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Analysis of Non-Standardized Traffic Calming Devices under Local Conditions of Pakistan

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***Abstract*—**The paper presents the issues regarding traffic calming devices in Pakistan. The problem is that no comprehensive analysis of the impacts of the traffic calming devices had been done previously.

The paper proposed answer to three questions: 1) What are the current practices of traffic calming devices in Pakistan 2) What guidelines and standard exist for installation of these devices? 3) What are the suitable measures for the execution of traffic calming devices?
To achieve these goals field survey and questionnaire survey was conducted in order to evaluate the current condition of traffic calming devices and to know the perception of general public about device suitability, quality and their agreement. Different agencies were visited which look after it and interviewed different officials to inquire about the design and maintenance of calming devices.
The major findings were: 1) Traffic calming devices are not constructed according to standard dimensions and there is lot of variations in implementation 2) Regulations regarding design, construction and installation of traffic calming devices are established at local level. 3) Suitable measures are suggested for the installation of traffic calming devices.

***Keywords*—** Traffic calming devices, Speed hump, Speed bump, Speed table, Steel stud

Abbreviations
TCD: Traffic calming device

I. INTRODUCTION

The term 'Traffic calming' has become the buzzword in the last decade throughout the nation. Speedy vehicles through residential areas, in an attempt to find ways to avoid congested arterial roadways, has become an issue for the safety of children. For that reason, traffic calming, specifically speed humps, are being installed as a solution to control these issues. For improving safety and quality of life of residents many countries have adopted different physical devices to prevent vehicular traffic in the occupant's area. Traffic calming create the roads that are safer for pedestrian, bicyclist and public transport. But in many cases traffic calming devices are installed randomly without study where no proper design and particularly no reflectors, marking and advance warning signs are used. These devices are mostly constructed in a way that may cut the path of water over the pavement surface. So installation of these devices may create negative effects due to uncontrolled deceleration and acceleration of vehicular movements on the service level of roadway and it may be a factor in reducing the service life of pavement.

The use of traffic calming devices is not considered good engineering practice. As no study on this issue have been found till date so the prime objectives of the study are to find out:

1. Current practices of traffic calming devices in Pakistan.
2. Guidelines available for the implementation of traffic calming devices.
3. Departments involved in traffic calming planning and implementation and to recommend suitable measures to counter the negative impacts of traffic calming devices.

Based on literature research, these appeared to be key questions which had not been addressed before in any case study or survey. So the objective of the current study is to obtain the information on traffic calming devices with respect to above concerns. The viewpoint of road users, residents, traffic engineers and officials is taken into consideration. The review is not technically oriented as it does not include engineering aspects or scientific research methodology but the focus of study is to identify the ways by which these calming devices have been used in residential areas. Community acceptance and factors having effect on it are evaluated.

The study depends on three main sources of information: 1) field survey 2) a survey carried out via questionnaire 3) in depth interviews with agency personnel.

Following the introduction, the literature is described having focus on the countries which have documented experience with traffic calming devices. Most of the documentation came from United States.

II. LITERATURE REVIEW

TABLE I SUMMARY OF FINDINGS ABOUT TRAFFIC CALMING DEVICES

	Area	Year	Device	Results
1	Spain	2018	Speed kidney	The design of speed kidney moderates the speed and minimizes the emergency response delays and the maintenance, inconvenience caused to the passengers, damages to the vehicles, the noise and vibrations. [1]
2	Indonesia	2018	Speed hump	Speed reduction mean for standard speed hump is substantially larger than speed reduction mean for non-standard speed hump. [2]
3	Bangladesh	2018	Speed hump	Proper placement and dimension of the speed humps is an imperative requirement to be solved by government by providing guidelines, standards, and policy. [3]
4	Spain	2018	Various devices	Women have highest road traffic incident (RTI) rate in case of minor injuries while men have highest RTI in case of serious and fatal injuries. Motorcycles are most risky mode of transport while public transport is safest. [4]
5	Egypt	2017	Speed hump	Pavement conditions are greatly influenced by existence of speed humps and their characteristics. [5]
6	India	2016	Speed hump	Speed hump could harm the bicyclists, unless proper considerations for bicyclists are made. [6]
7	Lithuania	2016	Speed hump, Speed bump, Raised crosswalk	Fatal and injury accidents decreased by 60%. Injured decreased by 63% People killed decreased by 82%. [7]
8	China	2014	Speed hump	By comparing body acceleration, wheel ground adhesion index and wheel load the best speed limit range of the speed hump can be determined. [8]
9	Malaysia	2013	Speed hump	Speed hump significantly reduces the speed and capacity of road. [9]
10	Thailand	2013	Speed hump	Speed hump profile can be estimated correctly by using quarter car model. [10]
11	South Africa	2012	Speed hump	Vehicle speed changes significantly with speed hump but their resultant highway capacity loss is also significant. [11]
12	Sweden	2011	Speed hump	Distance between speed hump and pedestrian crossing should be 10m or equal to length of two cars. [12]
13	Chile	2010	Speed hump	Seating in a motor vehicle, especially on the last row in a bus, may cause severe traumatic spine injuries as it passes over a speed hump. [13]
14	North America	2009	Various devices	Speed is most significant issue for installing a TCD. Community support is most important factor for the selection of TCDs. [14]
15	China	2008	Speed hump	Small inclinations should be added to the top of the hump for best performance. Response of optimal hump is smooth, gentle and symmetric at speeds different from the design speed. [15]
16	United States (Illinois)	2008	Speed hump	Speed humps are the most turbulent TCDs to the emergency vehicles response time. [16]
17	Turkey	2005	Speed bump	Speed bump should be build regarding testing standards. Drivers should be educated and strongly warned on the potential hazards of traversing past such measures too fast. [17]
18	United States (Iowa)	2002	Speed hump	Optimum spacing of speed humps/tables is 220-285 feet for temporary speed humps. [18]
19	United States (Oregon)	2000	Speed hump	An average delay to emergency response is 3.6 seconds per speed hump. Design, construction and placement of TCDs is done at local level. [19]

