EVALUATION OF TRAFFIC CALMING TECHNIQUES

A DISSERTATION REPORT

Submitted by

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CERTIFICATE

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Abstract

A speeding vehicle can be a menace to other road users particularly on roads where interaction between motorized and non-motorized traffic is high, such as residential streets, school zones and community areas. Although speed limit signs are placed in accordance with the requirements of the standards, much is left to the conscience of the drivers whether they should abide by them. Hence, controlling vehicular speeds is an important issue in traffic management. The best way to influence driver speed is through traffic management. One way of controlling speed is to use static speed control devices like bumps which produces discomfort while driver experiences while crossing over it. Road bumps play a crucial role in enforcing speed limits, thereby preventing over speeding of vehicles. It significantly contributes to the overall road safety objective through the prevention of accidents that lead to death of pedestrians and damage of vehicles.

This thesis aims to present the results of a study on the performance of road bumps used in Jalandhar cantonment in reducing vehicle speed. The purpose of this work is to study speed across bumps, like speed at bump, speed reduction, deceleration and acceleration by having a detailed survey of vehicular behavior near bumps of various heights. The speed profile of vehicles are determined and analyzed at various locations along the road prior to the bump, on the bump and after the bump. A critical speed change analysis has been conducted and the result presented for various vehicle category and type of bumps at various locations.

TABLE OF CONTENTS

S. No.	Content	Page No.
1	**Introduction**	
1.1	General	1-4
1.2	Road Bump	4-5
1.3	Speed Bump parameters	6
1.3.1	Length	6
1.3.2	Height	6
1.3.3	width	6
1.3.4	Profile	6
1.3.5	Spacing	7
1.3.6	Material, marking and signage	7
1.4	Speed Control Measures	7-12
1.5	Volume Controls	12
1.6	Need of Study	13
1.7	Purpose of the Study	13
1.8	Organization of the Report	13
2	**Literature Review**	
2.1	General	14
2.2	Overview of Study	14-18
3	**Research Methodology**	**19-21**
3.1	General	19
3.2	Study Area	19
3.3	Methodology for obtaining spot speeds of vehicles using RADAR Gun	19-21
4	**Analysis of Results and Discussion**	
4.1	General	22
4.2	Speed impacts of Bumps	22-26

	4.3	Impacts of materials and size	27
	4.4	Opinion Survey	28-30
5		**Conclusions and Recommendations**	**31**
6		**REFERENCES**	**32-33**
		Appendix 1	**34**
		Appendix 2	**35**

List of Tables:

S. No.	Description	Page No.
Table 2.1	Evaluation Criteria for Traffic Calming Issues	15
Table 3.1	Speed Bumps in Jalandhar Cantonment	19
Table 4.1	Average Speed at different Locations	22
Table 4.2	Impacts of Bumps for speed controls	23

List of Figures:

S. No.	Description	Page No.
Figure 1.1	Theory about how design of road bumps influences drivers crossing speed.	3
Figure 1.2	The connection between physical identities and characteristics of road bump.	4
Figure 1.3	Profile of speed Hump versus Speed Bump	5
Figure 1.4	Types of Speed Humps	5
Figure 1.5	Speed humps	8
Figure 1.6	Raised Crosswalks	9
Figure 1.7	Raised Intersections	9
Figure 1.8	Chicanes	11
Figure 2.1	Undulations—speed bumps, speed humps, and speed cushions	16
Figure 2.2	85th percentile speed profile observed at one of sites	17
Figure 2.3	Speed profiles at different distance with respect to hump	17
Figure 3.1	Radar gun	21
Figure 4.1	Speed impacts of speed bumps on vehicles	26
Figure 4.2	Results of opinion survey	28-29

CHAPTER – 1

INTRODUCTION

1.1 General

Since ancient period for any project with several objectives we, the people are working on one approach which is to find a solution that is safe and economical. Out of these two perspectives safety has always had more priority over economy. When it comes to safety on roads, traffic calming techniques play a vital role in the development and maintenance of a secure environment for road users i.e. vehicle drivers as well as pedestrians.

Traffic calming techniques emerged mainly in response to community concern for safety. Traffic calming has been implemented in Western nations in residential areas and neighbourhoods and cities because of the roads and paths between relatively safer cities. It was also agreed by experts that differences and differences in the speed and direction, and / or mass of vehicles usually determine the severity of traffic accidents. In the West, and are classified as very safe roads where driving speeds are relatively higher, but uniform. There is much less difference in direction and mass of the car. In the last twenty years, as well as residential areas and inner cities have become safer because of the 30 regions km / h in residential areas, despite considerable variation in the direction of the block and used vehicles.

Traffic calming techniques have played an important role in achieving safety by ensuring that low-speed driving and speed of small differences between different road users. The whole experience of different European countries indicates that the speed limit signs and other visual measures are not sufficient by itself to make drivers always choose the right speed. But when used together with the speed reducing other physical measures, significant effects can be observed.

Traffic calming actually change the perception of driver by installation of new physical features or by changing the street alignment, installation of safety barriers for safe and efficient movement of traffic and other public purposes (Institute of Transportation Engineers).

Traffic calming measures are quite common in modern society. Traffic calming measures are physical design techniques that encourage or force motorists to drive slow and constant speed.

They prevent speeding and can increase overall road safety. Traffic calming can also make streets more accessible and livable for other users such as pedestrians, cyclists and nearby residents. The main purpose of traffic calming measures is to reduce speed and create a safer traffic environment. Road bumps are one type of measures that is frequently used to reduce speed in residential areas. Traffic calming measures have to adapt to the specific condition of each location but in principle only one design of road bumps is needed. This design should lead to a comfortable crossing at speed lower than 15-20 km/h but as soon the speed increased it should be more uncomfortable to cross the road bumps. The design of ideal road bumps would make drivers hold their speed below 25 km/h at least when crossing a road bumps.

Figure 1.1 describe roughly how road bumps influence crossing speed. The designs of road bumps influences experienced driving comfort and through that drivers speed. If a road bump is designed in a way so that the driving discomfort does not increase very much as the speed increases, driver see no reason to slow down before crossing a road bump. In many cases, drivers estimate the discomfort of crossing against decrease travel time. Drivers are prepared to experience more discomfort if it will decrease their travel time, at least to some level. Road bumps are installed in different environments, on streets that have different characteristics. Car parking, interaction with vulnerable road users and other things that make up the character of a street have an effect on drivers and their speed choice.

