:15Pm	9	207	62	17	15	1:00Pm-1:15Pm	9	211	63	18	15
1:15Pm-1:30Pm	11	212	55	19	13	1:15Pm-1:30Pm	11	216	56	20	13
1:30Pm-1:45Pm	14	221	58	22	16	1:30Pm-1:45Pm	14	226	59	22	17
1:45Pm-2:00Pm	12	211	49	26	18	1:45Pm-2:00Pm	12	215	50	26	19
2:00Pm-2:15Pm	11	180	71	18	25	2:00Pm-2:15Pm	11	184	73	19	25
2:15Pm-2:30Pm	9	191	62	14	16	2:15Pm-2:30Pm	9	195	63	14	17
2:30Pm-2:45Pm	5	193	51	18	13	2:30Pm-2:45Pm	6	197	52	19	13
2:45Pm-3:00Pm	4	186	56	8	6	2:45Pm-3:00Pm	4	189	57	8	7
3:00Pm-3:15Pm	3	172	62	14	11	3:00Pm-3:15Pm	3	175	63	14	11
3:15Pm-3:30Pm	8	159	76	16	8	3:15Pm-3:30Pm	8	162	77	17	8
3:30Pm-3:45Pm	5	217	67	17	14	3:30Pm-3:45Pm	6	221	68	18	14
3:45Pm-4:00Pm	13	224	72	21	5	3:45Pm-4:00Pm	13	228	74	21	6
4:00Pm-4:15Pm	8	237	94	16	10	4:00Pm-4:15Pm	8	241	96	17	10
4:15Pm-4:30Pm	10	228	82	21	14	4:15Pm-4:30Pm	10	232	84	21	14
4:30Pm-4:45Pm	8	213	84	18	12	4:30Pm-4:45Pm	8	217	86	19	12
4:45Pm-5:00Pm	9	197	72	21	17	4:45Pm-5:00Pm	9	200	74	21	18
5:00Pm-5:15Pm	13	230	95	13	18	5:00Pm-5:15Pm	13	234	97	13	19
5:15Pm-5:30Pm	14	217	83	15	21	5:15Pm-5:30Pm	14	221	85	15	21
5:30Pm-5:45Pm	5	226	92	11	15	5:30Pm-5:45Pm	6	230	94	11	15
5:45Pm-6:00Pm	8	211	97	21	19	5:45Pm-6:00Pm	8	215	99	21	20
6:00Pm-6:15Pm	10	221	109	16	10	6:00Pm-6:15Pm	10	226	111	17	10
6:15Pm-6:30Pm	3	234	121	18	4	6:15Pm-6:30Pm	3	239	123	19	4
6:30Pm-6:45Pm	6	220	129	25	8	6:30Pm-6:45Pm	7	224	131	25	8
6:45Pm-7:00Am	4	216	121	23	10	6:45Pm-7:00Am	4	220	123	23	10
	<u>364</u>	<u>8945</u>	<u>3257</u>	<u>782</u>	<u>809</u>		<u>371</u>	<u>9110</u>	<u>3318</u>	<u>796</u>	<u>824</u>

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Traffic Count @ Each Segment with Speed Hump

Ayer tena to Wingate(Both Sides)

Posted Speed Limit=30km/hr(Invisible to Drivers)

Date 11/12/12(Monday)					Date 12/12/12(Tuesday)					Date 13/12/12(Wednesday)							
Vehicle Classification					Vehicle Classification					Vehicle Classification							
Cycle, Light	Mini	M.Bus	L.Bus		Cycle, Light	Mini	M.Bus	L.Bus		Cycle, Light	Mini	Bus	Track				
Motor Vehicle	Bus(Taxi)	&T	&Track		Motor Vehicle	Bus(Taxi)&Pick	&Track			Motor Vehicle	Bus(Taxi)	&Track					
Cycle& Bajaj	&Pick Up	Trailer		Time 15m interval	Cycle& Bajaj	Up	Trailer		Time 15m interval	Cycle& Bajaj	&Pick Up	Trailer					
7:00Am-7:15 Am	41	516	127	38	41	7:00Am-7:15 Am	41	525	129	39	41	7:00Am-7:15 Am	39	501	123	37	39
7:15Am-7:30 Am	24	437	138	51	13	7:15Am-7:30 Am	25	446	140	52	13	7:15Am-7:30 Am	24	425	134	50	13
7:30Am-7:45Am	16	462	116	35	21	7:30Am-7:45Am	17	470	118	36	21	7:30Am-7:45Am	16	449	113	34	20
7:45Am-8:00Am	19	448	111	27	26	7:45Am-8:00Am	19	457	113	28	26	7:45Am-8:00Am	18	436	108	26	25
8:00Am-8:15Am	30	365	138	35	29	8:00Am-8:15Am	30	371	140	36	30	8:00Am-8:15Am	29	354	134	34	28
8:15Am-8:30Am	24	386	159	49	33	8:15Am-8:30Am	25	393	162	50	34	8:15Am-8:30Am	24	375	155	47	33
8:30Am-8:45Am	19	389	149	35	95	8:30Am-8:45Am	19	396	151	36	96	8:30Am-8:45Am	18	378	144	34	92
8:45Am-9:00Am	14	402	167	46	95	8:45Am-9:00Am	14	410	171	47	96	8:45Am-9:00Am	13	391	163	45	92
9:00Am-9:15Am	19	446	154	35	95	9:00Am-9:15Am	19	454	157	36	96	9:00Am-9:15Am	18	433	150	34	92
9:15Am-9:30Am	16	424	138	38	95	9:15Am-9:30Am	17	432	140	39	96	9:15Am-9:30Am	16	412	134	37	92
9:30Am-9:45Am	11	386	116	32	95	9:30Am-9:45Am	11	393	118	33	96	9:30Am-9:45Am	11	375	113	32	92
9:45Am-10:00Am	22	392	86	24	95	9:45Am-10:00Am	22	399	88	25	96	9:45Am-10:00Am	21	381	84	24	92
10:00Am-10:15Am	24	356	151	17	95	10:00Am-10:15Am	25	363	154	18	96	10:00Am-10:15Am	24	347	147	17	92
10:15Am-10:30Am	5	370	127	16	95	10:15Am-10:30Am	6	377	129	17	96	10:15Am-10:30Am	5	360	123	16	92
10:30Am-10:45Am	0	416	105	16	95	10:30Am-10:45Am	0	424	107	17	96	10:30Am-10:45Am	0	404	102	16	92
10:45Am-11:00Am	16	392	89	12	95	10:45Am-11:00Am	17	399	91	12	96	10:45Am-11:00Am	16	381	87	12	92
11:00Am-11:15Am	14	362	68	10	95	11:00Am-11:15Am	14	369	69	10	96	11:00Am-11:15Am	13	352	66	9	92
11:15Am-11:30Am	11	397	140	14	95	11:15Am-11:30Am	11	404	143	14	96	11:15Am-11:30Am	11	386	137	14	92
11:30Am-11:45Am	22	343	184	43	95	11:30Am-11:45Am	22	349	187	44	96	11:30Am-11:45Am	21	333	179	42	92
11:45Am-12:00Am	22	373	197	12	95	11:45Am-12:00Am	22	380	201	12	96	11:45Am-12:00Am	21	362	192	12	92
12:00Am-12:15Am	8	400	186	11	95	12:00Am-12:15Am	8	407	190	11	96	12:00Am-12:15Am	8	389	181	11	92
12:15Am-12:30Am	3	416	176	15	10	12:15Am-12:30Am	3	424	179	15	10	12:15Am-12:30Am	3	404	171	15	9
12:30Am-12:45Am	11	451	3	18	4	12:30Am-12:45Am	11	459	3	19	4	12:30Am-12:45Am	11	438	3	18	4
12:45Am-1:00Pm	19	481	165	17	2	12:45Am-1:00Pm	19	490	168	18	2	12:45Am-1:00Pm	18	467	160	17	2
1:00Pm-1:15Pm	22	518	154	17	15	1:00Pm-1:15Pm	22	528	157	18	15	1:00Pm-1:15Pm	21	504	150	17	15
1:15Pm-1:30Pm	27	529	138	19	13	1:15Pm-1:30Pm	28	539	140	20	13	1:15Pm-1:30Pm	26	515	134	19	13
1:30Pm-1:45Pm	35	554	146	22	16	1:30Pm-1:45Pm	36	564	149	22	17	1:30Pm-1:45Pm	34	538	142	21	16
1:45Pm-2:00Pm	30	527	122	26	18	1:45Pm-2:00Pm	30	536	124	26	19	1:45Pm-2:00Pm	29	512	118	25	18
2:00Pm-2:15Pm	27	451	178	18	25	2:00Pm-2:15Pm	28	459	182	19	25	2:00Pm-2:15Pm	26	438	173	18	24
2:15Pm-2:30Pm	22	478	154	14	16	2:15Pm-2:30Pm	22	487	157	14	17	2:15Pm-2:30Pm	21	465	150	14	16
2:30Pm-2:45Pm	14	483	127	18	13	2:30Pm-2:45Pm	14	492	129	19	13	2:30Pm-2:45Pm	13	470	123	18	13
2:45Pm-3:00Pm	11	464	140	8	6	2:45Pm-3:00Pm	11	473	143	8	7	2:45Pm-3:00Pm	11	452	137	7	6
3:00Pm-3:15Pm	8	429	154	14	11	3:00Pm-3:15Pm	8	437	157	14	11	3:00Pm-3:15Pm	8	417	150	14	11
3:15Pm-3:30Pm	19	397	189	16	8	3:15Pm-3:30Pm	19	404	193	17	8	3:15Pm-3:30Pm	18	386	184	16	7
3:30Pm-3:45Pm	14	543	167	17	35	3:30Pm-3:45Pm	14	553	171	18	36	3:30Pm-3:45Pm	13	528	163	17	34
3:45Pm-4:00Pm	32	559	181	51	35	3:45Pm-4:00Pm	33	569	184	52	36	3:45Pm-4:00Pm	32	543	176	50	34
4:00Pm-4:15Pm	19	591	235	16	35	4:00Pm-4:15Pm	19	602	239	17	36	4:00Pm-4:15Pm	18	575	228	16	34
4:15Pm-4:30Pm	24	570	205	51	35	4:15Pm-4:30Pm	25	580	209	52	36	4:15Pm-4:30Pm	24	554	200	50	34
4:30Pm-4:45Pm	19	532	211	18	35	4:30Pm-4:45Pm	19	542	215	19	36	4:30Pm-4:45Pm	18	517	205	18	34
4:45Pm-5:00Pm	22	491	181	51	35	4:45Pm-5:00Pm	22	501	184	52	36	4:45Pm-5:00Pm	21	478	176	50	34
5:00Pm-5:15Pm	32	575	238	51	35	5:00Pm-5:15Pm	33	586	242	52	36	5:00Pm-5:15Pm	32	559	231	50	34
5:15Pm-5:30Pm	35	543	208	51	35	5:15Pm-5:30Pm	36	553	212	52	36	5:15Pm-5:30Pm	34	528	202	50	34
5:30Pm-5:45Pm	14	564	230	51	35	5:30Pm-5:45Pm	14	575	234	52	36	5:30Pm-5:45Pm	13	549	223	50	34
5:45Pm-6:00Pm	19	527	243	51	35	5:45Pm-6:00Pm	19	536	248	52	36	5:45Pm-6:00Pm	18	512	236	50	34
6:00Pm-6:15Pm	24	554	273	51	10	6:00Pm-6:15Pm	25	564	278	52	10	6:00Pm-6:15Pm	24	538	265	50	9
6:15Pm-6:30Pm	8	586	302	51	4	6:15Pm-6:30Pm	8	597	308	52	4	6:15Pm-6:30Pm	8	570	294	50	4
6:30Pm-6:45Pm	16	551	321	51	8	6:30Pm-6:45Pm	17	561	327	52	8	6:30Pm-6:45Pm	16	536	312	50	7
6:45Pm-7:00Am	11	540	302	23	10	6:45Pm-7:00Am	11	550	308	23	10	6:45Pm-7:00Am	11	525	294	22	9
	910	22361	7987	1408	2120		927	22776	8135	1434	2159		885	21740	7765	1369	2061