III. METHODOLOGY

This research was based on information from following three sources.

First: The first phase was to collect field data of traffic calming devices on different local roads, collectors, and major arterials of Lahore city. So a thorough field survey was conducted. By using personal knowledge, an initial list of about 120 spots was generated which were reported to have tried traffic calming in the last few years. From this list, one in three was selected randomly to be surveyed, managing to successfully conduct a survey in 37 of the 40 spots thus selected. Hence the sample included 37 spots reporting active traffic calming installations or planning programs.

Total eleven sites on local road, twenty-one sites on collectors, and five sites on arterial road, were selected. The objective was to collect data from different locations to compare the different info regarding traffic calming devices. Continuance of field survey was one month. All data were collected on day time. Photographs of the calming devices were also taken.

Two: Questionnaire survey of a large volume of residents was conducted who were living along these study streets and using these traffic-calming devices. The duration of questionnaire survey was from 1st June up to 30th June 2018 on the selected survey locations. The objective of the opinion survey was to know the demand of road users of different ages, genders, classes and professions regarding traffic calming. A total of three road categories were selected to obtain a clear picture that are arterial, collector, and local road.

Third: In-depth interviews were conducted with number of officials working in agencies to determine the extent to which these agencies have involved themselves in traffic calming. The agencies selected for interviews were the 6 largest in the Lahore. For the selected agencies, the officials were interviewed who assigned to handle traffic calming or to work on neighborhood issues. If there was no such assignment, the head of the section was interviewed that works most closely with local government's transportation programs. All persons thus identified were provided with a brief description of the study and were invited to participate in a detailed interview on their experiences with traffic calming. For those who agreed to participate, an interview was scheduled. The vast majority of the interviewees were traffic engineers or engineers in transportation or public work departments. In a very small number of cases interviewees were from other departments. In some agencies more than one person was interviewed.

- ***Interview guide***

For the interview, a list of questions was used as a guide. The interview format was one of a structured conversation rather than questionnaire administration; the aim was holistic understanding of the locality's traffic calming experience rather than for a detailed accounting of actions taken, devices used, or reactions to the experience. As a result, the interviews did not always cover every single question in equal detail, but did identify the main issues as each interviewee saw them. Most interviews took about thirty minutes, with a few considerably shorter and several longer discussions.

IV. DATA ANALYSIS

A. Data analysis from field survey

Three categories of road (Arterial, collector, local) in Lahore city are considered to investigate the effects of traffic calming devices. The sites are located in twenty-three of Lahore total communities. Locations are given in Table II. The sites in table are selected based on pedestrian generation, traffic flow and population density.

TABLE II LIST OF LOCALITIES & SITES SURVEYED DURING RESEARCH

Sr. #	Localities	Sites Included
1	Gulberg IV	Site-1
2	Model Town	Site-2, 13
3	Nisar Colony	Site-3, 11
4	Officers Colony	Site-4, 12
5	Walton Cantt Board Officers Housing Society	Site-5
6	DHA, Phase I	Site-6, 7
7	New Muslim Town	Site-8, 9
8	Main Gulberg	Site-10
9	Askari 11	Site-14,15,16,17,18,19
10	DHA, Phase VI	Site-20, 21, 22
11	Paragon City	Site-23
12	Gulberg III	Site-24
13	Mian Mir Colony	Site-25
14	Valencia	Site-26
15	Judicial Colony	Site-27
16	Agrics Town	Site-28
17	Garhi Shahu	Site-29, 30
18	Mughal Pura	Site-31
19	Dharampura	Site-32
20	Saddar	Site-33
21	Green Town	Site-34
22	Wapda Town	Site-35
23	Johar Town	Site-36, 37

These 37 sites are located in twenty-three of Lahore total communities. These sites exact location is presented in fig 1.