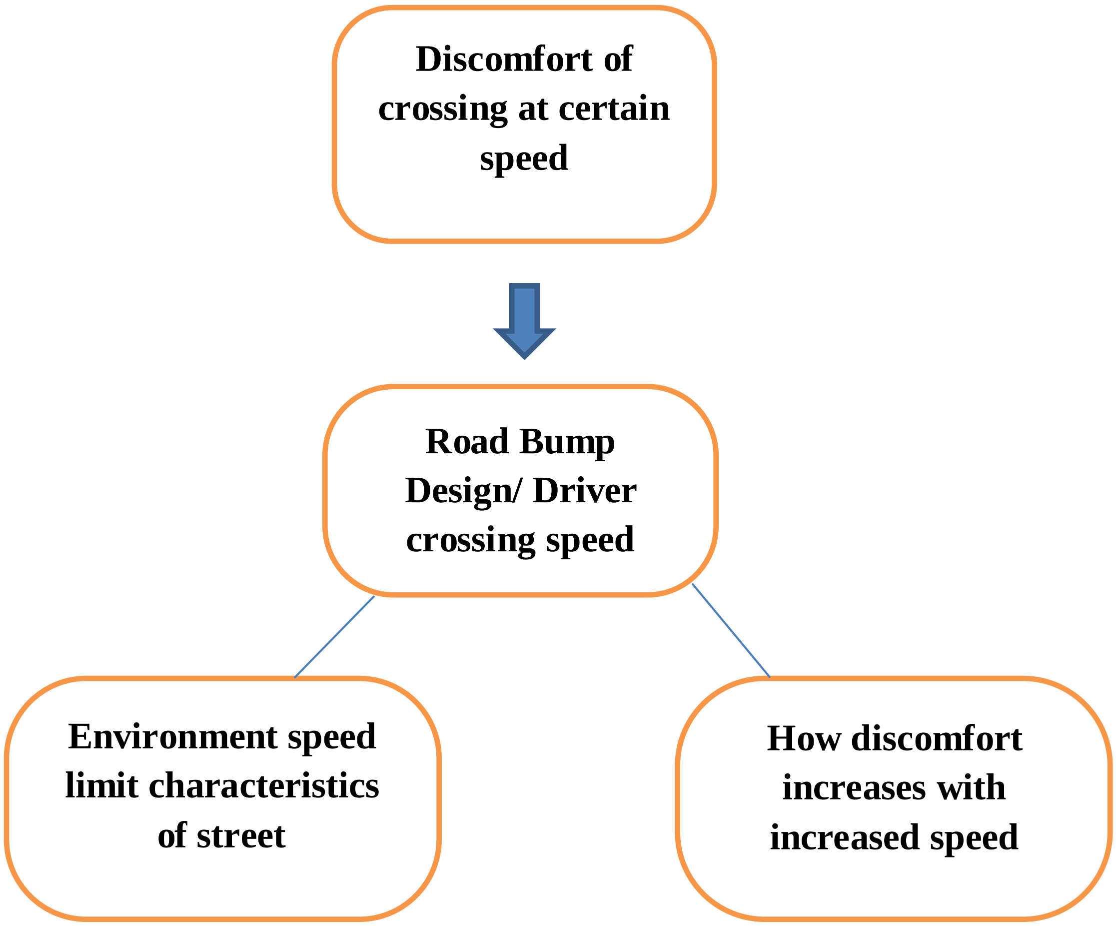


Figure 1.1: Theory about how design of road bumps influences drivers crossing speed.

A road bump is made from several different physical identities such as length, height, length of ramps etc. Physical identities control to the discomfort that road bumps produce. Vertical acceleration has been used to describe driving comfort when crossing road bumps. The connection between physical identities and characteristics of road bump is shown in figure 1.2.

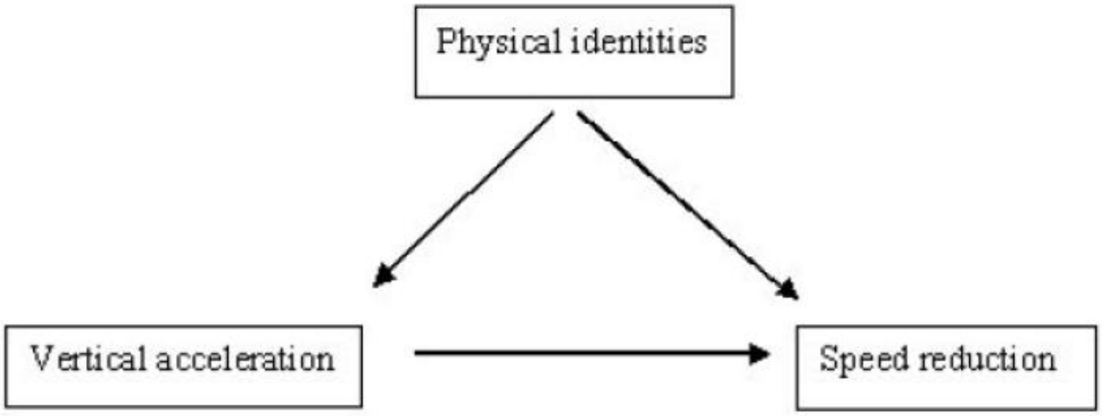


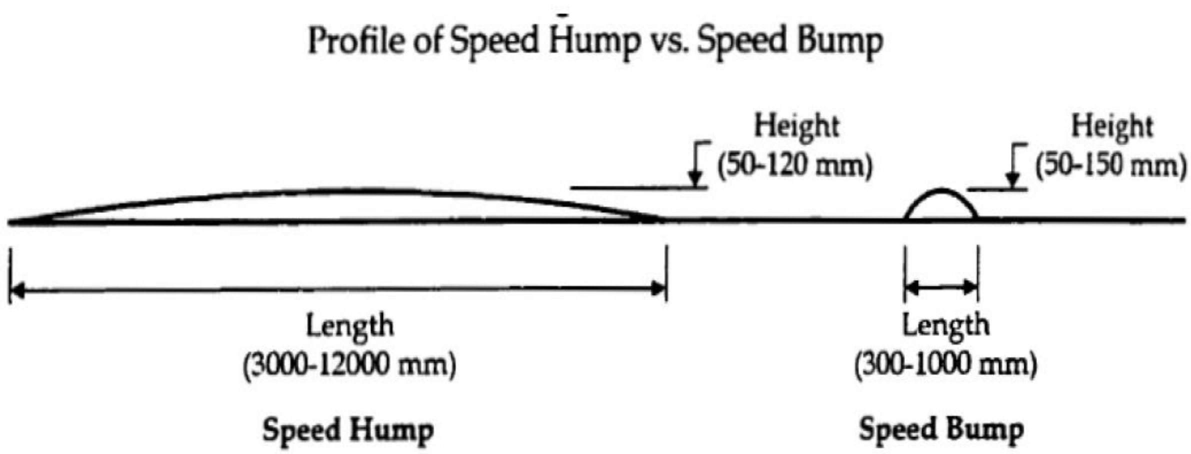
Figure 1.2: The connection between physical identities and characteristics of road bump.

The traffic calming measures to control speed and volume are discussed in the next sections.

1.2 Road Bumps

Road bumps are raised pavements spanning across or partly across a roadway, thus, forcing driver to reduce the speed of their vehicles in order to minimize uncomfortable bumping or vibrating sensations produced when traversing them. A road bump works by transferring an upward force to a vehicle, and its occupants, as it crosses the bump. The force produces a front-to-back pitching acceleration in vehicles having a wheelbase similar to the length of the bump that increases as the vehicles travel faster (weber et al,1998). At low speed the acceleration is of small amplitude. As speed increase the amplitude and pitching also increase, as does the displacement. At low speeds the speed bump gently lifts and pitches the vehicle. Only as speed increase do the acceleration become more apparent as a jolt to the vehicle and its occupants.

Road bumps are designed to promote the orderly traffic moment and improve safety. However, at certain location such as approaches to manned & unmanned level crossings, sharp curves, accident prone locations, congested residential streets; control of speed may become necessary to allow smooth flow of traffic. However in an uninterrupted flow facility, with a strong emphasis on traffic safety & management, use of road bump can’t be underestimated. Road bumps, where permitted to be installed, provide visual, audible and traffic stimuli which alerts drivers and cause them to slow down. These can have different heights, base widths and shape. In fact, no particular design is suitable for all the types of vehicles using the road. They are several meters long, about a tenth of a meter high, and can cover all or a portion of the width of a roadway. A speed hump is not the same as the much wider speed bump.



Source: IRC: 99-1998

Figure 1.3: Profile of speed Hump versus Speed Bump

Today, circular or "round top" bumps of various lengths and heights are the most common used as traffic calming measures. Other profiles such as sinusoidal and trapezoidal or "flat top" bumps have also been created. Bumps may be parabolic, circular, sinusoidal or trapezoidal in shape. Bump width may vary according to the road width (when constructed fully across the road), or to the constricted road width (when constructed partially across the road). Flat top trapezoidal bumps are particularly useful when combined with pedestrian crossing.