Appendix B

Speed Hump Geometry, Speed & Delay

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

02 to Hill Side School (Right Hand Side)

			B,M&MC				
SHL(cm)	Height	Grade	V25	V20	V15	V10	V5
755.9	9.67	-7.4	16.4	20	16.4	15	12
754.7	9	-5.6	20	17.3	16.1	14.6	12.3
755.2	8.17	-3.8	17.2	16.8	15.3	14.6	13.2
755.27	8.95	-5.60	17.87	18.03	15.93	14.73	12.50
			Car				
755.9	9.67	-7.4	15	13.8	13.6	13.6	12
754.7	9	-5.6	17	14.2	14	13.8	13.2
755.2	8.17	-3.8	16.6	16.3	15.2	14.3	13.6
			16.20	14.77	14.27	13.90	12.93
			M,P&T				
755.9	9.67	-7.4	20	18	20	22.5	16.4
754.7	9	-5.6	22	19.8	21.3	18.4	17.3
755.2	8.17	-3.8	21	20.3	19.6	17.8	16.8
			21.00	19.37	20.30	19.57	16.83
			M.Bus& T				
755.9	9.67	-7.4	18	16.4	16.4	15	13.8
754.7	9	-5.6	17.7	16.1	16.2	15.3	14.1
755.2	8.17	-3.8	19.2	17.1	16.5	16.1	14.7
			18.30	16.53	16.37	15.47	14.20
			L.Bus&TT				
755.9	9.67	-7.4	22.5	18	15	12	13.8
754.7	9	-5.6	23	17.9	16.1	13.1	12.9
755.2	8.17	-3.8	21	18.1	16.7	13.3	13.5
			22.17	18.00	15.93	12.80	13.40

Vehicle	Upstream Distance(M)@					Time Taken(Travel) in Seconds @					Average Speed(Km/Hr)				
	25	20	15	10	5	25	20	15	10	5	25	20	15	10	5
Cycle,motor & Bajaj	25	20	15	10	5	1.1	0.9	1.1	1.2	1.8	16.4	20.0	16.4	15.0	10.0
Light Vehicle	25	20	15	10	5	1.2	1.3	1.3	1.3	1.5	15.0	13.8	13.8	13.8	12.0
Mini Bus,pick up&Taxi	25	20	15	10	5	0.9	1	0.9	0.8	1.1	20.0	18.0	20.0	22.5	16.4
Bus	25	20	15	10	5	1	1.1	1.1	1.2	1.3	18.0	16.4	16.4	15.0	13.8
Track & Track Train	25	20	15	10	5	0.8	1	1.2	1.5	1.3	22.5	18	15	12	13.8

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Minarol to kotebe Kidanmihret(Both Sides)(8 speed Humps)									
B,M&MC									
SHL(cm)	Height	Grade	V25	V20	V15	V10	V5	Delay(veh-min)	
755	8.33	-4.3	16.4	20	16.4	15	10	2.15	
754	8.67	-8.3	17	19.5	16.1	14.6	9.9	4.65	
755.6	7.67	-10.5	17.9	21.2	17.8	14.7	11.1	10.55	
754.2	8.4	-7.8	18.1	22	18	14	12	11.62	
754.5	8.23	-2.3	25.7	29.5	22	19.4	22	6.97	
755.7	8.86	-0.3	25	27.5	22.7	20.9	19.8	8.40	
754.9	8.54	-11.3	26	25.7	23.2	21.1	20.8	9.83	
753.6	8.93	-6.4	26.9	26.1	24.4	22.5	21.5	11.08	
754.69	8.45	-6.40	21.63	23.94	20.08	17.78	15.89	8.16	
Car									
755	8.33	-4.3	20	15.9	17	17.1	16.5	72.51	
754	8.67	-8.3	19.2	18.8	16.9	16.4	15	78.55	
755.6	7.67	-10.5	18.3	17.6	18.1	15.6	14.7	64.45	
754.2	8.4	-7.8	19.5	19.1	18.8	15.2	13.3	88.62	
754.5	8.23	-2.3	20	16.1	14.3	14.4	14.4	94.67	
755.7	8.86	-0.3	21	17	15.2	13.9	14.8	106.75	
754.9	8.54	-11.3	19.8	17.9	14.9	15.1	14.3	62.44	
753.6	8.93	-6.4	23	21.7	20.3	19.7	15.6	86.61	
			20.10	18.01	16.94	15.93	14.83	81.83	
M,P&T									
755	8.33	-4.3	25.7	17.8	17.6	17.6	17.8	69.22	
754	8.67	-8.3	27	26.1	18.3	18.5	17.3	85.51	
755.6	7.67	-10.5	26.3	25.7	21.8	19.4	17.8	107.90	
754.2	8.4	-7.8	25.6	23.4	19.9	18.2	17	91.61	
754.5	8.23	-2.3	21.2	16.4	16.4	15.7	15	79.40	
755.7	8.86	-0.3	22	21.5	19.9	17.56	16.33	89.58	
754.9	8.54	-11.3	19.7	18.5	17.97	16.5	13.5	109.94	
753.6	8.93	-6.4	17.4	15.3	13.3	11.65	10.3	75.33	
			23.11	20.59	18.15	16.89	15.63	88.56	
Bus									
755	8.33	-4.3	20	19.1	17	16.1	13.6	12.08	
754	8.67	-8.3	21.2	20.8	19.4	18.7	16.2	14.17	
755.6	7.67	-10.5	19.5	18.6	16.7	14.5	13.5	16.25	
754.2	8.4	-7.8	22.4	21.3	20.9	19.6	17.8	20.42	
754.5	8.23	-2.3	16.4	15	15	14.9	12.9	21.25	
755.7	8.86	-0.3	17.6	16.7	15.8	15.3	14.99	23.75	
754.9	8.54	-11.3	19.9	18.98	18.75	18.6	17.8	20.00	
753.6	8.93	-6.4	20.2	19.65	18.85	17.96	17.85	18.75	
			19.65	18.77	17.80	16.96	15.58	18.33	
T&TT									
755	8.33	-4.3	19.6	19.4	17.3	16	14.6	5.78	
754	8.67	-8.3	21.5	20.6	19.9	18.8	17.9	7.20	
755.6	7.67	-10.5	20.9	19.9	18.3	17.4	16.7	6.70	
754.2	8.4	-7.8	19.9	18.97	17.85	17.5	16.65	5.53	
754.5	8.23	-2.3	18	16.2	14.9	16	16.2	8.04	
755.7	8.86	-0.3	17.8	17.5	16.95	16.76	15.97	7.54	
754.9	8.54	-11.3	18.5	17.94	16.89	16.56	16.7	6.53	
753.6	8.93	-6.4	23.5	22.93	23.5	24.55	23.75	7.20	
			19.96	19.18	18.20	17.95	17.31	6.82	

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Vehicle	Upstream Distance(M)@					Time Taken(Travel) in Seconds @					Average Speed(Km/Hr)				
	25	20	15	10	5	25	20	15	10	5	25	20	15	10	5
Cycle,motor & Bajaj	25	20	15	10	5	0.7	0.61	0.82	0.93	0.82	25.7	29.5	22.0	19.4	22.0
Light Vehicle	25	20	15	10	5	0.9	1.12	1.26	1.25	1.25	20.0	16.1	14.3	14.4	14.4
Mini Bus,pick up&Taxi	25	20	15	10	5	0.85	1.1	1.1	1.15	1.2	21.2	16.4	16.4	15.7	15.0
Bus	25	20	15	10	5	1.1	1.2	1.2	1.21	1.39	16.4	15.0	15.0	14.9	12.9
Track &Track Train	25	20	15	10	5	1	1.11	1.12	1.15	1.21	18	16.2	16.1	16	14.9

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Ferensay to Kagnew RA(Right Hand Side)(3 speed Humps)									
B,M&MC									
SHL(cm)	Height	Grade	V25	V20	V15	V10	V5	Delay(veh-min)	
770	7.83	-2.4	19.4	18.2	18.4	17.5	17.9	3.26	
771	7.97	-10.6	21.3	20.8	19.75	20.2	18.2	3.61	
770.4	8.1	-13.4	20.7	20.05	19.95	19.25	16.86	3.86	
770.47	7.97	-8.80	20.47	19.68	19.37	18.98	17.65	3.58	
Car									
755.9	9.67	-2.4	18.5	19.4	17.2	16.4	16.2	63.06	
754.7	9	-10.6	19.3	18.9	18.2	16.6	16.15	68.27	
755.2	8.17	-13.4	18.2	18.17	18.1	15.9	16	73.66	
755.27	8.95		18.67	18.82	17.83	16.30	16.12	68.33	
M,P&T									
755.9	9.67	-2.4	25.4	18.6	17.6	17.6	17.5	55.57	
754.7	9	-10.6	26.3	25.6	25.1	24.7	22.3	62.52	
755.2	8.17	-13.4	25.2	24.5	22.4	21.5	20.6	65.99	
755.27	8.95		25.63	22.90	21.70	21.27	13.27	61.36	
Bus									
755.9	9.67	-2.4	17	16.5	16.1	15.9	15.7	15.35	
754.7	9	-10.6	17.9	17.04	16.3	15.91	14.45	17.99	
755.2	8.17	-13.4	19	18.6	17.69	16.83	15.4	20.11	
755.27	8.95		17.97	17.38	16.70	16.21	15.18	17.82	
T&TT									
755.9	9.67	-2.4	17.3	16.2	15.8	16	15.8	8.8	
754.7	9	-10.6	18.6	17.9	17.24	16.78	16.24	10.4	
755.2	8.17	-13.4	17.85	18.5	17.85	16.45	14.45	12	
755.27	8.95		17.92	17.53	16.96	16.41	15.50	10.40	

Vehicle	Upstream Distance(M)@					Time Taken(Travel) in Seconds @					Average Speed(Km/Hr)				
	25	20	15	10	5	25	20	15	10	5	25	20	15	10	5
Cycle,motor & Bajaj	25	20	15	10	5	0.93	0.99	0.98	1.03	1.1	19.4	18.2	18.4	17.5	16.4
Light Vehicle	25	20	15	10	5	0.975	0.93	1.045	1.1	1.11	18.5	19.4	17.2	16.4	16.2
Mini Bus,pick up&Taxi	25	20	15	10	5	0.71	0.97	1.02	1.02	1.03	25.4	18.6	17.6	17.6	17.5
Bus	25	20	15	10	5	1.06	1.09	1.12	1.13	1.145	17.0	16.5	16.1	15.9	15.7
Track & Track Train	25	20	15	10	5	0.92	0.97	1.08	1.1	1.14	19.57	18.6	16.7	16	15.8