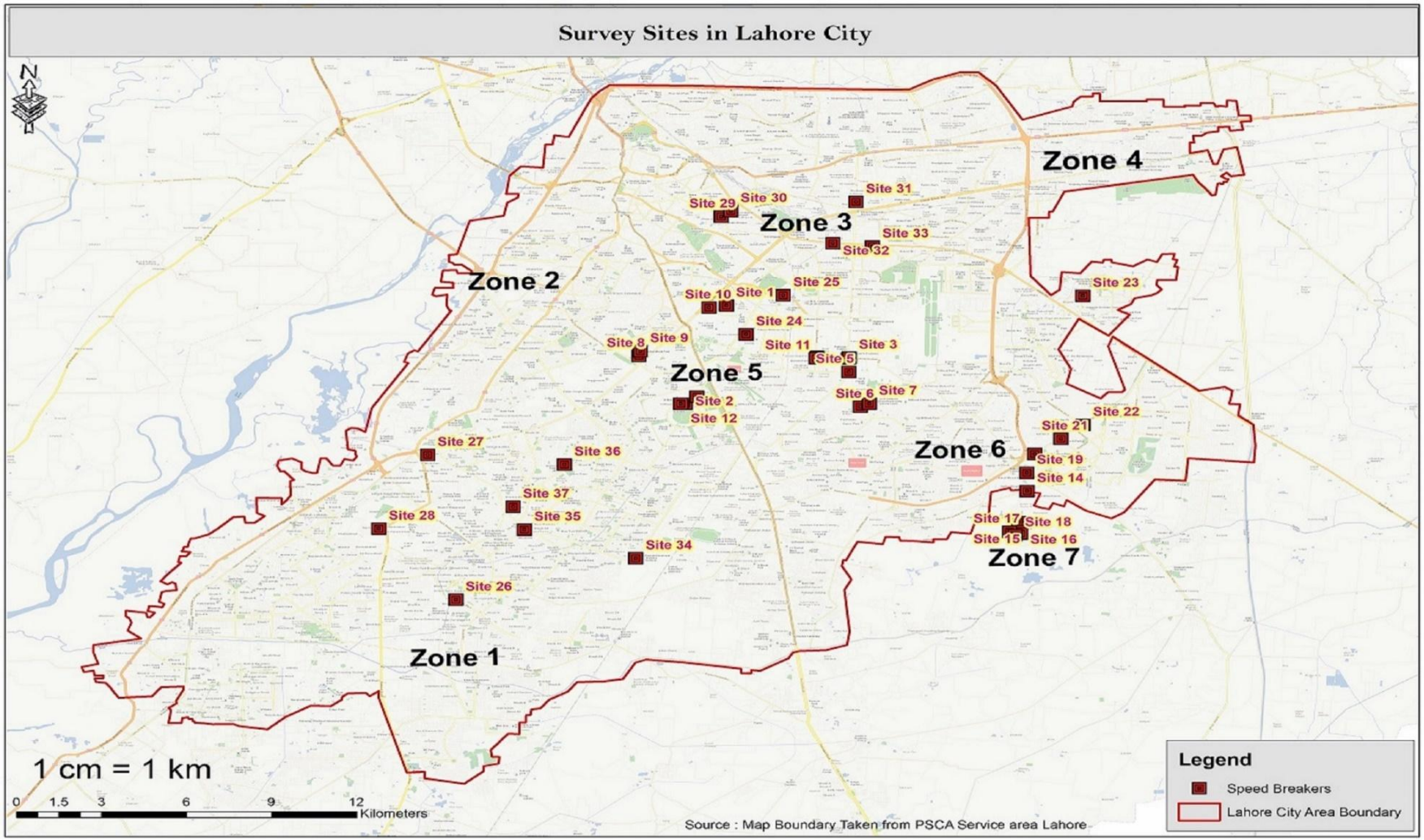

Figure 1. Location map of study sites in Lahore district

An inventory of traffic calming devices is done and more than 90 devices installed are found. For the analysis, only vertical traffic calming devices implanted on the roads of Lahore are selected. The sites irrelevant to research are rejected.