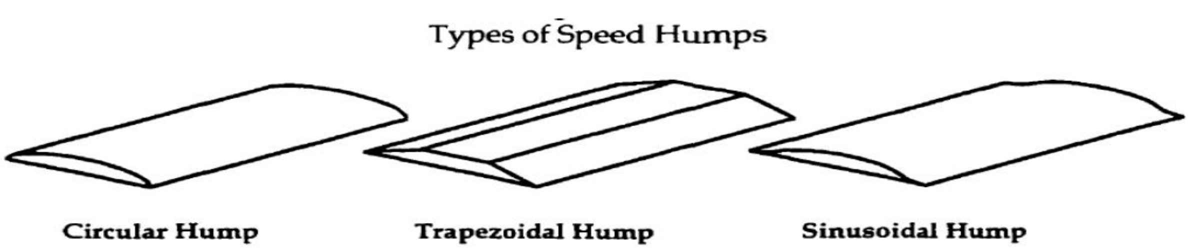


Figure 1.4 : Types of Speed Humps

1.3 SPEED BUMP PARAMETERS:-

Speed bumps can be fully described using several geometric and layout design parameters. The geometric design parameters are Length, height, profile and width. The layout design parameters are speed bump spacing and type of materials, marking and signage.

1.3.1 LENGTH:-

Length is the most important speed bump geometric design parameter. Effective bumps should be at least as long as an automobile wheelbase to isolate the effects of entering and exiting the bumps for these vehicles. Longer speed bumps should be used if heavier vehicles are expected. Experiments have shown that as lengths are increased peak accelerations tend to occur at higher speeds, and more linear dynamic effects are created. In general, longer bumps exhibit better characteristics for speed reduction. Longer bumps may be even better suited for heavy vehicles, although upper limits have not been firmly established.

1.3.2 HEIGHT:-

Speed bump heights can influence the magnitudes of vertical accelerations and the maximum levels of perceived discomfort. High bumps, may cause damage to vehicle undermanages as they exit the measures. Low bumps can be ineffective. Heights usually range from 50 to 120 mm, with the most common being 75 or 100 mm.

1.3.3 WIDTH:- Speed bumps can either span the entire width of a road or taper short of the curb or road edge. The advantage of the latter approach in an urban setting is that drainage at the curb and gutter is not affected, and installations are therefore less expensive. Drivers can attempt to exploit reduced widths and maneuvers around bumps unless preventative measures are taken.

1.3.4 PROFILE:-

The effects of speed bump profile, particularly the effects of varying the slopes of the entry and exit ramps, have not been examined as thoroughly as length or height. Research is ongoing to determine the optimal ramp slopes for various speed bump designs, particularly trapezoidal bumps. Circular, trapezoidal and sinusoidal speed bumps of equivalent dimensions have been found to perform about equally well, although the Dutch regard sinusoidal bumps as having the best dynamic characteristics at higher speeds.

1.3.5 SPACING:-

High bump crossing speeds can lead to high speeds between bumps, as can large distances between them. Since an objective of traffic calming is to reduce vehicle speeds over entire streets, the layout design or spacing of speed bumps is a key factor to be considered. Previous research from several countries suggests that to achieve overall speeds of 25 to 30 km/h, speed bumps should be placed between 40 and 60 meters apart. Greater spacing, up to 100 meters, can be used for speeds of 50 km/h. Bump spacing can be increased with the presence of additional traffic calming measures.

1.3.6 MATERIALS, MARKING AND SIGNAGE:-

Speed bumps with all speed reducing measures, should be highly visible to warn drivers to lower speeds and avoid vehicle damage or loss of control. This essentially eliminates the potential for any legal liability on the part of the public road authority. Most countries have developed special signs and markings for their speed bump installations, and pre-warnings, design speed signs, contrasting materials and protective bollards are usually employed.

1.4 Speed Control

Various speed control measures are discussed below:

(i) Speed Humps - Speed humps are rounded raised areas placed across the roadway. They are generally 3 to 4.25 m long (in the direction of travel), making them distinct from the shorter "speed bumps" found in many parking lots, and are 75 to 100 mm high. The profile of a speed hump can be circular, parabolic, or sinusoidal. They are often tapered as they reach the curb on each end to allow unimpeded drainage. These are shown in Figure 1.5.

Figure 1.5: Speed humps

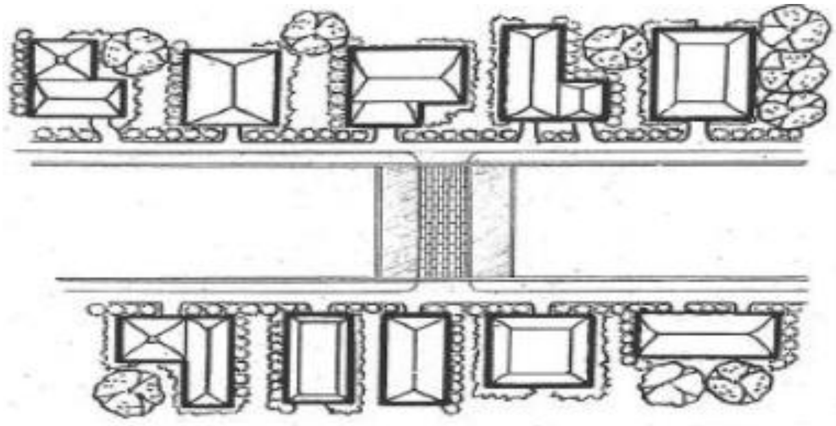
Speed Humps are good for locations where very low speeds are desired and reasonable, and noise and fumes are not a major concern.

(ii) Speed Tables – Speed tables are flat-topped speed humps often constructed with brick or other textured materials on the flat section. Speed tables are typically long enough for the entire wheelbase of a passenger car to rest on the flat section. Their long flat fields give speed tables higher design speeds than Speed Humps. The brick or other textured materials improve the appearance of speed tables, draw attention to them, and may enhance safety and speed-reduction.

Speed tables are good for locations where low speeds are desired but a somewhat smooth ride is needed for larger vehicles.

(iii) Raised Crosswalks – Raised crosswalks are Speed Tables outfitted with crosswalk markings and signage to channelize pedestrian crossings, providing pedestrians with a level street crossing. Also, by raising the level of the crossing, pedestrians are more visible to approaching motorists.

Raised crosswalks are good for locations where pedestrian crossings occur at haphazard locations and vehicle speeds are excessive.



Source:Pennsylvania's traffic calming handbook

Figure 1.6: Raised Crosswalks

(iv) Raised Intersections – Raised intersections are flat raised areas covering an entire intersection, with ramps on all approaches and often with brick or other textured materials on the flat section. They usually raise to the level of the sidewalk, or slightly below to provide a "lip" that is detectable by the visually impaired. By modifying the level of the intersection, the crosswalks are more readily perceived by motorists to be "pedestrian territory". Figure 1.7 shows patterns used on raised crosswalks.

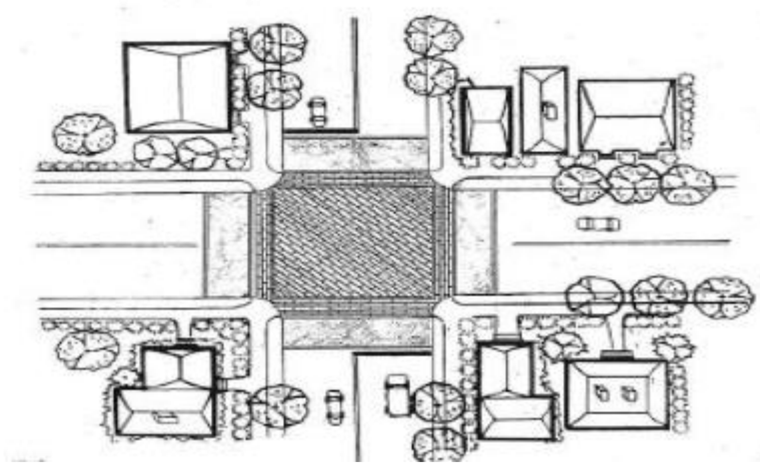


Figure 1.7 Raised Intersections

Raised intersections are good for intersections with substantial pedestrian activity, and areas where other traffic calming measures would be unacceptable because they take away scarce parking spaces.

(v) Textured Pavement - Textured and coloured pavement includes the use of stamped pavement or alternate paving materials to create an uneven surface for vehicles to traverse. They may be used to emphasize either an entire intersection or a pedestrian crossing, and are sometimes used along entire street blocks.