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Kara to Abado (Right Hand Side)(11 speed Humps)										
	SHL(cm)	Height	Grade	B,M&MC						
				V25	V20	V15	V10	V5	Delay(veh-min)	
	730	8.83	-4.7	34	27.3	24.7	25.4	25.4	6.70	
	740	7.5	-2.9	31	30.3	29.75	29.3	26.6	7.57	
	1090	6.17	-1.5	29.65	28.2	27.85	25.6	23.3	11.89	
	734	7.33	-1.7	30.2	28.3	27.7	26.2	22.7	7.57	
	1010	6.67	-3.6	28	26.8	26.1	24.7	23.4	9.73	
	1074	7.83	-4	25.56	24.6	23.7	22.8	20.7	8.43	
	1010.5	8.7	-5.1	26.45	25	24.2	23.4	19.6	9.52	
	1070	8.23	-4.5	25.2	23.7	22.55	21.43	18.9	8.22	
	1095	8.5	-4.8	22.65	21.67	21.34	20.75	17.83	12.33	
	1093	7.2	-3.7	25.35	24.13	21.56	19.34	17.89	14.06	
	1081	6.4	-4.5	21.15	20.34	19.23	17.07	15.24	10.60	
	975.23	7.58	-3.73	27.20	25.49	24.43	23.27	21.05	9.69	
				Car						
	730	8.83	-4.7	24.7	23.8	23.5	20.6	19.3	42.52	
	740	7.5	-2.9	26.7	25.4	25.105	24.2	23.3	52.19	
	1090	6.17	-1.5	27.56	25.75	24.68	23.8	22.65	61.85	
	734	7.33	-1.7	25.6	24.86	24.42	23.87	22.45	63.79	
	1010	6.67	-3.6	24	22.9	22.75	22.56	20.67	56.05	
	1074	7.83	-4	25.54	23.44	23.56	22.99	21.95	54.12	
	1010.5	8.7	-5.1	23.8	22.67	21.56	21.05	19.96	69.59	
	1070	8.23	-4.5	22.96	21.65	21.51	22.05	18.91	71.52	
	1095	8.5	-4.8	22.25	22.08	21.65	18.76	16.95	57.99	
	1093	7.2	-3.7	24.55	24.13	21.56	19.34	17.89	50.26	
	1081	6.4	-4.5	23.34	22.64	21.27	19.86	17.73	83.12	
	975.23	7.58	-3.73	24.64	23.57	22.87	21.73	20.16	60.27	
				M,P&T						
	730	8.83	-4.7	31.6	25.4	26.1	17.8	17.8	77.61	
	740	7.5	-2.9	32.34	31.32	30.65	27.8	25.7	81.57	
	1090	6.17	-1.5	31.89	29.57	26.57	24.43	22.86	85.27	
	734	7.33	-1.7	29.76	26.32	25.65	23.75	21.78	87.74	
	1010	6.67	-3.6	29.97	27.89	26.56	24.76	21.98	92.69	
	1074	7.83	-4	24.65	23.53	22.45	21.43	20.76	71.68	
	1010.5	8.7	-5.1	22.45	21.47	20.78	18.65	15.56	74.15	
	1070	8.23	-4.5	23.78	22.03	19.43	22.05	15.67	83.30	
	1095	8.5	-4.8	24.69	23.77	22.66	22.043	16.95	103.81	
	1093	7.2	-3.7	25.7	23.64	21.87	19.76	16.45	79.09	
	1081	6.4	-4.5	26.54	24.65	22.87	20.43	15.14	87.74	
	975.23	7.58	-3.73	27.58	25.42	24.14	22.08	19.15	84.06	
				Bus						
	730	8.83	-4.7	20.5	19.9	19.9	19.8	19.8	64.82	
	740	7.5	-2.9	21.56	20.43	20.03	19.35	19.24	71.38	
	1090	6.17	-1.5	23.53	22.44	21.56	19.87	19.34	54.02	
	734	7.33	-1.7	21.15	20.32	19.76	16.65	16.53	82.95	
	1010	6.67	-3.6	23.36	21.27	20.63	17.54	15.32	77.17	
	1074	7.83	-4	19.87	18.74	17.88	16.47	16.33	61.73	
	1010.5	8.7	-5.1	18.76	18.96	17.52	15.78	14.95	69.45	
	1070	8.23	-4.5	17.56	17.32	16.47	16.89	16.32	82.18	
	1095	8.5	-4.8	16.34	16.43	15.79	15.54	15.31	65.40	
	1093	7.2	-3.7	20.76	19.93	19.57	18.43	17.84	76.40	
	1081	6.4	-4.5	23.34	21.67	20.43	19.12	18.61	84.11	
	975.23	7.58	-3.73	20.61	19.76	19.05	17.77	17.24	71.78	
				T&TT						
	730	8.83	-4.7	20.69	20.3	20.1	19	18.7	27.38	
	740	7.5	-2.9	21.43	21.05	20.95	20.86	20.47	29.49	
	1090	6.17	-1.5	22.17	21.86	21.21	20.83	19.67	28.08	
	734	7.33	-1.7	21.57	21.16	20.64	20.43	19.73	25.98	
	1010	6.67	-3.6	24.56	24.21	22.51	22.42	17.98	25.98	
	1074	7.83	-4	22.34	22.13	21.46	20.17	19.65	32.30	
	1010.5	8.7	-5.1	17.54	17.86	16.36	15.23	14.43	31.59	
	1070	8.23	-4.5	18.65	18.27	17.15	14.26	13.89	37.21	
	1095	8.5	-4.8	17.35	17.13	16.54	15.98	14.51	30.19	
	1093	7.2	-3.7	23.51	22.93	21.83	20.07	18.64	30.89	
	1081	6.4	-4.5	23.97	23.42	21.12	19.97	17.52	29.91	
	975.23	7.58	-3.73	21.25	20.94	19.99	19.02	17.74	29.91	

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Abeyem Wossen (Right Hand Side)(5 speed Humps)									
B,M&MC									
SHL(cm)	Height	Grade	V25	V20	V15	V10	V5	lay(veh-m)	
755	7.67	-6.7	20.9	19.9	17.45	16.15	16.1	9.99	
754.5	7.17	-7.6	21.35	19.1	18.3	17.25	14.65	10.77	
753.8	7	-5.4	22.14	21.75	19.65	18.87	13.43	11.55	
755.4	8.67	-6.8	19.45	18.76	18.6	17.35	15.2	12.33	
756.2	8.5	-3.1	19.22	18.87	17.54	16.2	14.39	10.80	
754.98	7.802	-5.92	20.61	19.68	18.31	17.16	14.75	11.09	
Car									
755	7.67	-6.7	22.67	20.1	17.3	16.8	16.2	119.44	
754.5	7.17	-7.6	23.2	21.54	20.2	18.95	16.45	127.40	
753.8	7	-5.4	23.5	21.75	20.1	18.54	15.65	125.41	
755.4	8.67	-6.8	20.45	18.43	16.75	15.9	15.35	117.45	
756.2	8.5	-3.1	19.22	18.54	17.89	16.7	15.78	133.37	
754.98	7.802		21.808	20.072	18.448	17.378	15.886	124.616	
M,P&T									
755	7.67	-6.7	24.56	23.78	21.56	20.34	18.43	136.80	
754.5	7.17	-7.6	25.1	24.54	22.32	21.65	18.67	134.70	
753.8	7	-5.4	25.22	24.24	23.32	21.23	18.98	126.28	
755.4	8.67	-6.8	22.34	22.65	21.34	19.87	16.78	122.07	
756.2	8.5	-3.1	22.97	20.77	20.21	19.38	17.47	143.12	
754.98	7.802		24.038	23.196	21.75	20.494	18.066	132.59	
Bus									
755	7.67	-6.7	18.9	17.4	16.6	16.6	15.3	60.39	
754.5	7.17	-7.6	19.98	18.56	17.24	15.67	14.86	60.91	
753.8	7	-5.4	20	19.32	18.62	16.93	14.86	62.66	
755.4	8.67	-6.8	18.45	18.80	17.75	16.54	14.00	55.69	
756.2	8.5	-3.1	18.4	17.3	16.2	15.12	14.24	64.40	
754.98	7.802		19.146	18.276	17.282	16.172	14.652	60.81	
T&TT									
755	7.67	-6.7	18	17.1	16.5	16.6	14.7	41.12	
754.5	7.17	-7.6	19.65	18.75	17.21	16.27	15.5	45.89	
753.8	7	-5.4	21.4	20.32	19.56	17.89	16.3	51.40	
755.4	8.67	-6.8	19.20	17.32	16.43	15.27	14.20	48.95	
756.2	8.5	-3.1	20.1	19.5	17.8	16.3	13.5	47.73	
754.98	7.802		19.67	18.598	17.5	16.466	14.84	47.02	

Vehicle	Upstream Distance(M)@					Time Taken (Travel) in Seconds @					Average Speed (Km/Hr)				
	25	20	15	10	5	25	20	15	10	5	25	20	15	10	5
Cycle,motor&Bajaj	25	20	15	10	5	0.95	0.95	1.1	1.12	1.12	18.9	18.9	16.4	16.1	16.1
Light Vehicle	25	20	15	10	5	0.9	1.05	1.04	1.07	1.12	20.0	17.1	17.3	16.8	16.1
Mini Bus,pickup&Taxi	25	20	15	10	5	0.95	1.025	1.1	1.025	1.04	18.9	17.6	16.4	17.6	17.3
Bus	25	20	15	10	5	0.95	1.035	1.085	1.085	1.12	18.9	17.4	16.6	16.6	16.1
Track &Track Train	25	20	15	10	5	1	1.05	1.09	1.11	1.12	18.00	17.1	16.5	16	16.1

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Salite Mihret to Summit(Both Sides)(8 speed Humps)										
B,M&MC										
	SHL(cm)	Height	Grade	V25	V15	V10	V5	Delay(veh-min)		
	755.6	9.83	-2.6	18.5	16.8	17.1	17	30.56		
	756	8	-5.4	20.4	17.54	16.89	14.5	31.49		
	756.3	7.33	-5.1	21	19.3	17.4	16.3	32.88		
	755.3	8.17	-3.2	19.32	17.3	16.21	15.3	34.64		
	757	7	-6.8	23.3	20.34	18.87	17.3	36.12		
	755.8	7.5	-7.4	22	20.43	18.67	15.23	31.49		
	754.9	6.63	-10.7	24.45	22.3	20.34	18.2	33.81		
	754	7.43	-2.8	20.54	18.21	17.43	15.65	37.97		
	755.61	7.74	-5.50	21.19	19.03	17.86	16.19	33.62		
				Car						
	755.6	9.83	-2.6	20.8	18.3	18.1	17.1	179.13		
	756	8	-5.4	21.76	17.78	15.89	15.5	185.76		
	756.3	7.33	-5.1	21.45	18.32	17.11	15.87	185.76		
	755.3	8.17	-3.2	20.32	18.8	16.79	14.36	165.86		
	757	7	-6.8	23.45	20.78	19.45	17.33	208.98		
	755.8	7.5	-7.4	22	18.6	17.31	15.66	195.71		
	754.9	6.63	-10.7	21.76	18.97	16.85	15.33	189.74		
	754	7.43	-2.8	20.32	18.63	16.84	14.74	202.35		
				21.48	18.77	17.29	15.74	189.16		
				M,P&T						
	755.6	9.83	-2.6	19.1	18.4	18.2	17.6	96.51		
	756	8	-5.4	24.2	20.89	19.88	17.35	98.42		
	756.3	7.33	-5.1	26.33	22.78	20.38	14.78	92.07		
	755.3	8.17	-3.2	23.56	20.55	18.33	16	101.59		
	757	7	-6.8	26.45	22.88	20.98	18	90.48		
	755.8	7.5	-7.4	24	20.65	18.57	16.87	106.36		
	754.9	6.63	-10.7	26.5	22.78	20.69	16.87	108.58		
	754	7.43	-2.8	22.35	18.65	16.29	14.53	105.40		
				24.06	20.95	19.17	16.50	99.93		
				Bus						
	755.6	9.83	-2.6	19.5	19.2	18.8	16.89	10.62		
	756	8	-5.4	18.86	16.22	14.66	13.22	9.65		
	756.3	7.33	-5.1	20.33	17.55	16.05	15.11	11.58		
	755.3	8.17	-3.2	19.34	16.78	14.89	12.56	12.22		
	757	7	-6.8	19.24	16.23	15.55	13.67	12.55		
	755.8	7.5	-7.4	19.15	17.45	15.88	13.99	10.94		
	754.9	6.63	-10.7	20.3	16.77	15.66	14.25	11.26		
	754	7.43	-2.8	20.2	18.85	17.96	17.85	12.55		
				19.62	17.38	16.18	14.69	11.42		
				T&TT						
	755.6	9.83	-2.6	18.56	15.9	15.8	14.8	88.04		
	756	8	-5.4	19.65	17.77	16.44	14.32	93.72		
	756.3	7.33	-5.1	20.32	17.96	16.87	14.4	85.2		
	755.3	8.17	-3.2	18.45	16.46	13.53	9.67	99.4		
	757	7	-6.8	19.88	15.65	13	11.11	107.92		
	755.8	7.5	-7.4	19.22	15.35	14.77	13.33	99.4		
	754.9	6.63	-10.7	21.57	17.47	15.36	13.54	116.44		
	754	7.43	-2.8	19.05	15.88	13.44	9.66	102.24		
				19.59	16.56	14.90	12.60	99.05		