Tendency of traffic calming devices

The type of traffic calming devices which are found during investigation by their type consist of speed table, speed bump, speed hump and steel studs. From the field survey the tendency of used devices in Lahore city is found as shown in table III and fig 2.

TABLE III. TENDENCY OF TRAFFIC CALMING DEVICES

Traffic Calming Device	%age of the Devices Used
Sinusoidal speed hump	10.9
Circular speed hump	41.8
Parabolic speed hump	4.5
Flat-topped speed hump	5.5
Speed hump (Inappropriate shape)	5.5
Speed Table	10.9
Speed bump	13.2
Steel Studs	7.7

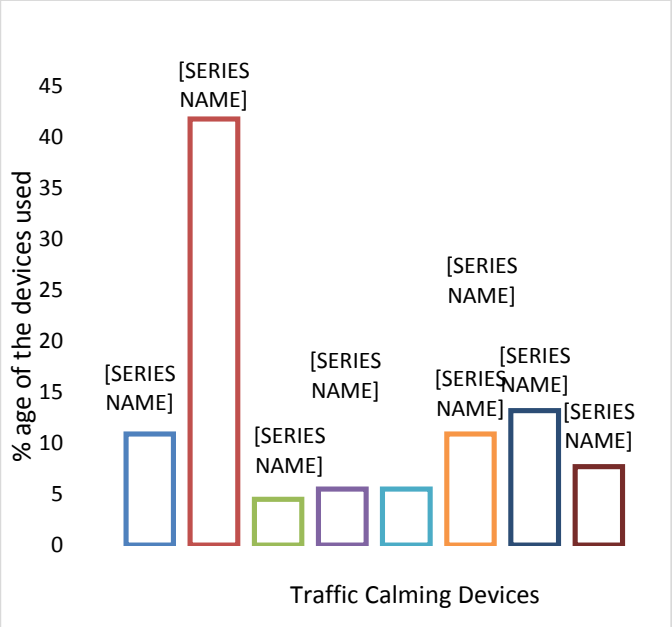

Figure 2. Trend of traffic calming devices used in the city

Four typical design profiles of speed humps are found in Lahore city that are sinusoidal, circular, parabolic and flat-topped.as shown in the following figures.

Figure 3. Speed humps at four leg intersection (Muslim Town)

Reflectors and Marking

Table IV lists the survey locations and number of calming devices on each site investigated in the study. Status of calming devices regarding reflectors and marking is also presented in the table.

TABLE IV REFLECTORS & MARKINGS USED ON TRAFFIC CALMING DEVICES

Site No.	Site Name	Calming Device	# of Calming devices	Reflectors	Marking
Site-1	Syed Maratib Ali road	Steel studs	1	✗	✗
Site-2	Model Town Circular road	Circular speed humps at junction	2	✓	✓
Site-3	Tufail road	Circular speed humps at junction	2	✓	✗
Site-4	Walton road	Parabolic speed hump at junction	1	✓	✓
Site-5	Walton road	Speed table	1	✓	✗
Site-6	Street 1	Flat-topped speed hump	1	✗	✗
Site-7a	Street 10	Circular speed hump	1	✓	✗
		Circular speed hump	1	✗	✗
		Circular speed hump	1	✗	✗
Site-7b	Street 7	Speed hump (Inappropriate shape)	1	✗	✗
Site-8a	Service Road	Sinusoidal & flat-topped speed humps at junction	2	✗	✗
Site-8b	Service Road	Steel studs	3	✗	✗
Site-9a	Main Abdul Waheed st & Ayoubia Market road	Parabolic, Circular, Sinusoidal &Flat-topped speed humps at junction	4	✗	✗
				1 hump has reflectors	1 hump has marking
Site-9b	Ayoubia Market road	Steel studs	1	✗	✗
Site-10a	Zahoor Ilahi road	Speed table	1	✗	✗
Site-10b	Zahoor Ilahi road	Sinusoidal speed hump	1	✗	✗
Site-11	Khursheed Alam road	Circular speed hump at junction	1	✓	✗
Site-12	Shami road	Circular speed hump at junction	1	✓	✗
Site-13a	Model Town Ferozpur link road	Circular speed humps at junction	4	✓	✓
				1 hump has no reflectors	
Site-13b	Model Town Ferozpur link road	1 Sinusoidal & 3 Circular speed humps at junction	4	✓	✓
				2 hump have no reflectors	
Site-14	Askari 11 Underpass	Speed bump	4	✗	✓
Site-15	Street 31-40	Speed bump	5	✗	✓
Site-16	Service Road	Flat-topped speed hump	1	✗	✗