Textured pavements are good for "main street" areas where there is substantial pedestrian activity and noise is not a major concern.

(vi) Traffic Circles - Traffic circles are raised islands, placed in intersections, around which traffic circulates. They are good for calming intersections, especially within neighbourhoods, where large vehicle traffic is not a major concern but speeds, volumes, and safety are problems.

(vii) Roundabouts - Roundabouts require traffic to circulate counter clockwise around a centre island. Unlike Traffic Circles, roundabouts are used on higher volume streets to allocate right-of-way between competing movements.

These are good for:

- Locations with a history of accidents.
- Intersections where queues need to be minimized.
- Intersections with irregular approach geometry.
- Providing inexpensive-to-operate traffic control as an alternative to a traffic signal.
- Handling a high proportion of U-turns, and Locations with abundant right-of-way.

Chicanes - Chicanes are curb extensions that alternate from one side of the street to the other, forming S-shaped curves. Chicanes can also be created by alternating on-street parking, either diagonal or parallel, between one side of the street and the other. Each parking bay can be created either by restriping the roadway or by installing raised, landscaping islands at the ends of each parking bay. These are good for locations where speeds are a problem but noise associated with speed humps and related measures would be unacceptable. These are shown in Figure 1.8.

(Source: City of Iowa City, Iowa)

Figure 1.8: Chicanes

(viii) Re-aligned Intersections - Realigned intersections are changes in alignment that convert T-intersections with straight approaches into curving streets that meet at right-angles. A former “straight-through” movement along the top of the T becomes a turning movement. While not commonly used, they are one of the few traffic calming measures for T-intersections, because the straight top of the T makes deflection difficult to achieve, as needed for Traffic Circles. They are good for T-intersections.

(ix) Neckdowns–They are curb extensions at intersections that reduce the roadway width from curb to curb. They “pedestrianize” intersections by shortening crossing distances for pedestrians and drawing attention to pedestrians via raised peninsulas. They also tighten the curb radii at the corners, reducing the speeds of turning vehicles. They are good for intersections with substantial pedestrian activity and areas where vertical traffic calming measures would be unacceptable because of noise considerations.

(x) Centre-Island Narrowings - A centre island narrowing is a raised island located along the centreline of a street that narrow the travel lanes at that location. Centre island narrowings are often landscaped to provide a visual amenity. Placed at the entrance to a neighbourhood, and often combined with textured pavement, they are often called “gateway islands.” Fitted with a gap to allow pedestrians to walks through at a crosswalk, they are often called “pedestrian refuges.”

Centre Island Narrowings are good for entrances to residential areas, and wide streets where pedestrians need to cross.

(xi) Chokers - Chokers are curb extensions at midblock locations that narrow a street by widening the sidewalk or planting strip. If marked as crosswalks, they are also known as safe crosses. Two-lane chokers leave the street cross section with two lanes that are narrower than the normal cross section. One-lane chokers narrow the width to allow travel in only one direction at a time, operating similarly to one-lane bridges. They are good for areas with substantial speed problems and no on-street parking shortage.

1.5 Volume Control

Various volume control traffic calming measures are:

(i) Full Closures - Full street closures are barriers placed across a street to completely close the street to through-traffic, usually leaving only sidewalks open. They are good for locations with extreme traffic volume problems and where several other measures have been unsuccessful.

(ii) Half Closures - Half closures are barriers that block travel in one direction for a short distance on otherwise two-way streets. They are good for locations with extreme traffic volume problems and when non-restrictive measures have been unsuccessful.

(iii) Diagonal Diverters - Diagonal diverters are barriers placed diagonally across an intersection, blocking through movements and creating two separate, L-shaped streets. Like half closures, diagonal diverters are often staggered to create circuitous routes through the neighbourhood as a whole, discouraging non-local traffic while maintaining access for local residents. They are good for inner-neighbourhood locations with non-local traffic volume problems.

(iv) Median Barriers - Median barriers are islands located along the centreline of a street and continuing through an intersection so as to block through movement at a cross street.

They are good for:

- Local street connections to main streets where through traffic along the continuing local street are a problem.
- Main streets where left-turns to and/or from the side street are unsafe.

For this project work speed control measures (speed bumps) were considered as subject of interest.

1.6 Need of the Study

The aggressive growth in the number of road users is a major concern for traffic engineers and planners. As number of road users increases, the burden on existing transportation system for providing the best Level of Service (LOS) increases and if this system does not perform well, there is a likelihood of occurring accident due to lack of implementation of engineering, enforcement or/and education measures.

It is necessary to evaluate the techniques involved in a transportation system to assess the performance of the system at a point of time. Evaluation of traffic calming technique is required to have a check on the fulfilment of the objective with which these were planned, designed and implemented, to say to make streets safe and usable.

1.7 Objectives of the Study

The objectives of this project work were:

(i) To evaluate speed control measures (speed bumps) present in Jalandhar Cantonment.

(ii) To get a comparative overview between mechanical speed bumps and speed bumps constructed using material.

(iii) How traffic calming device (speed hump) effect the macroscopic flow of road.

1.8 Organisation of the report

The report is organised as below:

- Chapter 1 introduces the topic and enlightens the need and objective of the study.
- In the second chapter, the previous works done by researchers and academicians related with the topic are studied.
- In the third chapter, field study for the project is discussed.
- Analysis of results and discussion are mentioned in chapter 4.
- The conclusions and recommendations are summarized in chapter 5.

CHAPTER – 2

LITERATURE REVIEW

2.1 General

Considering the objectives of the project literature review was done to study about various aspects of traffic calming techniques. Some of the studies are summarised in the following section.

2.2 Overview of studies

The City of Calgary (2010) summarised evaluation criteria for traffic calming issues. Issues were evaluated according to criteria which reflect the goals of traffic calming specifically safety and liveability - as well as objectives of reducing speed and short-cutting volume, and minimising conflicts between road users. Community support was also considered in the evaluation, as a basis for assigning higher priority to areas with higher levels of community support.

Since the number, type and extent of issues will vary from one area to another, it is not possible to use a quantitative means of assigning ratings to each area. Instead, each criterion is evaluated on a subjective basis, on a scale of zero to five, ten or twenty, depending on the relative importance of each criterion. In each case, a higher score represents a more significant issue.

The suggested evaluation criteria for traffic calming issues are given in Table 2.1.

Table 2.1: Evaluation Criteria - Traffic Calming Issues

Criteria	Measurement	Rating	
		Scale	Indicator
Speed	24-hour 85th percentile speeds in both directions (during daytime hours for school and playground zones)	0 to 20	20 represents area with highest recorded speed differentials and greatest number of streets with speeding
Volume	Daily traffic volume	0 to 20	20 represents area with highest daily traffic volume relative to road classification
Collisions	Collision rate and severity of reported collisions in 3 years at most significant location (most recent data available)	0 to 20	20 represents area with highest number and severity of collisions
Safety	Sidewalks - proportion of neighbourhood streets with continuous sidewalks on at least one side	0 to 5	5 represents area with fewest sidewalks
	Pedestrian - number of schools and major pedestrian generators in area, and numbers of pedestrians	0 to 10	10 represents area with highest number of pedestrian generators and highest level of pedestrian use
	Cyclists - number of designated bicycle routes in area, and number of cyclists	0 to 20	5 represents area with highest number of bicycle routes and highest level of bicycle use
Community support	Percentage of households supporting requested action	0 to 20	20 represents area with highest level of support

Pau M. (2002) found that many studies conducted over the last 20 years show that speed bumps have only a limited effect in decreasing traffic speed, especially compared to better designed passive speed control devices, such as speed humps or cushions. These findings were confirmed during an investigation conducted in an Italian town. Besides the well known phenomena, such as sudden slow down and acceleration before and after the bump (which is often a source of accidents). It was observed that drivers tend to perform all sorts of maneuvers to reduce their discomfort as much as possible when approaching the undulation. This fact is particularly evident on streets where the speed bumps do not extend over the entire street. This kind of misplacement seems to encourage drivers to perform avoidance maneuvers, such as short deviations into the opposite lanes or parking lanes and bus stops. The study was an attempt to reach a qualitative and quantitative classification of possible alterations in drivers' behaviour due to the presence of the speed bumps. The result of more than 25,000 observations of cars and motorcycles reveal that speed bumps, where not properly installed, induce many drivers (up to 50% for cars and up to 85% for motorcyclists) to avoid the undulation to reduce the level of noise and vibrations perceived inside/on the vehicle. Figure 2.1 shows different type of humps and Figure 2.2 shows speed profile over them.