Vehicle	Upstream Distance(M)@					Average Speed(Km/Hr)									
	25	20	15	10	5	20	15	10	5	25	20	15	10	5	
Cycle,motor & Bajaj	25	20	15	10	5	0.975	1.085	1.05	1.06	#REF!	18.5	16.6	17.1	17.0	
Light Vehicle	25	20	15	10	5	0.99	1.04	1.05	1.05	#REF!	18.2	17.3	17.1	17.1	
Mini Bus,pick up&Ta	25	20	15	10	5	0.92	0.98	0.99	1.02	#REF!	19.6	18.4	18.2	17.6	
Bus	25	20	15	10	5	1.04	1.04	1.07	1.06	#REF!	17.3	17.3	16.8	17.0	
Track & Track Train	25	20	15	10	5	1.1	1.13	1.16	1.22	#REF!	16.4	15.9	16	14.8	

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Goro RA to jakros Junction (Both Sides)(8 speed Humps)													
	SHL(cm)	Height	Grade(%)	B,M&MC			V10	V5	Delay(veh-min)				
				V25	V20	V15							
	754.5	6.83	-4.3	34.6	29.45	25.67		24.43	19.4	8.53			
	754.6	5.83	-5.4	28.45	26.22	25.3		23.33	21.4	9.10			
	756.7	7.5	-4.5	24.78	22.68	21.54		19.54	17.88	9.95			
	754.5	8.33	-9.9	24.42	21.98	20.56		18.77	16.43	11.09			
	754.8	5.33	-11.2	29.43	26.76	25.11		23.66	20.76	9.81			
	753.8	7.13	-7.4	21.56	19.76	17.43		16.88	15.97	11.23			
	755.5	7.4	-7.9	22.46	20.83	18.76		17	15.9	9.10			
	756.3	6.67	-7.3	23.22	20.14	18.33		16.22	14.77	8.95			
	755.09	6.88	-7.24	26.12	23.48	21.59		19.98	17.81	9.72			
				Car									
	754.5	6.83	-4.3	18.1	16.18	16.2		15.9	15.8	428.12			
	754.6	5.83	-5.4	24.54	22.76	20.87		17.55	15.55	460.35			
	756.7	7.5	-4.5	21.54	20.33	19.54		16.87	14.65	475.69			
	754.5	8.33	-9.9	19.91	19	18.2		17.32	16.6	460.35			
	754.8	5.33	-11.2	23.99	22.32	20.58		18.68	16.66	491.03			
	753.8	7.13	-7.4	18.65	18.2	17.45		16.58	14.76	498.71			
	755.5	7.4	-7.9	18.78	17.56	16.89		16	13.33	514.05			
	756.3	6.67	-7.3	19.96	18.64	17.22		13.4	14.11	454.21			
	755.09	6.88		20.68	19.37	18.37		16.54	15.18	472.81			
				M,P&T									
	754.5	6.83	-4.3	19.5	18.6	17.8		17	16.4	347.71			
	754.6	5.83	-5.4	24.43	21.78	20.65		16.43	11.54	359.70			
	756.7	7.5	-4.5	22.22	20.43	18.96		17.68	13.22	371.68			
	754.5	8.33	-9.9	18.88	17.21	15.56		14.33	12.54	383.67			
	754.8	5.33	-11.2	25.89	23.77	21.65		20.67	15.9	377.68			
	753.8	7.13	-7.4	17.45	19.56	17.24		14.77	11.67	378.52			
	755.5	7.4	-7.9	18.44	16.54	14.33		12.55	10.25	383.67			
	756.3	6.67	-7.3	22.94	18.43	16.88		15.89	12.55	342.91			
	755.09	6.88		21.22	19.54	17.88		16.17	13.01	368.19			
				Bus									
	754.5	6.83	-4.3	17.1	15.7	16.4		15.7	15.4	152.16			
	754.6	5.83	-5.4	21.33	22.3	19.54		17.34	14.87	153.22			
	756.7	7.5	-4.5	19.22	17.45	15.33		14.78	13.22	158.50			
	754.5	8.33	-9.9	17.24	15.67	13.22		12.65	9.56	166.43			
	754.8	5.33	-11.2	24.34	21.87	18.99		16.32	13.67	184.92			
	753.8	7.13	-7.4	19.56	23.45	17.67		15	13.12	176.99			
	755.5	7.4	-7.9	18.76	17.67	15.54		13.43	12.22	171.71			
	756.3	6.67	-7.3	18.43	16.65	15.55		13.34	12.26	205.52			
	755.09	6.88		19.50	18.85	16.53		14.82	13.04	171.18			
				T&TT									
	754.5	6.83	-4.3	17.73	16.4	15.7		16	15.49	218.81			
	754.6	5.83	-5.4	23.23	20.23	17.89		17.34	15.21	210.85			
	756.7	7.5	-4.5	20.34	17.67	15.45		13.24	10.67	234.72			
	754.5	8.33	-9.9	17.26	14.69	15.67		13.33	10.23	250.64			
	754.8	5.33	-11.2	20.35	18.3	16.77		18.88	14.34	246.66			
	753.8	7.13	-7.4	18.88	19	18.33		17	16.75	258.59			
	755.5	7.4	-7.9	20.23	21.67	20.45		18.45	14.9	219.60			
	756.3	6.67	-7.3	23.4	17.89	16.34		13.78	11	242.68			
	755.09	6.88		20.18	18.23	17.08		16.00	13.57	235.32			

Vehicle	Upstream Distance(M)@					Time Taken(Travel) in Seconds @					Average Speed(Km/Hr)				
	25	20	15	10	5	25	20	15	10	5	25	20	15	10	5
Cycle,motor & Bajaj	25	20	15	10	5	0.52	0.86	0.94	0.9	0.93	34.6	20.9	19.1	20.0	19.4
Light Vehicle	25	20	15	10	5	0.995	1.07	1.11	1.14	1.135	18.1	16.8	16.2	15.8	15.9
Mini Bus,pick up&Taxi	25	20	15	10	5	0.925	0.97	1.01	1.06	1.095	19.5	18.6	17.8	17.0	16.4
Bus	25	20	15	10	5	1.05	1.15	1.1	1.15	1.17	17.1	15.7	16.4	15.7	15.4
Track & Track Train	25	20	15	10	5	1.015	1.095	1.15	1.15	1.165	17.73	16.4	15.7	16	15.5

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Ayer tena to Wingate(Both Sides) 8												
				B,M&MC								
	SHL(cm)	Height	Grade	V25	V15	V10	V5	Delay(veh-min)				
	1103.5	8.64	-3.2	48.5	46.7	46.2	46	16.7335				
	1105	9.83	-6.8	46.4	50.76	45.78	43.3	17.075				
	1120	7.67	-5.7	49.7	46.54	46.3	42.56	18.441				
	1102.3	7.84	-3.3	46.4	42.67	41.54	39.05	22.8805				
	1120.9	9.42	-5.6	44.45	42.34	39.87	36.89	25.271				
	1118	8.17	-6.3	50.33	46.67	44.54	43.37	24.588				
	1117.5	7.79	-3.8	49.68	46.76	44.89	43.24	28.686				
	1103.5	7.12	-2.8	51.3	47.35	46.55	44.22	25.954				
	1111.34	8.31	-4.69	48.35	46.22	44.46	42.33	22.45				
				Car								
	1103.5	8.64	-3.2	47.5	44.68	43.25	40.76	765.39				
	1105	9.83	-6.8	49.34	43.45	41.65	35.89	751.96				
	1120	7.67	-5.7	40	34	33.3	32.1	671.39				
	1102.3	7.84	-3.3	46.57	40.24	36.89	36.5	822.46				
	1120.9	9.42	-5.6	45.77	42.24	40.14	38.16	822.46				
	1118	8.17	-6.3	49.86	43.78	41.67	39.2	788.89				
	1117.5	7.79	-3.8	46.86	42.67	36.66	30.2	738.53				
	1103.5	7.12	-2.8	46.43	38.63	35.98	29.89	671.39				
	1111.34	8.31		46.54	41.21	38.69	35.34	754.06				
				M,P&T								
	1103.5	8.64	-3.2	51.4	45.4	43.4	42.3	303.3427833				
	1105	9.83	-6.8	50.45	44.68	43.13	42.74	320.12855				
	1120	7.67	-5.7	54.55	49.38	46.93	44.53	323.7255				
	1102.3	7.84	-3.3	52.37	49.54	45.87	43.96	287.756				
	1120.9	9.42	-5.6	47.43	44.84	43.53	41.87	347.7051667				
	1118	8.17	-6.3	50.43	46.32	44.74	43.34	371.6848333				
	1117.5	7.79	-3.8	51.43	47.88	45.33	43.65	398.0624667				
	1103.5	7.12	-2.8	53.6	47.43	45.89	44.85	366.8889				
	1111.34	8.31		51.46	46.93	44.85	43.41	339.91				
				Bus								
	1103.5	8.64	-3.2	36	34.6	33.33	30.7	140.01				
	1105	9.83	-6.8	39	36.55	34.77	32.67	142.65				
	1120	7.67	-5.7	45.69	42.56	41.43	39.64	147.93				
	1102.3	7.84	-3.3	43.68	39.88	34.57	32.37	158.50				
	1120.9	9.42	-5.6	39.44	36.85	37.65	34.43	163.78				
	1118	8.17	-6.3	47.54	43.17	40.15	40.05	147.93				
	1117.5	7.79	-3.8	48	43.86	41.44	37.59	146.88				
	1103.5	7.12	-2.8	48.8	43.76	41.53	38.77	174.35				
	1111.34	8.31		43.52	40.15	38.11	35.78	152.75				
				T&TT								
	1103.5	8.64	-3.2	40	32.7	30	29.4	189.37				
	1105	9.83	-6.8	41.45	39.87	37.68	34.6	198.92				
	1120	7.67	-5.7	50.21	44.69	38.76	37.19	230.74				
	1102.3	7.84	-3.3	48.16	43.27	42.77	40.87	230.74				
	1120.9	9.42	-5.6	44.63	40.32	39.33	35.23	214.83				
	1118	8.17	-6.3	46.24	40.63	38.75	33.15	246.66				
	1117.5	7.79	-3.8	48.24	44.39	41.76	36.77	274.51				
	1103.5	7.12	-2.8	49.18	41.58	39.74	34.83	290.42				
	1111.34	8.31		46.01	40.93	38.60	35.26	234.52				

Vehicle	Upstream Distance(M)@					Average Speed(Km/Hr)							
	25	20	15	10	5	20	15	10	5	25	20	10	5
Cycle,motor & Bajaj	25	20	15	10	5	0.33	0.335	0.345	0.365	#REF!	54.5	52.2	49.3
Light Vehicle	25	20	15	10	5	0.5	0.53	0.54	0.56	#REF!	36.0	33.3	32.1
Mini Bus,pick up&Taxi	25	20	15	10	5	0.4	0.425	0.435	0.457	#REF!	45.0	41.4	39.4
Bus	25	20	15	10	5	0.52	0.52	0.54	0.7	#REF!	34.6	33.3	25.7
Track & Track Train	25	20	15	10	5	0.47	0.55	0.6	0.62	#REF!	38.3	30	29.0

Appendix C

Questionnaire

ADDIS ABABA UNIVERSITY
Addis Ababa Institute of Technology
School of Civil and Environmental Engineering

PERSONAL QUESTIONNAIRE

Dear Respondents;

I am attending my MSc study in the stream of Road and transport Engineering at **Addis Ababa Institute of Technology (AAIT)**. Currently, I am doing a research study entitled with, **“The effect of speed calming Measures on Traffic flow at selected Roads in Addis Ababa”**.