Site No.	Site Name	Calming Device	# of Calming devices	Reflectors	Marking
Site-17	Service Road	Circular speed humps	2	✗	✓
				✗	✗
Site-18	Service Road	Circular speed humps	4	✓	✓
Site-19	Service Road	Speed bump + Speed stud	1	✗	✓
Site-20	Shabir Sharif Road	Speed table	1	✓	✗
		Speed bump	1	✗	✗
Site-21	Shabir Sharif Road	Speed table	2	✓	✗
Site-22	Shabir Sharif Road	Speed table	2	✓	✗
		Speed table + Speed studs	2	✓	✗
Site-23	Main Boulvard	Sinusoidal speed hump + Steel Studs	1	✗	✓
		Steel studs	1	✗	✗
		Sinusoidal speed hump	1	✓	✗
Site-24	Sir Syed Road	Flat-topped speed hump	1	✗	✗
		Speed bump	1	✓	✗
		Speed table	1	✗	✗
Site-25	Jail Road	Speed hump (Inappropriate shape)	1	✗	✗
Site-26	Valencia main Blvd	Circular speed hump	3	✓	✓
Site-27	Local Street	Sinusoidal speed hump	4	✗	✓
Site-28	Agrics Town Rd	Circular speed hump	5	✗	✓
Site-29	Davis Road	Circular speed hump + Steel studs	2	✗	✓
Site-30	Durand Road	Circular speed hump	2	✗	✓
Site-31	Shalimar Link Road	Parabolic speed hump	1	✗	✗
Site-32a	Allama Iqbal Road	Steel studs	1	✗	✗
Site-32b	Allama Iqbal Road	Circular speed hump	1	✗	✗
Site-33	Zarrar Shaheed Road	Parabolic speed hump	1	✗	✗
Site-34	Madar-e-Millat Road	Circular speed hump	1	✗	✓
Site-35	Wapda Avenue	Circular speed hump	1	✓	✓
Site-36	Shadewal Road	Speed hump (Inappropriate shape)	1	✗	✗
Site-37	Service Road	Speed hump (Inappropriate shape)	2	✗	✗

Material used for traffic calming devices

The following graph shows the percentage proportion of the material used for calming devices.

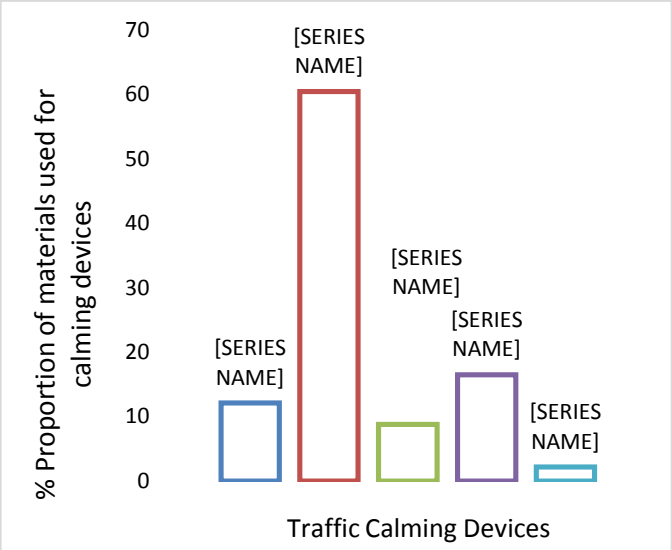

Figure 4. Material used for traffic calming devices

Condition of traffic calming devices

Most of the traffic calming devices were found in good conditions. Following table and graph shows the percentage proportion of the good, normal and poor devices.

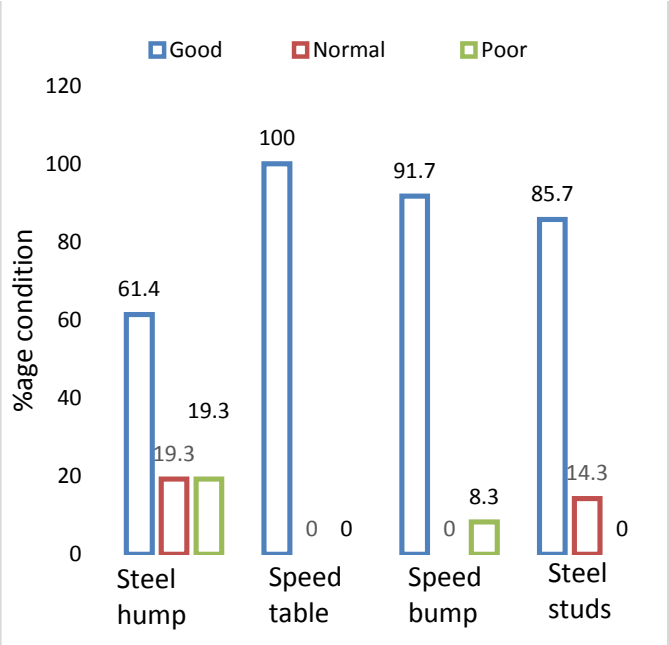

Figure 5. Condition of traffic calming devices

B. Data analysis from questionnaire survey

According to the capacity and function, roads are divided into different categories roads that are arterial, collector and local road. The sample was taken non-statistically due to limited availability of resources, budget and manpower. Sample size is denoted by "n".