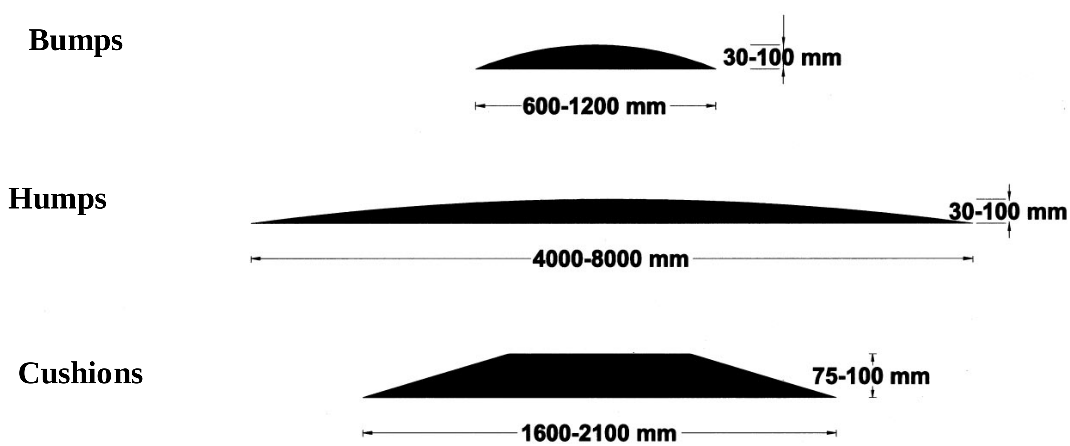


Figure 2.1: Undulations—speed bumps, speed humps, and speed cushions

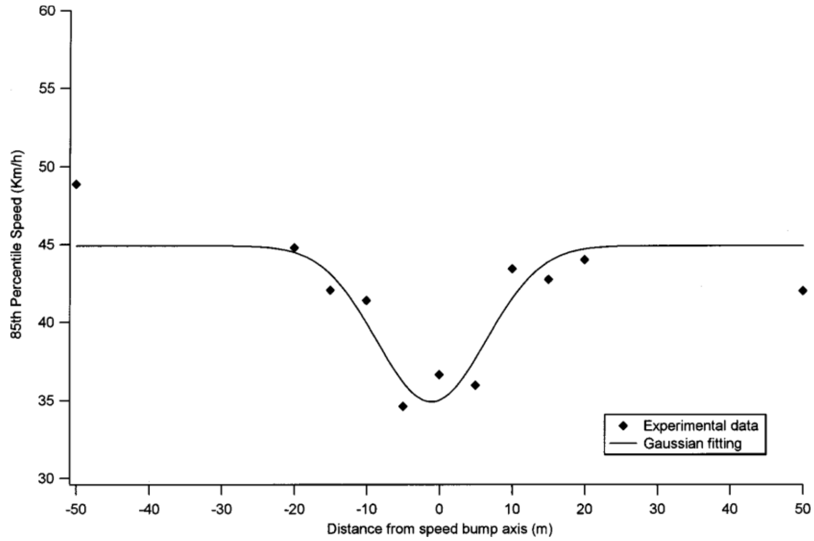


Figure 2.2: 85th percentile speed profile observed at one of sites

Barbosa et al., (2000) found that the influence of traffic calming measures on the speed of unimpeded vehicles has been investigated by evaluating differences in speed profiles obtained from various combinations of traffic calming measures. A case study has been conducted in the City of York (UK) focusing on traffic calming measures such as speed humps (flat-topped and round topped), speed cushions and chicanes implemented in sequence. Vehicles' passing times were simultaneously recorded at 16 points along each traffic calmed link. From these data a speed profile for each individual vehicle could be derived. An empirical model was developed using multiple regression analysis techniques based on data collected at three calibration sites. Speeds along these links were described as a function of the input speed, the type of measure and the distance between measures.

The speed profile model was shown to be a good representation for the data from the calibration sites. It efficiently predicted speeds of unimpeded vehicles over a given combination of traffic calming measures in sequence. The validation process, based on data collected at three validation sites, also indicated that the model provided a good representation of the observed profiles at these sites. The independent variables considered in the model to describe `speed' were as follows:

(i) The entry speed (V_1) is the initial speed in the link which was assumed as the speed measured at the first sensor during data collection (noting that this was taken as indicative of free flow speed) (in km/h);

(ii) Distance to (dt) is the distance to the next measure in the direction of travel (in m);

(iii) Distance from (df) is the distance from the previous measure also measured in the direction of travel (in m);

(iv) Hump (H) is the dummy variable which indicates the presence of a hump (0 or 1);

(v) Table (T) is the dummy variable which indicates the presence of a table (0 or 1);

(vi) Cushion (C) is the dummy variable which indicates the presence of a speed cushion (0 or 1);and

(vii) Chicane (Ch) is the dummy variable which indicates the presence of a chicane (0 or 1).

The recommended speed profile model is given by eqn 2.1 and the speed profile is showing in Figure 2.3.

$$Speed = -8.73 + 0.62V_1 + 0.23dt + 0.78df - 0.0012dt^2 - 0.0137df^2 + 8.5E-05df^3 - 4.48H - 6.71T - 0.86C - 2.01Ch \quad (2.1)$$

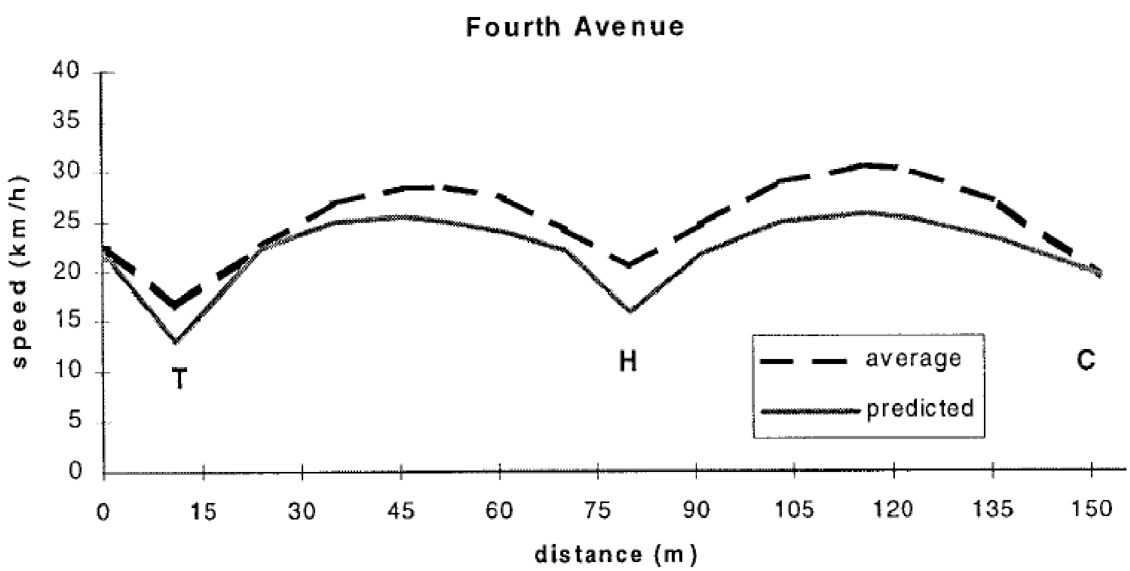


Figure 2.3 Speed profiles at different distance with respect to hump

CHAPTER – 3

RESEARCH METHODOLOGY

3.1 General

The changes in behaviour on the road and reductions in accident rates are the only meaningful criteria for success, if one is truly interested in the promotion of traffic safety (Wilde, 1971). Field study is important to asses these changes. For evaluation of traffic calming technique observations related to significant change in speed of vehicles due to bumps, number of accidents, safety and community support were taken for the study area.