The research is conducted for the partial fulfillment of the **masters of Science** in Road and Transport Engineering stream.

Your personal reaction and response will be kept strictly confidential. Only I and my academic supervisors will access the information that you share to me and exclusively used for the research work. Therefore, I request you to complete the questionnaire genuinely to help me to finalize the research on time.

I would like to thank you for your cooperation, and looking forward to receive your response early.

With best regards;

Part I

Personal Background

1. Gender
 - 1) Male
 - 2) Female
2. Age
 - 1) 18-35
 - 2) 36-60
 - 3) above 60
3. Educational background
 - 1) 1----12
 - 2) Certificate
 - 2) college (Diploma)
 - 3) BSC
 - 4) MSc. and above

Part II

Please mark (✓) on the best idea and explain in the space provided if any.

4. How do you travel place to place in the Transportation system?
 1. As a Driver
 2. As a Passenger
 3. Both alternatively
5. How much you going on roads which have speed humps
 1. Always
 2. Usually,
 3. often
 4. sometimes
 5. Never
6. What do you suppose the placement of speed humps on road segments?
 1. Properly placed by keeping perfect visibility
 2. Improper placement with lack of perfect visibility
 3. Specify any idea beyond the two
.....
7. How can drivers adopt and accustom the purpose of speed humps on road segments?
 1. They anger due to the presence of speed humps
 2. They talk the advantage of speed hump even they reduce the vehicle speed
 3. They simply pass the hump and no care for safety
 4. Any idea please specify
.....
8. Do speed humps effective for the reduction of crush, damage and loss of life in Addis Ababa?
 1. Yes, they reduce the accident
 2. Slightly reduce the accident
 3. No, they do not reduce the accident
 4. No correlation
9. If the answer for question no 8 is 3, what is the reason for this?
 1. Drivers do not respect the speed limit
 2. Pedestrians do not respect the traffic law
 3. The speed humps are not adopted well by road users
 4. All are the causes

5. Any idea, please
specify.....
10. How do you evaluate the geometry of speed humps with the road?
1. Effectively fitted with the road
 2. Rise and fall /improper geometry/
 3. Creates cracks on roads
 4. No idea
11. What is the potential effect of speed humps on adjacent road which have no speed humps?
1. Creates many vehicles prefer the road and cause congestion
 2. Cause damage of the road due to excess vehicles going there
 3. Cause collision of vehicles, crush of people and property
 4. all are the occasions
12. On which vehicle does the discomfort of speed hump probably high?
1. Bus
 2. Taxi
 3. Mini bus
 4. Light vehicle
 5. Motor cycle
 6. Others
13. Which type of Speed hump is most comfortable when crossing over (longitudinal view)?
1. Trapezoidal
 2. Sinusoidal/parabolic
 3. Circular
14. How do you evaluate the effectiveness of speed hump on minimization of speeds in the city?
1. Largely decrease the car speed
 2. Slightly decrease the car speed.
 3. No effect on speed reduction.
 4. Any idea.....
15. How much is your travel speed decreased due to the presence of speed hump?
1. 0---2km/hr
 2. 2---4km/hr
 3. 4---6km/hr
 4. 6---8km/hr
 5. 8---9km/hr
 6. Above 10km/hr

16. How much speed humps affect emergency vehicles like hospital ambulances, police, and Fire and emergency vehicles?
 1. Excessively affect the movement to reach on time
 2. Sometimes affect the movement to reach on time
 3. No effect on their movement
 4. Any other.....
17. How do you observe the impact of speed humps on the side road users?
 1. Cars closely approach toward the edge and cause damage and frustration
 2. Going away from the interior edge and save them
 3. Simply prefer going
 4. No effect at all
18. How do you see the sign description of speed humps on roads?
 1. The sign is clearly informed
 2. The sign information is lacked
 3. The information is described in wrong way
 4. No need of information
19. Is the spacing/frequency/ of speed humps convenient for motor vehicles?
 1. Installed in normal interval to enhance movement and safety
 2. Are not installed in uniform interval
 3. It is variable as the geometrical nature of the road
 4. Any idea, specify.....
20. What problems mostly facing peoples which are dwelling/living around roads that have speed humps?
 1. Problem of noisy leading to hearing impairments
 2. Problem of restlessness
 3. Problem of shocking
 4. All are expected
21. The angle /installation direction/of speed humps is
 1. Good

- 2. Fair
 - 3. Bad
 - 4. None
22. What hydro-vehicular effect do speed humps have?
- 1. Cause flooding which is difficult for driving of vehicle
 - 2. Bring siltation that pound at the upstream side and cause of slippery of road users
 - 3. Both are the effects
 - 4. Do not have any effect
23. What do you feel/sense when the vehicle cross over the speed hump?
- 1. Shivering
 - 2. Vertical acceleration
 - 3. Horizontal acceleration
 - 4. All are expected
24. How many minutes you lost /delay on travel of roads which have speed humps?
- 1. 0----2
 - 2. 2----4
 - 3. 4----6
 - 4. 6----8
 - 5. 8----10
 - 6. Above 10

Part III

Please write your best solution for the following cases:

- 1. What do you propose for reduction of excessive speed if speed humps are not effective?.....
- 2. What is the psychological effect of speed humps on drivers?.....
- 3. Is the profile of rumble strips and speed humps on public roads are comfortable for residents? Please describe.....
- 4. Could you please mention the effective speed reducing measures?.....
- 5. How much is the posted speed limit compatible with the nature of speed hump?.....

Part III

Rate the following ideas/draw backs/ as per the allocated value

- | | | | |
|-----------------------------|-----------|---------------------------|------------|
| Very comfortable | =4 | Uncomfortable | = 1 |
| Comfortable | =3 | Very Uncomfortable | =0 |
| Slightly Comfortable | =2 | | |

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

S.No	Speed Hump Problems identified	Degree of comfort				
		4	3	2	1	0
1	Disables with wheel chairs on the car					
2	For pregnant passengers					
3	Elder passengers on any type of car					
4	Passengers which sit at the rear					
5	Effect on erected passengers					

Thank You !!!!!!!!!!!

አዲስ አበባ ዩኒቨርሲቲ

አዲስ አበባ ኢንስቲትዩት ኦፍ ቴክኖሎጂ

የሲቪል እና አካባቢ ምህንድስና ት/ት ክፍል

ግላዊ መጠይቅ

ውድ የመጠይቁ መላሾች:-

እኔ በአዲስ አበባ ዩኒቨርሲቲ በአዲስ አበባ ኢንስቲትዩት ኦፍ ቴክኖሎጂ የ2ኛ ዲግሪ ትምህርቴን እየተከታተልኩ እገኛለሁ በመሆኑም ጥናት(ሪሶርች) እየሰራሁ የምገኝህ ሆን የጥናቱም ርዕስ"በአዲስ አበባ ከተማ ውስጥ በመንገድ ላይ የሚገነቡ የፍጥነት መቀነሻዎች(ማብረጃዎች) በመንገድ ተጠቃሚዎች ላይ ያላቸው ተፅዕኖን በተመለከተ ነው።ይህ ጥናት የሚሰራው በመንገድ እና ትራንስፖርት ትምህርት የ2ኛ ዲግሪ ትምህርትን ለማጠናቀቅ ነው።እርስዎ የሚሰጡት ግብረ መልስ ምስጥሩ የተጠበቀ እና ለዚህ ጥናት አላማ ብቻ ያደረገ ሲሆን እኔና የትምህርት ክፍሉ ብቻ የምንጠቀምበት ይሆናል።ስለዚህ ይህንን መጠይቅ በእውነታ ላይ ተመስርተው ሞልተው ከሰጡኝ ጥናቱን በሰዓቱ ለማጠናቀቅ ስለሚረዱኝ ባለዎት ጊዜ እንዲተባበሩኝ ስል እጠይቃለሁ።ላደረጉልኝ ትብብር ትልቅ ምስጋና እያቀረብኩ በቶሎ መጠይቁን ሞልተው እንደሚሰጡኝ በመተማመንነው።

ከሰላምታጋር

ክፍል - 1

- 1. ፆታ
 - ሀ. ወንድ ለ. ሴት
- 2. እድሜ
 - ሀ.18 - 35 ለ. 36 - 60 ሐ.ከ60 በላይ
- 3. የትምህርት ደረጃ
 - 1. 1-12 ኛ
 - 2. ሰርትፊኬት 3. ዲግሪ
 - 4. ኮሌጅ(ዲፕሎማ)
 - 5. 2ኛ ዲግሪ እና ከዚያ በላይ

ክፍል-2

የተሻለ ይሆናል የሚሉትን ሃሳብ(✓) በማድረግ እና በተሰጠው ክፍት ቦታ ላይ ያለዎትን ሃሳብ ያስቀምጡ

4. ከቦታ ቦታ የሚንቀሳቀሱት እንዴት ነው?
 1. እንደ ሹፌርሁኝ በመንዳት 2. እንደ ተሳፋሪ ሁኔ 3. በተለያዩ ጊዜ ሁለቱንም
5. ፍጥነት መቀነሻ (ማብረጃ) ባለው መንገድ ላይ ስንት ጊዜ ይሄዳሉ?
 1. ሁልጊዜ 2. አብዛኛውን ጊዜ 3. ዘወትር 4. አንዳንድ ጊዜ 5. ሂጃላቅም
6. በመንገድ ላይ ስለተሰሩት የፍጥነት መቀነሻዎች ምን ሃሳብ አለዎት?
 1. እይታን በሚያሳልጥ መልኩ በትክክል ተቀምጠዋል 2. እይታን በሚከለክል መልኩ ተቀምጠዋል
 3. ሀሳብ ካለዎት _____
7. የፍጥነት መቀነሻ ባላቸው መንገዶች ላይ አሽከርካሪዎች የፍጥነት መቀነሻዎቹን አላማ እንዴት ይቀበሉታል?
 1. የፍጥነት መቀነሻ መኖሩ ያናድዳቸዋል
 2. ምንም እንኳን ፍጥነታቸውን ቢቀንሰባቸውም ስለፍጥነት መቀነሻዎች ጥቅም ያውቃሉ
 3. ስለደህንነት ሳይጨነቁ አልፈዋቸው ይነዳሉ
 4. ሀሳብ ካለዎት -----
8. በከተማይቱ ያሉት የፍጥነት መቀነሻዎች ጉዳት ግጭትንና ሞትን ቀንሰዋል ብለው ያስባሉ?
 1. አዎ በጣም ቀንሰዋል 2. በተወሰነ ደረጃ ቀንሰዋል 3. ምንም አልቀነሱም 4. ከጉዳት ጋር ግንኙነት የላቸውም
9. በተራ ቁጥር 8 ለተጠቀሰው ጥያቄ መልስዎ 3 ከሆነ ምክንያቱ ምንድን ነው?
 1. አሽከርካሪዎች የፍጥነት መቀነሻ ህግን ስለማያከብሩ
 2. እግረኞች የፍጥነት የትራፊክ ህግን ስለማያከብሩ
 3. የፍጥነት መቀነሻዎቹ በመንገድ ተጠቃሚዎች ያልተለመዱ በመሆናቸው
 4. ሁሉም ምክንያት ናቸው
 5. ሌላ ሀሳብ ካለዎት -----
10. የፍጥነት መቀነሻዎቹን ዲዛይን ከመንገዱ አንጻር እንዴት ያዩታል?