TABLE V SAMPLE SIZE n

Sample size (n)	
Arterial	70
Collector	130
Local	200
Total	**400**

Survey was categorized according to four groups that are gender, age, vehicle type and profession. The characteristics of study group is presented in the following table.

TABLE VI CHARACTERISTICS OF STUDY GROUP

	N (%)		N (%)
Gender		**Age**	
Female	22.97	Less than 25	42.40
Male	75.97	Greater than 25	56.54
Vehicle Type		**Profession**	
Car/Taxi	29.33	Driver	21.20
Bus	22.97	Police	35.34
Truck	2.47	Student	25.44
Motor Bike	41.34	Transport Operator	3.53
Cycle	2.83	Others	13.43

From opinion survey, it is found that respondents have vast variation in the response. The comparison of respondent's perception is provided in following table.

TABLE VII COMPARISON OF RESPONDENTS PERCEPTION

Question: 1

Aspect	Road Classification	Proportion (%)				
		Very good	Good	Fair	Poor	Very poor
Public acceptance	Arterial	17.1	45.7	28.6	2.9	5.7
	Collector	15.3	47.8	23.9	13	0
	Local Road	15.4	55.5	20.8	6.4	1.98
		15.5	53	22.3	7.1	2.1

Question: 2

Aspect	Road Classification	Proportion %		
		Reduced safety	No change	Increased safety
Effect of speed breaker on traffic safety	Arterial	31.4	2.9	65.7
	Collector	30.4	8.7	60.9
	Local Road	25.2	4.5	70.3
		26.9	4.95	68.2

Question: 3

Aspect	Road Classification	Proportion %	
		Yes	No
User satisfaction of material used	Arterial	68.6	31.4
	Collector	58.7	41.3
	Local Road	74.3	25.7
		71	28.97

Question: 4

Aspect	Road Classification	Proportion %				
		Strongly disagree	Disagree	Ambivalent	Agree	Strongly Agree
Speed breaker damages the vehicles?	Arterial	14.3	25.7	14.3	25.7	20
	Collector	6.5	23.9	19.6	36.95	13
	Local Road	9.9	42.1	10.4	28.2	9.4
		9.9	37.1	12.4	29.3	11.3

Question: 5

Aspect	Road Classification	Proportion %			
		Fatal	Major	Minor	No accident
Any accident occurred due to speed breakers?	Arterial	5.7	20	45.7	28.6
	Collector	8.7	8.7	36.9	45.7
	Local Road	4.9	11.9	34.7	48.5
		5.7	12.4	36.4	45.6

Question: 6

Aspect	Road Classification	Proportion %				
		Strongly disagree	Disagree	Ambivalent	Agree	Strongly Agree
Congestion due to traffic calming device	Arterial	2.9	31.4	11.4	51.4	2.9
	Collector	8.7	34.8	15.2	41.3	0
	Local Road	3.5	51.5	10.9	30.7	3.5
		4.2	46.4	11.7	34.9	2.8

Question: 7

Aspect	Road Classification	Proportion %				
		Strongly disagree	Disagree	Ambivalent	Agree	Strongly Agree
Traffic diversion to another street	Arterial	54.3	0	14.3	31.4	0
	Collector	10.9	23.9	19.6	43.5	2.2
	Local Road	8.4	55.9	11.4	20.8	3.5
		14.5	43.8	13.1	25.8	2.8

Question: 8

Aspect	Road Classification	Proportion %				
		Very much	Somewhat	Not so much	Not at all	No comment
User friendliness w.r.t dimensions	Arterial	8.6	25.7	37	17.3	11.4
	Collector	6.5	30.5	37	6.5	19.5
	Local Road	7.9	30.2	12.9	12.9	36.1
		7.8	29.7	19.8	12.4	30.3

Question: 9

Aspect	Road Classification	Proportion %			
		Noise	Air	Vibration	All
Environmental effect of traffic calming devices	Arterial	14.3	17.1	14.3	54.3
	Collector	26.1	13	19.6	41.3
	Local Road	36.6	6.9	10.5	46
		32.1	9.2	12.4	46.3

Question: 10

Aspect	Road Classification	Proportion %	
		Yes	No
Fuel consumption due to traffic calming device	Arterial	71.4	28.6
	Collector	76.1	23.9
	Local Road	80.2	19.8
		78.4	21.6

C. Data analysis from agency representatives

Comments of officials and my observations are presented in the following table.