3.2 Study Area

Jalandhar Cantonment was selected as the study area. The following are the locations where speed bumps are constructed or placed in Jalandhar Cantonment (Table 3.1):

Table 3.1: Speed bumps in Jalandhar Cantonment

Sl. No.	Location	Type	Dimensions (all in mm)	Speed limit on road (kmph)
1	Deep Nagar	Mechanical	340x45	30
2	Dushera Ground.	Mechanical	340x45	30
3	Recruiting Head Quaters	Mechanical	340x55	30
4	Garha Road	Mechanical	340x45	30
5	Officers Colony	Material	2700x30	20
6	Rama Mandi	Material	2700x30	20
7	KV-1	Mechanical	750x60	20
8	Residency quarters 1	Material	1600x75	20

Sl. No.	Location	Type	Dimensions (all in mm)	Speed limit on road (kmph)
9	Residency quarters 2	Material	1600x80	20
10	Residency quarters 3	Material	1600x75	20
11	Residency quarters	Material	2100x75	20
12	Church lane	Mechanical	750x70	20
13	Church lane	Mechanical	750x70	20
14	Church	Material	2700x75	20

Among these six locations were chosen for field observations. They are speed bumps at:

(i) Deep Nagar

(ii) Dushera Ground.

(iii) Recruiting Head Quaters

(iv) Garha Road

(v) Officers Colony

(vi) Rama Mandi

3.3 Data Collection

Radar gun was used to collect speed data. Speed observations were taken on working days during off peak hours so that less interaction between vehicles could be maintained. Impeded vehicles were not of interest as their speeds were affected by lead vehicle rather than by traffic calming measures (Barbosa et. al., 2000). The performa for spot speed observations is given in Appendix 1.

Figure 3.1: Radar gun

Success of traffic calming schemes depends, not only on objective empirical measures, but on the overwhelming support of the local community, which in turn depends upon the openness of consultation process (Taylor and Tight, 1997). So, an opinion survey was conducted over the performance of speed bumps inside the Jalandhar Cantonment. Performa is given in Appendix 2.

CHAPTER – 4

ANALYSIS OF RESULTS AND DISCUSSION

4.1 General

After compiling the observations, results are analysed and discussed in this section. Speed impacts of bumps were visible. For different speed bumps, impacts of material and size were also observed. Besides these, public opinion and safety aspect are discussed in the next sections.

4.2 Speed impacts of bumps

The speed of vehicles was observed before and after the bump. The average speeds with standard deviation are given in Table 4.1.Speed impacts of speed bumps are given in Table 4.2.

Table 4.1: Average speeds at different locations

(standard deviations in parentheses)

Sl. No.	Location	Direction	Average speed of 2-W motorised vehicle (kmph)		Average speed of 4-W motorised vehicle (kmph)	
			before bump	After bump	before bump	After bump
1	Deep Nagar	Towards Deep Nagar	33.43 (6.20)	19.26 (4.57)	34.24 (5.24)	18.95 (3.25)
		Towards Dushera Ground	33.42 (5.10)	19.37 (4.78)	39.44 (13.61)	19.22 (2.95)
2	Dushera Ground	Towards main market	33.42 (6.19)	20.86 (4.07)	28.63 (5.50)	16.50 (1.85)
		Towards Sansarpora	32.80 (7.95)	20.94 (8.34)	35.27 (5.37)	18.45 (3.30)
3	Recruiting Head Quaters	Towards market	31.00 (5.51)	19.61 (4.60)	36.00 (7.75)	17.20 (3.77)
		Towards NH1	28.61 (3.95)	19.16 (4.89)	32.67 (6.28)	20.50 (4.37)

S no.	Location	Direction	Average speed of 2-W motorised vehicle (kmph)		Average speed of 4-W motorised vehicle (kmph)	
			Before bump	After bump	Before bump	After bump
4	Garha Road	Towards KV	26.93 (5.31)	21.30 (4.50)	30.75 (4.81)	23.56 (3.48)
		Towards Main Gate	28.00 (5.99)	20.53 (4.09)	30.50 (4.95)	14.00 (0.00)
5	Officers Colony	Towards main market	29.58 (5.37)	16.39 (2.51)	31.57 (6.33)	16.36 (3.71)
		Towards Residential colony	31.47 (5.75)	16.00 (1.45)	34.00 (7.62)	15.86 (1.77)
6	Rama Mandi	Towards NH1	31.08 (5.34)	19.89 (5.13)	34.10 (4.95)	20.80 (6.00)
		Towards Cant	29.21 (4.44)	20.02 (5.52)	28.46 (4.22)	20.23 (4.49)
7	Main market cantt	Towards Jalandhar city	30.96 (5.43)	26.39 (5.45)	32.17 (4.06)	26.42 (5.02)
		Towards Cantt	32.06 (6.98)	25.11 (6.49)	33.33 (1.63)	24.50 (5.54)

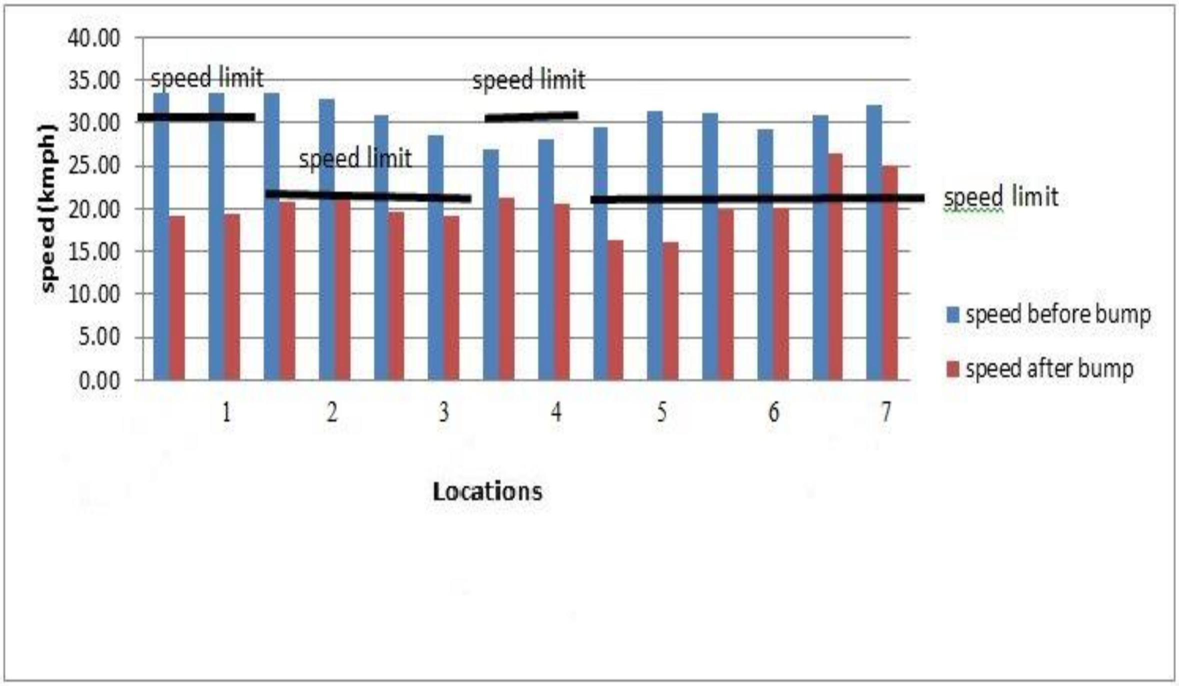
Table 4.2: Impacts of bumps for speed control