1. በትክክል ከመንገዱ ጋር የሚስማማ ነው 2. ወጣ ገባ ወይም የማይጣጣም ነው

3. መንገዱ እንዲሰነጣጠቅ እያደረገ ነው 4. ሀሳብ የለኝም

11. የፍጥነት መቀነሻ ያለው መንገድ በአካባቢው ለሚገኝ የፍጥነት መቀነሻ ለሌለው መንገድ ምን ውጤት አለው?

1. ብዙ መኪና እንዲጓዝበት እና የትራፊክ መጨናነቅ እንዲኖርበት ያደርጋል

2. መንገዱ መኪና ስለሚበዛበት በአጭር ጊዜ ውስጥ እንዲጎዳ ያደርጋል

3. መኪኖች እንዲጋጨ፣ ሰዎች እንዲጎዱ እናን ብረት እንዲወድም ያደርጋል

4. ሁሉም የሚከሰቱ ናቸው

12. በየትኛው የትራንስፖርት ሰጪ ተሽከርካሪ ላይ የፍጥነት መቀነሻ በአንጻራዊነት ያለመመቸት ጉዳት አለው?

1. አውቶቡስ 2. ታክሲ 3. ሚኒባስ 4. የቤት መኪና

5. ሞተር ሳይክል 6. ሌሎች

13. የትኛው አይነት የፍጥነት መቀነሻ ለማቋረጥ ምቹነት ይሰጣል?

1. ትራፒደይዳል 2. ሲኖሲዳል (ፓራቦሊክ) 3. ክብ (ሰርኩላር)

14. በከተማ ውስጥ ያለው የፍጥነት መቀነሻ (ማብረጃ) ምን ያክል ፍጥነትን ቀንሷል ብለው ያስባሉ?

1. በከፍተኛ ደረጃ ቀንሷል 2. በመካከለኛ ደረጃ ቀንሷል

3. ለፍጥነት መቀነስ አስተዋፅኦ የለውም 4. ሌላ ሀሳብ ካለዎት -----

15. የፍጥነት መቀነሻ በመኖሩ ምክንያት ፍጥነትዎ በምን ያክል ቀንሷል ብለው ያስባሉ?

1. 0----2ኪ/ሰ. 2. 2----4ኪ/ሰ. 3. 4----6ኪ/ሰ. 4. 6----8ኪ/ሰ.

1. 8----10ኪ/ሰ. 6. >10ኪ/ሰ.

16. የፍጥነት መቀነሻ በመኖሩ ምክንያት ምን ያክል የህክምና አምቡላንሶች ፣ የአሳትና ድንገተኛ መኪናዎች ስራቸውን ማከናወን አልቻሉም ብለው ያስባሉ?

1. በጣም ስለሚያዘጋጅባቸው ስራቸውን በአግባቡ ለመፈፀም አልቻሉም

2. አንዳንድ ጊዜ ፍጥነታቸውን ይገድብባቸዋል

3. በፍጥነታቸው ላይ ጉዳት የለውም

4. ሌላ ሀሳብ ካለዎት -----

17. በመንገዱ አጠገብ በሚጠቀሙ ሰዎች ላይ የፍጥነት መቀነሻ ምን ተፅዕኖ አለው?

1. መኪናዎች ወደውጭ (ጫፍ) እንዲጠጉ ስለሚያደርግ ሰዎች በመኪና እንዲጎዱና ፍርሃት እንዲያደርግባቸው ያደርጋል።

2. መኪኖች ወደ ውስጠኛው መስመር ስለሚጠጉ ጉዳት ይቀንሳል
3. መኪኖች ያለምንም ተፅዕኖ በፍጥነት መቀነሻው ላይ በቀላሉ መሄድን ይመርጣሉ
4. ምንም ተፅዕኖ የለውም

18. የፍጥነት መቀነሻ ምልክቶችን እንዴት ይገመግሟቸዋል?

1. ምልክቶቹ በትክክል ተቀምጠዋል
2. ምልክቶቹ በትክክል አልተቀመጡም
3. ምልክቶቹ የተገለፁት በትክክለኛ መንገድ አይደለም
4. ለምልክቶቹ መግለጫ አያስፈልግም

19. የፍጥነት መቀነሻዎቹ ርቀት ለመኪኖች ምቹ ነው ብለው ያስባሉ?

1. አዎ በተገቢው ርቀት ተቀምጠው እንቅስቃሴን ያፋጥናሉ
2. በተገቢው ርቀት አልተቀመጡም
3. ርቀታቸው እንደ መንገዱ አቀማመጥ ይወሰናል
4. ሌላ ሀሳብ ካለዎት -----

20. ፍጥነት ማብረጃ (መቀነሻ) ባሉባቸው መንገዶች አካባቢ የሚኖሩ ማህበረሰብ ምን አይነት ችግር ይገጥማቸዋል?

1. የመኪና ድምፅ ጩኸት ብሎም የመስማት ችግር
2. እረፍት ማጣትና መረበሽ እንዲሁም መደንገጥ
3. ሁሉም ይከሰታሉ

21. የፍጥነት መቀነሻ ከመንገድ አቅጣጫ አንፃር ምን ይመስላል?

1. ጥሩ ነው
2. ተገቢ ነው
3. መጥፎ ነው
4. ሀሳብ የለኝም

22. የፍጥነት መቀነሻዎች ምን አይነት የውሃ - መኪናዊ ተፅዕኖ አላቸው?

1. ጎርፍ ስለሚያስከትሉ ለማሽከርከር ያስቸግራል
2. በላይ በኩል የደለል ክምችት ስለሚኖር መኪና ያንሸራትታል
3. ሁሉም ይከሰታሉ
4. ምንም አይነት ተፅዕኖ የላቸውም

23. መኪና በፍጥነት መቀነሻ ላይ ሲያልፍ ምን ምልክት ያሳያል?

1. ይንቀጠቀጣል
2. ወደ ላይ ይዘላል

3. ወደ ጎን ይንቀሳቀሳል

4. ሁሉም ይከሰታሉ

24. የፍጥነት መገደቢያ በመኖሩ ምክንያት በጉዞ ላይ ምን ያክል ደቂቃ ያባክናሉ(ይዘገያሉ)?

1. 0--2 2. 2--4 3. 4--6 4. 6--8 5. 8--10 6. >10

ክፍል - 3

ትክክለኛ የሚሉትን ሃሳብ በፀ-ሁፍ ያስቀምጡ።

1. የፍጥነት መቀነሻ ውጤታማ አይደለም ብለው ካሰቡ ምን ቢደረግ ይሻላል ብለው ያስባሉ?

2. የፍጥነት መቀነሻ በአሽከርካሪዎች ስነ - ባህሪ ላይ ምን ተጽዕኖ አለው?

3. የፍጥነት መቀነሻዎች ማለትም Speed Hump/breaker/ እና /Rumble strip/ በህዝብ መንገድ ላይ ምቹነት አላቸው? ሀሳብዎን ይግለፁ?

4. ከላይ ከተጠቀሱት የፍጥነት መቀነሻዎች የተሻለ ቴክኖሎጂ ካለ ይጥቀሱ?

5. ለፍጥነት መቀነሻ የተለጠፈው የፍጥነት መገደቢያ ከፍጥነት መቀነሻው አሰራር ጋር ይስማማል? ሀሳብዎን ይግለፁ

ክፍል-4

በሚከተለው ሰንጠረዥ የተጠቀሱትን ሀሳቦች ባለው እውነታ ላይ ተመስርተው የምቹነት ደረጃቸውን ይግለፁ።

በጣም ምቹ = 4

የማይመች = 1

ምቹ = 3

በጣም የማይመች = 0

መካከለኛ = 2

ተ.ቁ	የፍጥነት መገደቢያ መግለጫ	የምቹነት ደረጃ				
		4	3	2	1	0
1	በተሽከርካሪ ወንበር ለሚጓዙ አካል ጉዳተኞች					
2	ነፍሰ ጡር ለሆኑ እናቶች					
3	የእድሜ ባለፀጋ ለሆኑ ሰዎች					
4	ከኋላ ወንበር ለተቀመጡ ተሳፋሪዎች					
5	ቆመው ለሚጓዙ ተሳፋሪዎች					

አመሰግናለሁ!!!!!!!!!!!!

Appendix D

Field Images



Figa to salitemihret



Jakros to Goro R.A



Wosen to Abeyem Hotel



Noc to Tor hayloch to Wingate

Appendix E

Result of Regression Analysis

E.1 Regression Analysis for Car

A. Delay versus A. SHL, A. SHH, G, A. S @25m

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S @25m

Regression Equation

$$A.D = 136 - 0.450 A.SHL - 34.0 A. SHH - 12.90 G + 27.74 A. S @25m$$

Coefficients

Table 4.6 statistics of delay at 25m for car

Term	T-Value	P-Value
Constant	0.62	0.540
A.SHL	-2.22	0.031
A. SHH	-1.70	0.096
G	-1.73	0.090
A. S @25m	8.49	0.000

R-sq=0.69

R-sq Adj=0.72

$$A.S@25m = -15.31 + 0.047A.SHL - 0.062 G, R-Sq.Adj=0.58$$

$$A.S@25m = 19.25 + 1.03 A.SHH + 0.55 G, R-Sq.Adj=0.81$$

B. Delay versus A. SHL, A. SHH, G, A. S @20m

Regression Analysis: A.D versus A.SHL, A. SHH, G, A.S @20m

Regression Equation

$$A. D = 199 - 0.472 A.SHL - 37.4 A. SHH - 10.99 G + 29.35 A. S @20m$$

R-sq	R-sq(adj)
0.68	0.65

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Analysis of Variance

Source	F-Value	P-Value
Regression	26.20	0.000
A.SHL	5.04	0.029
A. SHH	3.32	0.074
G	2.08	0.155
A.S @20m	67.19	0.000

A.S@20m= 17.12+1.06 A.SHH+0.485 G, R-Sq.Adj=0.67

A.S@20m= -15.82+0.045A.SHL-0.045 G,R-Sq.Adj=0.61

C. Delay versus A. SHL, A. SHH, G, A. S @15m

Regression Analysis: A.D versus A.SHL, A. SHH, G, A.S @15m

Regression Equation

$$A.D = 206 - 0.474 A.SHL - 37.5 A. SHH - 11.24 G + 30.68 A.S @15m$$

Coefficients

Table 4.7 statistics of delay at 15m for car

Term	Coef	T-Value	P-Value
Constant	206	0.88	0.381
A.SHL	-0.474	-2.17	0.035
A. SHH	-37.5	-1.78	0.081
G	-11.24	-1.44	0.156
A.S @15m	30.68	7.86	0.000

Model Summary

R-sq	R-sq(adj)
0.66	0.63

$R^2=0.66$ and $R^2=0.64$ indicate that the dependent and independent variables have good correlation at 95% confidence level which is significant.

Analysis of Variance

Source	DF	F-Value
Regression	4	24.40
A.SHL	1	4.73
A. SHH	1	3.18
G	1	2.08
A.S @15m	1	61.75

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

$$A.S@15m = -15.82 + 0.044A.SHL - 0.114 G, R-Sq.Adj=0.6$$

$$A.S@15m = 15.96 + 1.02 A.SHH + 0.455 G, R-Sq.Adj=0.06$$

D. Delay versus A. SHL, A. SHH, G, A. S @10m

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S @10m

Regression Equation

$$A. D = 281 - 0.473 A.SHL - 46.5 A. SHH - 12.85 G + 32.12 A. S @10m$$

Coefficients

Table 4.8 statistics of delay at 10m for car

Term	Coef	T-Value	P-Value
Constant	281	1.14	0.260
A.SHL	-0.473	-2.05	0.046
A. SHH	-46.5	-2.11	0.040
G	-12.85	-1.59	0.119
A. S @10m	32.12	7.33	0.000

Model Summary

R-sq	R-sq(adj)
0.64	61.01%

R^2 adj=0.6 indicate a good correlation of dependent and independent variables.