TABLE VIII AGENCIES VISITED DURING RESEARCH

Sr. #	Agency	Officer Name	Designation	Comments	Observations
1	**The Urban Unit (UU)**	Zuhair Aslam	Senior Specialist Transport Planning & Management	Urban Unit has initiated the development of the Punjab Geometric Design Manual (PGDM). The Manual is expected to provide guidelines for provincial departments, development authorities and local governments towards using standardized roadway design procedures and guidelines meeting the expectancy of the local drivers, and thus contributing towards provision of safe roadway designs.	PGDM Manual has been developed through a long consultative process involving technical experts to ensure the quality and value for its use. The Manual is a dynamic document and current edition is still a draft document that requires continuous review and feedback by the stakeholders on a regular basis which will be incorporated in the final document.
		Dr. Syed Murtaza	Transport Planner	Currently there is no policy which is followed for the construction of speed breakers	
2	**National Engineering Services Pakistan (NESPAK)**	Arshad Malik	Prinicipal Engineer (Highway Section)	NESPAK has received many requests from general public and officials for the installation of calming devices throughout the city. But currently there is no policy which is followed. NESPAK follows design standards of OMAN.	NESPAK officials have limited knowledge and guidance to make decisions to implement traffic calming devices.
3	**Traffic Engineering & Planning Agency (TEPA)**	Waqar Aslam	Senior Traffic Engineer	According to official, Calming devices should be installed only when it is unavoidable. Agency only offer technical help in the construction of devices. Speed table is better than any other traffic calming measures because it causes less damage to vehicles. TEPA does not recommend traffic calming devices even though the request may be valid.	TEPA did not use proper design specifications for the installed traffic calming devices.
4	**City District Govt. Lahore (CDGL)**	Muhammad Tariq Effendi	Metropolitan Officer (Infrastructure)	26 Roads are in the jurisdiction of CDGL and we only look after the calming devices at these 26 roads. There is no policy for installation of calming devices. We suggest calming devices when we get intimation from TEPA or CTP. Speed table should be installed instead of any other traffic calming device.	CDGL had passed many resolutions against dangerous and illegally constructed traffic calming devices in the city but unfortunately concerned authorities of road department failed to implement such bill passed by the elected representatives so far.
5	**City Traffic Police (CTP)**	Athar Ismail	Superintendent of Police (SP)	We do not install or deal with any traffic calming device. Only two speed humps were suggested in the start of ring road because pressure from the community was increasing for installation.	LRA approved the use of speed hump without analyzing the impact they may have upon vehicles speed or safety.
6	**Lahore Development Authority (LDA)**	-	-	-	No official available dealing with traffic calming.

CONCLUSION

D. Conclusion from field survey

Tendency of traffic calming devices

Among all types of TCDs installed in city, the most commonly used are the speed humps because of its low cost and effectiveness in reducing speed. Speed humps are of various shapes are found that includes sinusoidal speed hump (10.9%), circular speed hump (41.8%), parabolic speed hump (4.5%), flat-topped speed hump (5.5%) and speed humps of inappropriate shape (5.5%). Speed bumps are 13.2 %, speed tables are 10.9% and steel studs are 7.7%.

Reflectors and marking on traffic calming devices

Most of the calming devices do not have marking and reflectors so far. Reflectors should be installed on all calming devices implanted on arterials connecting major roads of the city in order to avoid road mishaps, which are increasing day by day.

Material used to construct traffic calming devices

In Lahore, 60.4% traffic calming devices are constructed by asphalt and concrete and 12.1% are made up by rubber. While traffic calming devices constructed by metals, tuff tiles or cement are of 8.8%, 16.5 % and 2.2% respectively.

Condition of traffic calming devices

It is necessary to ensure good quality of TCDs in order to avoid any mishap. In Lahore 61.4 % speed humps are in good condition while speed table, speed bump and steel stud are in good conditions with 100%, 91.7% & 85.7% respectively. According to survey, 19.3% speed humps and 8.3 % speed bumps are in poor conditions because of non-availability of reflectors, marking and poor material used.

E. Conclusion from questionnaire survey

Public acceptance

Question one of the questionnaire survey was to ask about acceptance each resident have for traffic calming devices. Survey found that 9.2% residents opposed to the traffic calming devices and 90.8% residents were in favor (15.5% public marked it very good, 53% marked it good while 22.3 % people marked it fair). So overall public supports traffic calming devices because maximum percentage of people marked these measures positively.