(standard deviations in parentheses)						
Sl. No.	Location	Direction	Average reduction in speed (kmph)		Average % reduction in speed	
			2-W motorised vehicle	4-W motorised vehicle	2-W motorised vehicle	4-W motorised vehicle
1	Deep Nagar	Towards Deep Nagar	14.17 (5.23)	15.29 (5.94)	41.83 (10.89)	43.61 (11.89)
		Towards Dushera Ground	14.05 (5.81)	20.22 (5.91)	41.33 (13.61)	50.54 (9.13)
2	Dushera Ground	Towards main market	12.77 (5.39)	12.13 (5.91)	36.93 (12.09)	40.57 (11.75)
		Towards Pragpora	11.86 (7.71)	16.82 (5.81)	35.20 (18)	46.75 (11.15)
3	Recruiting Head Quarter	Towards market	11.39 (5.53)	18.80 (9.2)	35.80 (14.19)	50.17 (16.13)
		Towards NH1	9.45 (3.38)	12.17 (5.91)	33.40 (11.71)	36.42 (11.96)
4	Garha Road	Towards KV	5.63 (2.85)	7.19 (3.76)	20.53 (8.71)	22.51 (11.09)
		Towards Main Gate	7.47 (3.31)	16.50 (4.95)	26.10 (8.44)	53.49 (7.55)
5	Officers Colony	Towards main market	13.18 (5.06)	15.21 (5.71)	43.25 (10.7)	46.98 (11.83)
		Towards Residential colony	15.47 (5.9)	18.14 (6.87)	47.46 (11.15)	52.14 (7.89)
6	Rama Mandi	Towards NH1	11.19	35.72	11.19	38.48

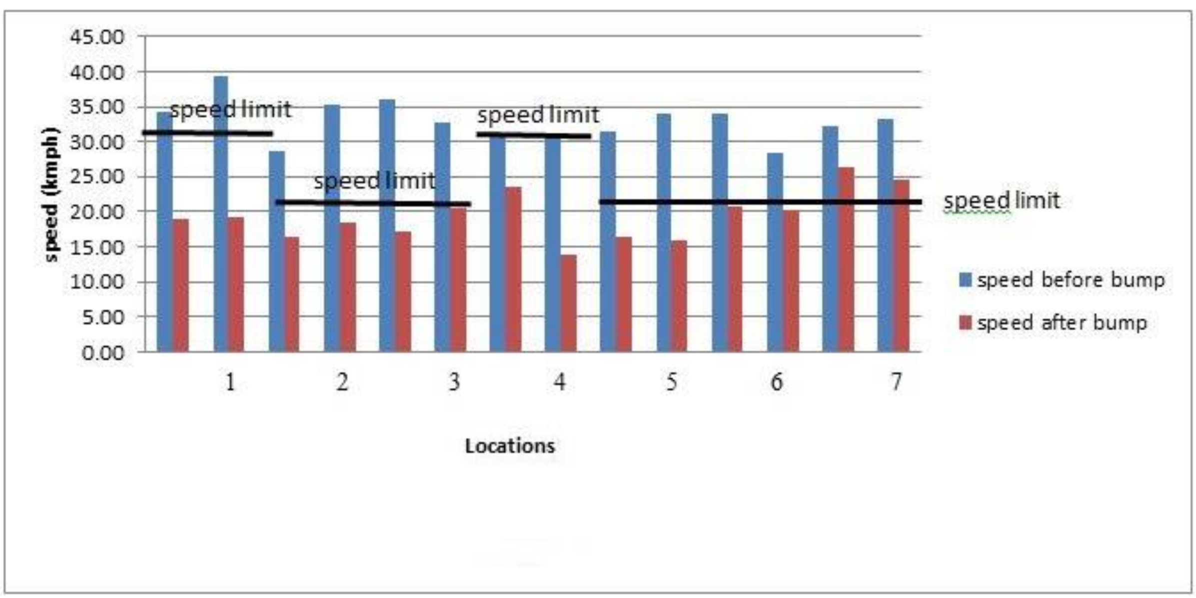
(standard deviations in parentheses)

Sl. No.	Location	Direction	Average reduction in speed (kmph)		Average % reduction in speed	
			2-W motorised vehicle	4-W motorised vehicle	2-W motorised vehicle	4-W motorised vehicle
			(4.63)	(3.72)	(11.97)	(12.3)
		Towards Cantonment	9.19 (4.48)	8.23 (4.92)	31.55 (14.55)	28.18 (14.95)
7	Main market cantt	Towards Jalandhar city	4.57 (2.08)	5.75 (2.22)	14.95 (7.41)	18.34 (8.39)
		Towards Cantt	6.94	8.83	21.74	26.14
			(3.65)	(6.27)	(11.23)	(17.77)

From Table4.1 and Table 4.2 it can be noticed that average decrease in speed is more than 22% at most of the locations except two locations; Garha Road (towards Towards KV) and Rama Mandi (towards Cantonment). At Garha Road most of the vehicles come from main gate and considering this factor two speed bumps have been provided one at each side of the gate of Garha Road. In front of Rama Mandi road is at downward slope towards NH1 direction due to which decrease in speed after speed bump is less. Near Main market cantonment, decrease in speed is not much with that cross-drainage structure. Figure 4.1 depicts the speed impacts of speed bumps in Jalandhar Cantonment. From these bar charts it is clear that motorised vehicles are driving at more than the prescribed speed limit on road.



(a) 2-w motorised vehicles



(b) 4-w motorised vehicles

Figure 4.1: Speed impacts of speed bumps on vehicle

4.3 Impacts of Material and Size

If we compare the operational performance of two types of speed bumps, then we find that mechanical speed bumps cause more decrease in speed than the speed bumps which are constructed using material on road. It is given in Table 4.3.Comparisons of size of bumps for mechanical bumps and bumps constructed using material are given in Table 4.4 and Table 4.5 respectively. It was found that for both types of speed bumps, bumps having large size decrease the speed more than those of small size.

- **Table showing Comparison between mechanical speed bumps and speed bumps constructed using material**

Type of vehicle	Average decrease in speed (kmph)		Average % decrease in speed	
	mechanical	material	mechanical	material
2-W motorised vehicle	14.22	9.87	43.47	28.84
4-W motorised vehicle	17.22	15.94	48.32	39.57

- **Table showing Comparison between mechanical speed bumps having different size**

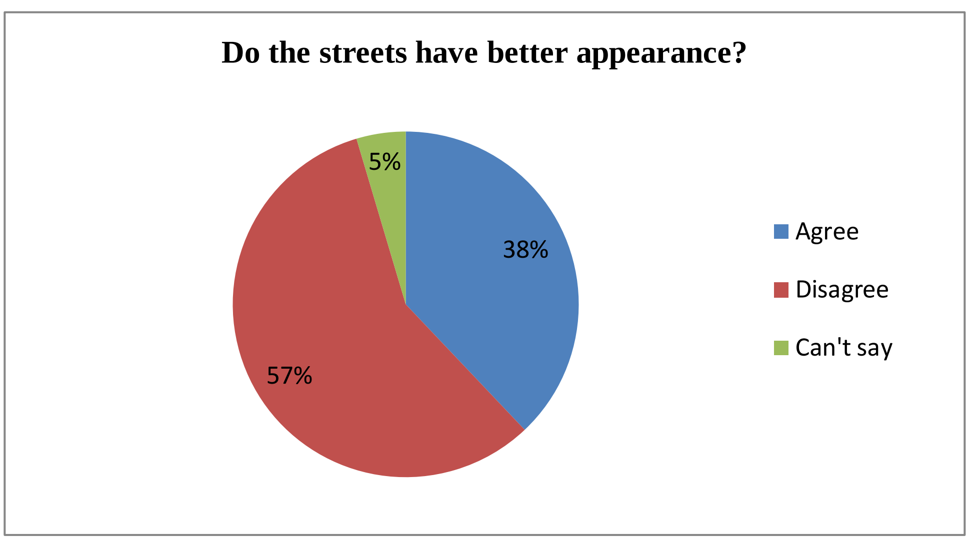
Type of vehicle	Average decrease in speed (kmph)		Average % decrease in speed	
	340 mm x 45 mm	750 mm x 70 mm	340 mm x 45 mm	750 mm x 70 mm
2-W motorised vehicle	14.11	14.32	41.58	45.36
4-W motorised vehicle	17.76	16.68	47.08	49.56