Analysis of Variance

Source	DF	F-Value
Regression	4	21.73
A.SHL	1	4.20
A. SHH	1	4.44
G	1	2.52
A. S @10m	1	53.67

$$A. S@10m = -15.32 + 0.041A.SHL - 0.057 G, R-Sq.Adj=0.62$$

The speed at the 10m upstream distance has positive relationship with speed hump length and negative relationship with the longitudinal grade of the road.

$$A. S@10m = 13.19 + 1.28 A.SHH + 0.47 G, R-Sq.Adj=0.2$$

The speed of 10m upstream distance has both positive relationship with speed hump height and grade.

E. Delay versus A. SHL, A. SHH, G, A. S @5m

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S@5m

Regression Equation

$$A. D = 256 - 0.391 A.SHL - 50.1 A. SHH - 14.08 G + 33.66 A. S@5m$$

Coefficients

Table 4.9 statistics of delay at 5m for car

Term	Coef	T-Value	P-Value
Constant	256	1.01	0.318
A.SHL	-0.391	-1.68	0.099
A. SHH	-50.1	-2.19	0.033
G	-14.08	-1.69	0.097
A. S@5m	33.66	6.91	0.000

R-sq	R-sq(adj)
61.76%	58.64%

Analysis of Variance

Source	DF	F-Value
Regression	4	19.79
A.SHL	1	2.83
A. SHH	1	4.82
G	1	2.85
A. S@5m	1	47.80

$$A. S@5m = -13.9 + 0.038A.SHL - 0.05 G, R-Sq.Adj=0.59$$

Speed has a negative relation with grade and positive relation with length of speed hump.

$$A. S@5m = 11.12 + 1.24 A.SHH + 0.445 G, R-Sq.Adj=0.26$$

E. 2 Regression Analysis for Bajaj, Cycle and Motorcycle

A. Delay versus A. SHL, A. SHH, G, A. S @25m

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S @25m

Regression Equation

$$A. D = 43.9 - 0.0158 A.SHL - 0.19 A. SHH + 1.113 G - 0.085 A. S @25m$$

Coefficients

Table 4.10 statistics of delay at 25m for Bajaj,cycle&Motor

Term	Coef	T-Value	P-Value
Constant	43.9	2.11	0.039
A.SHL	-0.0158	-0.81	0.423

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

A. SHH	-0.19	-0.09	0.928
G	1.113	1.45	0.153
A. S @25m	-0.085	-0.28	0.777

The P-value indicates that the variables are vital to keep the regression model.

Model Summary

R-sq	R-sq(adj)
0.51	0.05

Analysis of Variance

Source	DF	F-Value
Regression	4	0.85
A.SHL	1	0.65
A. SHH	1	0.01
G	1	2.09
A. S @25m	1	0.08

B. Delay versus A. SHL, A. SHH, G, A. S @20m

Regression Analysis: A.D versus A.SHL, A. SHH, G, A.S @20m

Regression Equation

$$A. D = 43.1 - 0.0147 A.SHL - 0.12 A. SHH + 1.114 G - 0.116 A. S @20m$$

Coefficients

Table 4.11 statistics of delay at 20m for Bajaj,cycle&Motor

Term	Coef	T-Value	P-Value
Constant	43.1	2.05	0.045
A.SHL	-0.0147	-0.75	0.457
A. SHH	-0.12	-0.06	0.956
G	1.114	1.45	0.153
A.S @20m	-0.116	-0.36	0.721

Model Summary

R-sq	R-sq(adj)
0.05	0.03

Analysis of Variance

Source	DF	F-Value
Regression	4	0.86
A.SHL	1	0.56
A. SHH	1	0.00
G	1	2.10

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

A.S @20m	1	0.13
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C. Delay versus A. SHL, A. SHH, G, A. S @15m

Regression Analysis: A.D versus A.SHL, A. SHH, G, A.S @15m

Regression Equation

$$A.D = 44.9 - 0.0200 A.SHL - 0.19 A. SHH + 1.114 G + 0.007 A. S @15m$$

Table 4.12 statistics of delay at 15m for Bajaj,cycle&Motor

Coefficients

Term	Coef	T-Value	P-Value
Constant	44.9	2.10	0.040
A.SHL	-0.0200	-0.97	0.335
A. SHH	-0.19	-0.09	0.930
G	1.114	1.45	0.154
A.S @15m	0.007	0.02	0.982

Model Summary

R-sq	R-sq(adj)
0.02	0.00

Analysis of Variance

Source	DF	F-Value
Regression	4	0.83
A.SHL	1	0.95
A. SHH	1	0.01
G	1	2.09
A.S @15m	1	0.00
Error	57	
Total	61	

D. Delay versus A. SHL, A. SHH, G, A. S @10m

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S @10m

Regression Equation

$$A.D = 44.5 - 0.0189 A.SHL - 0.17 A. SHH + 1.113 G - 0.017 A. S @10m$$

Coefficients

Table 4.13 statistics of delay at 10m for Bajaj,cycle&Motor

Term	Coef	T-Value	P-Value
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Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Constant	44.5	2.07	0.043
A.SHL	-0.0189	-0.93	0.358
A. SHH	-0.17	-0.08	0.935
G	1.113	1.45	0.154
A. S @10m	-0.017	-0.05	0.959

Model Summary

	R-sq	R-sq(adj)
	0.055	0.0

Analysis of Variance

Source	DF	F-Value
Regression	4	0.83
A.SHL	1	0.86
A. SHH	1	0.01
G	1	2.09
A. S @10m	1	0.00

E. Delay versus A. SHL, A. SHH, G, A. S @5m

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S@5m

Regression Equation

$$A. D = 44.1 - 0.0183 A.SHL - 0.16 A. SHH + 1.116 G - 0.030 A. S@5m$$

Coefficients

Table 4.14 statistics of delay at 5m for Bajaj,cycle&Motor

Term	Coef	SE Coef	T-Value	P-Value
Constant	44.1	21.7	2.04	0.046
A.SHL	-0.0183	0.0199	-0.92	0.362
A. SHH	-0.16	2.13	-0.08	0.940
G	1.116	0.770	1.45	0.153
A. S@5m	-0.030	0.317	-0.10	0.924

Model Summary

	R-sq	R-sq(adj)
	0.052	0.05

Analysis of Variance

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Source	DF	F-Value	P-Value
Regression	4	0.83	0.511
A.SHL	1	0.84	0.362
A. SHH	1	0.01	0.940
G	1	2.10	0.153
A. S@5m	1	0.01	0.924

Generally, the speed hump length and height have high effect on 15m upstream distance and the speed has high negative effect on delay at 20m. And speed has positive impact at 15m distance.

E.3 Regression Analysis (Multinomial): For Pick Up, Mini Bus & Taxi

A. Delay versus A. SHL, A. SHH, G, A. S @25m

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S @25m

Regression Equation

$$A.D = 250 - 0.031 A.SHL - 34.5 A. SHH - 7.59 G + 6.19 A. S @25m$$

Coefficients

Table 4.15 statistics of delay at 25m for Pick up, Minibus & Taxi

Term	Coef	T-Value	P-Value
Constant	250	1.89	0.064
A.SHL	-0.031	-0.24	0.811
A. SHH	-34.5	-2.68	0.010
G	-7.59	-1.55	0.127
A. S @25m	6.19	3.28	0.002

Model Summary

R-sq	R-sq(adj)
31.73%	26.94%

The R-sq adj=0.269 indicates that good relation of dependent and independent variables.

Analysis of Variance

Source	DF	F-Value	P-Value
Regression	4	6.62	0.000
A.SHL	1	0.06	0.811

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

A. SHH	1		7.20	0.010
G	1		2.40	0.127
A. S @25m	1		10.74	0.002

B. Delay versus A. SHL, A. SHH, G, A. S @20m

Regression Analysis: A.D versus A.SHL, A. SHH, G, A.S @20m

Regression Equation

$$A.D = 265 - 0.052 A.SHL - 33.5 A. SHH - 6.74 G + 6.67 A. S @20m$$

Coefficients

Table 4.16 statistics of delay at 20m for Pick up,Minibus&Taxi

Term	Coef	T-Value	P-Value
Constant	265	2.00	0.051
A.SHL	-0.052	-0.40	0.689
A. SHH	-33.5	-2.63	0.011
G	-6.74	-1.38	0.173
A.S @20m	6.67	3.39	0.001

Model Summary

R-sq	R-sq(adj)
32.49%	27.75%

Analysis of Variance

Source	DF	F-Value
Regression	4	6.86
A.SHL	1	0.16
A. SHH	1	6.90
G	1	1.90
A.S @20m	1	11.50

C. Delay versus A. SHL, A. SHH, G, A. S @15m

Regression Analysis: A.D versus A.SHL, A. SHH, G, A.S @15m

Regression Equation

$$A. D = 271 - 0.037 A.SHL - 35.1 A. SHH - 7.50 G + 6.63 A. S @15m$$

Coefficients

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Table 4.17 statistics of delay at 15m for Pick up,Minibus&Taxi

Term	Coef	T-Value	P-Value
Constant	271	2.03	0.047
A.SHL	-0.037	-0.29	0.773
A. SHH	-35.1	-2.73	0.008
G	-7.50	-1.53	0.131
A.S @15m	6.63	3.32	0.002

Model Summary

R-sq	R-sq(adj)
32.02%	27.25%

Analysis of Variance

Source	DF	F-Value
Regression	4	6.71
A.SHL	1	0.08
A. SHH	1	7.47
G	1	2.35
A.S @15m	1	11.03

D. Delay versus A. SHL, A. SHH, G, A. S @10m

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S @10m

Regression Equation

$$A. D = 311 - 0.058 A.SHL - 37.5 A. SHH - 7.00 G + 7.08 A. S @10m$$

Coefficients

Table 4.18 statistics of delay at 10m for Pick up,Minibus&Taxi

Term	Coef	T-Value	P-Value
Constant	311	2.27	0.027
A.SHL	-0.058	-0.44	0.661
A. SHH	-37.5	-2.91	0.005
G	-7.00	-1.43	0.158
A. S @10m	7.08	3.34	0.001

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
100.036	32.17%	27.41%	20.35%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	4	270547	67637	6.76	0.000

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

A.SHL	1	1950	1950	0.19	0.661
A. SHH	1	84979	84979	8.49	0.005
G	1	20484	20484	2.05	0.158
A. S @10m	1	111880	111880	11.18	0.001

E. Delay versus A. SHL, A. SHH, G, A. S @5m

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S@5m

Regression Equation

$$A. D = 302 - 0.030 A.SHL - 39.3 A. SHH - 11.35 G + 6.77 A. S@5m$$

The speed hump length, height and grade have in direct relationship with delay and speed at 5m of upstream distance has direct relation with delay.