Safety

Question two of survey asked whether residents perceived an increase in safety due to installation of calming devices. Lahore city reported mixed results. Some respondents (26.9%) reported that by using these devices traffic has not always slowed enough to satisfy residents. While most respondents (68.2%) felt that traffic calming is largely successful. Other respondents (4.95%) agreed that there were no changes regarding safety.

User satisfaction for material used for calming devices

For the question which deals with the suitability of material used for the traffic calming devices at roads, high proportion (71%) of respondents stated their agreement that the devices material is suitable, while on the contrary low proportion (28.97%) of respondents stated that they are not satisfy with the material used for calming devices as it is dissatisfactory & trouble causing for travelers according to them.

Damage to vehicles

Question four was to ask the residents whether calming devices damage the vehicles or not. 47% respondents were either disagreed or strongly disagreed with the point that traffic calming is causing damage to the vehicles when passing over it, while 12.4% were ambivalent. Rest of the respondents were agreed that calming devices damage the vehicles as the suspension of the vehicles is not normally made according to these non-standardized devices which can cause damage to them.

Accident occurrence

Prime focus of traffic calming devices is to reduce fatal incidents & injuries. Response from respondents revealed that 5.7% people faced fatal accidents, 12.4% faced major accidents and 36.4% faced minor accidents due to calming devices. Remaining 45% people faced no accident. Respondents said that vehicles swung out of control after hitting the calming device at high speed.

Congestion

It is surprising to know that most of the respondents (50.6%) in all road categories stated that the calming devices do not cause congestion. While remaining 37.7% were agreed over this point and 11.7% were ambivalent.

Traffic diversion

Common response to this question was that the calming devices do not divert the traffic. 58.3% respondents were disagreed, 28.6% agreed that there was diversion of traffic. While remaining 13.1% were ambivalent.

User friendliness w.r.t dimensions

From the survey results, 37.5% of total respondents stated that calming devices are user friendly with respect to dimensions. 42.7% respondents declared it non user friendly.

Environmental effect

Along with positive impacts, environmental problem is always one of the major concerns of traffic calming devices. Almost all the road users were agreed to the point that traffic calming devices are causing environmental problem as these are increasing noise, air pollution and vibration of vehicles.

Fuel consumption

From the data analysis, it can be shown that most of the respondents (79%) stated that the implantation of calming devices has increased fuel consumption.

F. *Conclusion from agencies dealing with traffic calming devices*

Public acceptance

After visiting several agencies and conducting interviews, it is clear that no agency has formulated traffic calming policy till time. None of them defined that what types of traffic calming devices can be used. No agency indicated the departments that should be consulted before the installation of these devices and what studies need to be conducted before and after the implementation. No one gathered and analyzed data on the traffic complaint or evaluated the suitability of the requested device or where it can be used.

The answer to the question whether planning organizations are involved in traffic calming or providing any technical assistance was that there is very little such activity to date. Almost all interviewee claimed to be doing absolutely nothing related to traffic calming. Urban Unit has put out guidelines on traffic calming as part of its management program but it is also in review process. Almost every interviewee stated that they were not aware of the diversion issue and did not consider it before installing a device and had even never studied the traffic on alternate routes before and after installation of a calming device to check for diversion.

Many of interviewee were unfamiliar with the details of department's budget and were unsure how projects and programs had been funded. They did not remember the details or have access to a detailed accounting.

RECOMMENDATIONS

Based on the research, the undermentioned factors have been found that should be considered in the policy:

Public education:

There should be awareness campaigns organized by the agencies to give the knowledge about traffic calming to the residents that will help them in the selection of suitable device. The knowledge includes effect of calming device height, signage, markings, spacing etc.

Involvement of the Public:

Traffic calming devices should be installed only after getting consent and opinions from the occupants which are directly affected by these devices. Common people can be involved by many ways like public events, meetings, leaflets and walkabouts.

Standard application process:

There should be a proper way to request for a traffic calming device installation. For this purpose, there should be at least one organization in the city which will specifically deal with the said purpose.

Evaluation process:

After getting request, the concerned official will visit the location to check the validity of the request received.

Approved devices:

Concerned department should check out whether the desired device should be approved or not. There should be testing process to come to know the possible pros and cons of the alternate devices before taking decision.

Installation process:

There should be a sequence that which request should be addressed firstly. These sequence can be made based on the severity of the need and availability of funds.

Funding source:

Who will provide funds for the desired project?

Detailed map for emergency routes:

A map depicting all emergency service routes should be drawn by the help of traffic engineers and emergency department's personnel. The devices which have high impact on response time should not be installed on these routes. The map updation should be done on regular basis.

Future development:

A survey should be conducted to know the opinions of residents about the installed devices to develop a guideline for future installation.

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