➢ **Table showing Comparison of size of speed bumps constructed using material**

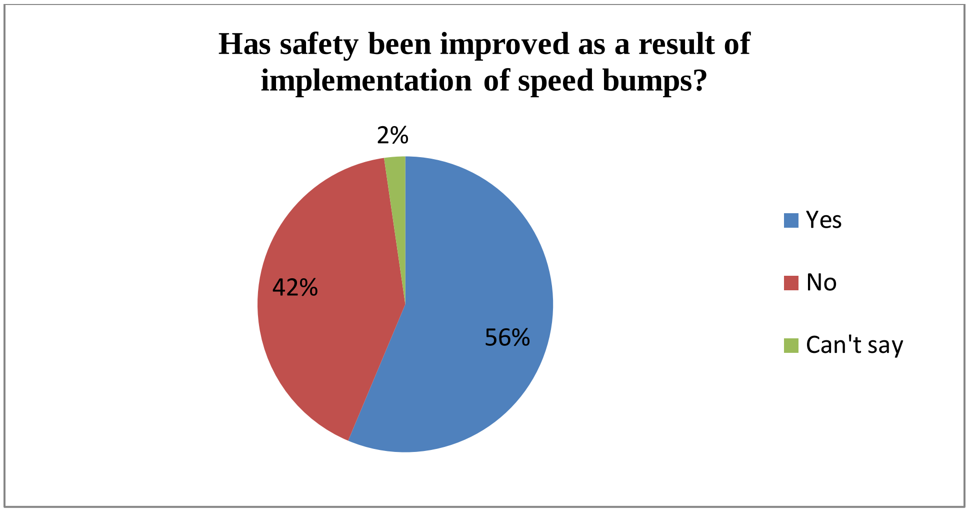
Type of vehicle	Average decrease in speed (kmph)		Average % decrease in speed	
	1600 mm x 75 mm	2700 mm x 30 mm	1600 mm x 75 mm	2700 mm x 30 mm
2-W motorised vehicle	6.55	10.98	23.32	30.68
4-W motorised vehicle	11.84	17.31	38.00	40.10

4.4 Opinion Survey

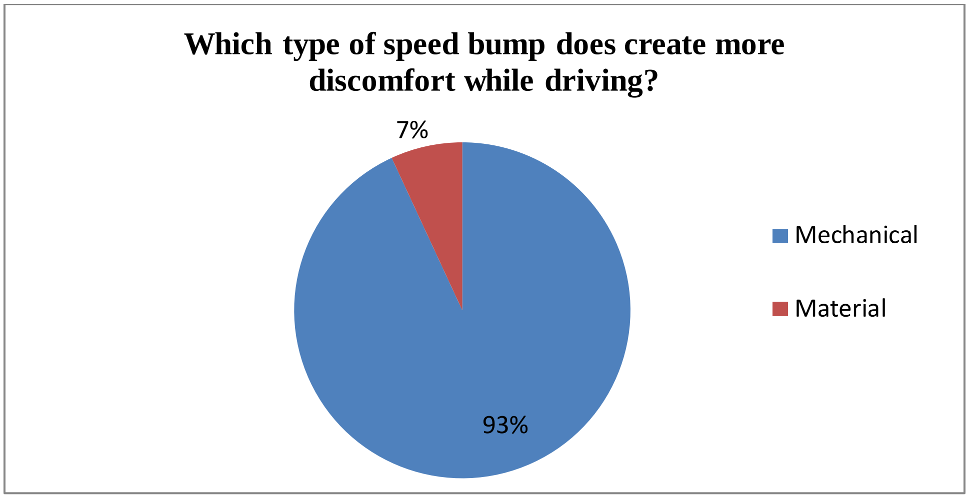
To have an eye on what community thinks about the traffic calming scheme which is speed bumps in this project, the opinions of road users have been collected. It was a population of 87 which constituted students, security personnel, cycle rickshaw drivers etc. Results are shown in Figure 4.2. These pie charts show that there is a need to work on the appearance as the condition of roads is deteriorated due to vehicle movement. On one side, speed bumps are improving the safety of people by forcing the drivers to reduce their vehicle's speed, on the other hand they are not comfortable (as in case of mechanical bumps) for some sections of persons that include children, senior citizens, patients and challenged persons by creating jerks at bump.



(a)



(b)



(c)

Figure 4.2: Results of opinion survey

(a) Do the streets have better appearance?

By collecting the opinion survey at various locations from various people at Jalandhar cantonment, the result was that the 57% of people which include students, driver, and security personnel disagree with appearance of streets with in Jalandhar cantonment. 38% agree with appearance of streets and only 5% was unable say about the appearance.

So thus it is Recommended that the streets must be give better appearance and its improvement should be made so that road may be free from pot holes and detoriated surface with vehicles should be improved which will improve the comfort and safety of road users.

(b) Has safety been improved as a result of implementation of speed bumps?

Majority of people 56% agree with that the safety has been improved with the implementation of speed bumps, 42% disagree with safety improvement due to speed humps and only 2% was unable to say anything. so according to this result the safety has been improved as the pedestrian enjoy freedom. The recommendation is that the proper signs should be placed so that the driver will be aware about speed hump due to this safety will improve as i have seen that majority of speed bumps are without signs.

(c) Which type of speed bump does create more discomfort while driving?

While collecting opinion survey from people it was concluded that about 93% people said that mechanical speed bumps creates discomfort only 7% said material speed bumps create discomfort. So it is thus concluded that mechanical speed humps create more discomfort than the material speed bump.

Mechanical speed humps are more efficient in speed decreasing and thus provide more safety but creates more discomfort while driving. So conclusion is that safety is given a priority over comfort.

CHAPTER – 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Following conclusions could be drawn from the project work:

1. Average percentage decrease is more than 22 % at all locations except recruiting headquarters and officers colony.
2. Average percentage decrease in number of accidents from 2010 to 2012 is more than 11 %.
3. Mechanical speed bumps are better in reducing the speed of vehicles than the speed bumps constructed by material.
4. The level of discomfort is lower with the speed bumps constructed by material than that with mechanical speed bumps.
5. Speed bumps of large size are more effective in decreasing the speed of vehicles.
6. Many of the drivers are not following the prescribed speed limits on roads which are 20 kmph and 30 kmph inside the Jalandhar Cantonment.

5.2 Recommendations

On the basis of the conclusions mentioned above, following recommendations can be made:

1. There is a problem of jerk while encountering the mechanical speed bumps. To overcome this, some other alternatives such as speed cushion or speed table can be implemented.
2. Speed bumps should be implemented on entire road width since there is a tendency in some drivers to cross the bumps over the left portion of the road width.
3. For a particular type of speed bumps, bumps having larger size should be used to improve the safety.
4. There is a need to implement some speed control measure again on the road from NH1 immediately.
5. Actions are required to enforce the traffic rules properly and some educational campaigns can be organised to educate people about the same.

A comprehensive study can be done with interest in bicyclists and pedestrians that have the maximum proportion among road users inside Jalandhar cantonment.

CHAPTER – 6

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Appendix 1

SPOT SPEEDS			
Type of Speed bump :			
Location :		**Direction of flow :**	
2-W motorised vehicles		**4-W motorised vehicles**	
before bump	**after bump**	**before bump**	**after bump**

Appendix 2

JALANDHAR CANTONMENT

Opinion Survey for operational performance of Speed Bumps

Name: Occupation:

1. Do the streets have better appearance?

   Agree ☐ Disagree ☐ Can't say ☐

2. Has safety improved as a result of implementation of speed bumps?

   Yes ☐ No ☐ Can't say ☐

3. Which type of speed bump creates more discomfort while driving?

   Mechanical ☐ Material ☐ Can't say ☐