Coefficients

Table 4.19 statistics of delay at 5m for Pick up,Minibus&Taxi

Term	Coef	T-Value	P-Value
Constant	302	2.21	0.031
A.SHL	-0.030	-0.25	0.807
A. SHH	-39.3	-3.07	0.003
G	-11.35	-2.19	0.032
A. S@5m	6.77	3.51	0.001

Model Summary

R-sq	R-sq(adj)
34.70%	30.03%

Analysis of Variance

Source	DF	F-Value
Regression	4	7.44
A.SHL	1	0.06
A. SHH	1	9.45
G	1	4.81
A. S@5m	1	12.33

E.4 Regression Analysis (Multinomial): For M.Bus. and Track

A. Delay versus A. SHL, A. SHH, G, A. S @25m

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S @25m

Regression Equation

$$A.D = 104.0 + 0.0497 A.SHL - 19.51 A. SHH - 1.62 G + 3.16 A. S @25m$$

Coefficients

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Table 4.20 statistics of delay at 25m for Medium Minibus&Truck

Term	Coef	T-Value	P-Value
Constant	104.0	1.68	0.098
A.SHL	0.0497	0.84	0.402
A. SHH	-19.51	-3.26	0.002
G	-1.62	-0.71	0.482
A. S @25m	3.16	3.14	0.003

Model Summary

R-sq	R-sq(adj)
39.70%	35.47%

Analysis of Variance

Source	DF	F-Value
Regression	4	9.38
A.SHL	1	0.71
A. SHH	1	10.62
G	1	0.50
A. S @25m	1	9.83

B. Delay versus A. SHL, A. SHH, G, A. S @20m

Regression Analysis: A.D versus A.SHL, A. SHH, G, A.S @20m

Regression Equation

$$A. D = 112.1 + 0.0398 A.SHL - 19.99 A. SHH - 1.52 G + 3.53 A. S @20m$$

Coefficients

Table 4.21 statistics of delay at 20m for Medium Minibus&Truck

Term	Coef	SE Coef	T-Value	P-Value
Constant	112.1	61.6	1.82	0.074
A.SHL	0.0398	0.0587	0.68	0.501
A. SHH	-19.99	5.93	-3.37	0.001
G	-1.52	2.27	-0.67	0.507
A.S @20m	3.53	1.05	3.35	0.001

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
46.2998	40.92%	36.78%	31.98%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
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Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Regression	4	84645	21161.1	9.87	0.000
A.SHL	1	984	984.1	0.46	0.501
A. SHH	1	24375	24375.4	11.37	0.001
G	1	956	955.6	0.45	0.507
A.S @20m	1	24042	24042.1	11.22	0.001
Error	57	122189	2143.7		
Total	61	206834			

C. Delay versus A. SHL, A. SHH, G, A. S @15m

Regression Analysis: A.D versus A.SHL, A. SHH, G, A.S @15m

Regression Equation

$$A. D = 116.2 + 0.0527 A.SHL - 20.87 A. SHH - 1.93 G + 3.23 A. S @15m$$

The speed hump length and speed have direct relation with delay. And speed hump height and grade have indirect relation.

Coefficients

Table 4.22 statistics of delay at 15m for Medium Minibus&Truck

Term	Coef	T-Value	P-Value
Constant	116.2	1.82	0.074
A.SHL	0.0527	0.87	0.389
A. SHH	-20.87	-3.44	0.001
G	-1.93	-0.83	0.408
A.S @15m	3.23	2.91	0.005

Model Summary

R-sq	R-sq(adj)
38.42%	34.10%

Analysis of Variance

Source	DF	F-Value
Regression	4	8.89
A.SHL	1	0.75
A. SHH	1	11.81
G	1	0.70
A.S @15m	1	8.44

D. Delay versus A. SHL, A. SHH, G, A. S @10m

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S @10m

Regression Equation

$$A. D = 127.1 + 0.0574 A.SHL - 22.26 A. SHH - 1.97 G + 3.23 A. S @10m$$

Coefficients

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

Table 4.23 statistics of delay at 10m for Medium Minibus&Truck

Term	Coef	T-Value	P-Value
Constant	127.1	1.93	0.059
A.SHL	0.0574	0.93	0.355
A. SHH	-22.26	-3.60	0.001
G	-1.97	-0.84	0.402
A. S @10m	3.23	2.75	0.008

Model Summary

R-sq	R-sq(adj)
37.57%	33.19%

Analysis of Variance

Source	DF	F-Value
Regression	4	8.57
A.SHL	1	0.87
A. SHH	1	12.94
G	1	0.71
A. S @10m	1	7.55

E. Delay versus A. SHL, A. SHH, G, A. S @5m

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S@5m

Regression Equation

$$A. D = 127.1 + 0.0659 A.SHL - 22.30 A. SHH - 2.19 G + 3.05 A. S@5m$$

Coefficients

Table 4.24 statistics of delay at 5m for Medium Minibus&Truck

Term	Coef	T-Value	P-Value
Constant	127.1	1.87	0.066
A.SHL	0.0659	1.04	0.303
A. SHH	-22.30	-3.54	0.001
G	-2.19	-0.93	0.356
A. S@5m	3.05	2.44	0.018

Model Summary

R-sq	R-sq(adj)
35.99%	31.50%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value
Regression	4	74436	18609	8.01
A.SHL	1	2507	2507	1.08
A. SHH	1	29186	29186	12.57

Assessing Effect of Speed Hump on Traffic Flow in Addis Ababa at Selected Segments

G	1	2010	2010	0.87
A. S@5m	1	13833	13833	5.96

E.5 Regression Analysis (Multinomial): For Truck Trailer and Large Bus

A. Delay versus A. SHL, A. SHH, G, A. S @ 25m

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S @25m

Regression Equation

$$A. D = 209.7 - 0.1373 A.SHL - 27.28 A. SHH - 4.07 G + 8.07 A. S @25m$$

Coefficients

Table 4.25 statistics of delay at 25m for Medium L.bus&T.T

Term	Coef	T-Value	P-Value
Constant	209.7	2.35	0.022
A.SHL	-0.1373	-1.61	0.112
A. SHH	-27.28	-3.21	0.002
G	-4.07	-1.26	0.214
A. S @25m	8.07	5.93	0.000

Model Summary

R-sq	R-sq(adj)
50.11%	46.61%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value
Regression	4	249920	62480	14.32
A.SHL	1	11377	11377	2.61
A. SHH	1	45062	45062	10.32
G	1	6902	6902	1.58
A. S @25m	1	153564	153564	35.18

B. Delay versus A. SHL, A. SHH, G, A. S @ 20m

Regression Analysis: A.D versus A.SHL, A. SHH, G, A.S @20m

Regression Equation

$$A. D = 227.0 - 0.1471 A.SHL - 27.71 A. SHH - 4.09 G + 8.34 A.S @20m$$

Coefficients

Table 4.26 statistics of delay at 20m for Medium L.bus&T.T

Term	Coef	T-Value	P-Value
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Constant	227.0	2.41	0.019
A.SHL	-0.1471	-1.59	0.118
A. SHH	-27.71	-3.15	0.003
G	-4.09	-1.22	0.227
A.S @20m	8.34	5.37	0.000

Model Summary

	R-sq	R-sq(adj)
	46.43%	42.67%

Analysis of Variance

Source	DF	F-Value
Regression	4	12.35
A.SHL	1	2.52
A. SHH	1	9.90
G	1	1.49
A.S @20m	1	28.85

C. Delay versus A. SHL, A. SHH, G, A. S @ 15m

Regression Analysis: A.D versus A.SHL, A. SHH, G, A.S @15m

Regression Equation

$$A.D = 244.1 - 0.1389 A.SHL - 29.66 A. SHH - 3.97 G + 8.54 A.S @15m$$

Coefficients

Table 4.27 statistics of delay at 15m for Medium L.bus&T.T

Term	Coef	T-Value	P-Value
Constant	244.1	2.53	0.014
A.SHL	-0.1389	-1.50	0.140
A. SHH	-29.66	-3.33	0.002
G	-3.97	-1.17	0.246
A.S @15m	8.54	5.26	0.000

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
68.9360	45.68%	41.87%	36.85%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	4	227828	56957	11.99	0.000
A.SHL	1	10652	10652	2.24	0.140

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A. SHH	1	52556	52556	11.06	0.002
G	1	6542	6542	1.38	0.246
A.S @15m	1	131472	131472	27.67	0.000
Error	57	270874	4752		
Total	61	498702			

D. Delay versus A. SHL, A. SHH, G, A. S @ 10m

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S @10m

Regression Equation

$$A.D = 213.9 - 0.0905 A.SHL - 28.13 A. SHH - 4.39 G + 7.81 A. S @10m$$

Coefficients

Term	Coef	T-Value	P-Value
Constant	213.9	2.16	0.035
A.SHL	-0.0905	-0.97	0.339
A. SHH	-28.13	-3.04	0.004
G	-4.39	-1.25	0.216
A. S @10m	7.81	4.62	0.000

Model Summary

R-sq	R-sq(adj)
41.32%	37.20%

Analysis of Variance

Table 4.28 statistics of delay at 10m for Medium L.bus&T.T

Source	DF	Adj SS	Adj MS	F-Value
Regression	4	206049	51512	10.03
A.SHL	1	4781	4781	0.93
A. SHH	1	47532	47532	9.26
G	1	8031	8031	1.56
A. S @10m	1	109694	109694	21.36

E. Delay versus A. SHL, A. SHH, G, A. S @ 5

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S@5m

Regression Equation

$$A.D = 218 - 0.0301 A.SHL - 31.58 A. SHH - 4.87 G + 6.86 A. S@5m$$

Coefficients

Table 4.29 statistics of delay at 5m for Medium L.bus&T.T

Term	Coef	T-Value	P-Value
Constant	218	2.02	0.048
A.SHL	-0.0301	-0.31	0.758
A. SHH	-31.58	-3.17	0.002
G	-4.87	-1.32	0.193

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A. S@5m	6.86	3.66	0.001
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Model Summary

R-sq	R-sq(adj)
34.64%	30.05%

Analysis of Variance

Source	DF	F-Value
Regression	4	7.55
A.SHL	1	0.10
A. SHH	1	10.02
G	1	1.73
A. S@5m	1	13.36
Error	57	
Total	61	

E.6 Regression Analysis of all Vehicle Groups

In section 4.3 Modeling and regression analysis of individual vehicle was developed at upstream side of each of existing speed hump structure. A regression relation was developed for 25m upstream distance which divided in to 5 gaps. To recognize the combined effect of variables, it is necessary to model the whole data in one single modeling. It is as such presented in the following manner.

Regression Analysis: A.D versus A.SHL, A. SHH, G, A. S @25m, A.S @20m, A.S @15m, A. S @10m, A. S@5m

Regression Equation

$$A.D = -33.7 - 0.0076 A.SHL - 10.12 A. SHH - 4.84 G + 16.73 A. S @25m + 2.07 A. S @20m - 1.25 A. S @15m - 2.35 A. S @10m - 9.48 A. S@5m$$

The equation shows that the delay of the vehicles has a direct relationship with speed at 25m, 20 and indirect relationship with speed hump height & width, grade of road, speed at 15m, 10m&5m.

Coefficients

Table 4.31 statistics of delay at 25m for all vehicles

Term	Coef	T-Value	P-Value
Constant	-33.7	-0.38	0.701
A.SHL	-0.0076	-0.10	0.922
A. SHH	-10.12	-1.23	0.221
G	-4.84	-1.61	0.108
A. S @25m	16.73	3.15	0.002
A.S @20m	2.07	0.27	0.784
A.S @15m	-1.25	-0.13	0.897

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A. S @10m	-2.35	-0.27	0.790
A. S@5m	-9.48	-1.66	0.098

The negative T-value indicates that the values are laid on the left of the mean.

$$R\text{-sq}=0.31$$

$$R\text{-sq}(\text{adj})=0.29$$

R-square 0.31 and R-sq adj. 0.29 indicates the weak relation of dependent and independent variables.

Analysis of Variance

	DF	F-Value
Regression	8	12.05
A.SHL	1	0.01
A. SHH	1	1.50
G	1	2.60
A. S @25m	1	9.95
A.S @20m	1	0.08
A.S @15m	1	0.02
A. S @10m	1	0.07
A. S@5m	1	2.75