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COMPARATIVE STUDY OF DESIGN AND PLANNING PROCESS OF TRAFFIC CALMING DEVICES

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Abstract: Speeding traffic on neighborhood streets and high through traffic volume affects the safety and quality of residents lives resulting in a loss of amenity for residents. Traffic calming is a way to design streets using physical measures to control the dominance and speed of motor vehicles. Many countries e.g. USA, UK, Canada, Netherlands, Australia, and South Africa have sophisticated and organized methods to carry out the whole process. While most of the Asian countries as Japan does not have well defined and systematic study process to facilitate traffic calming process.
This paper discusses about a comparative study of traffic calming device design guidelines, decision making process, installation policy, and the evaluation of effectiveness of a few of the most popular traffic calming devices. A before and after study of traffic speed, accident, traffic flow, environmental aspects and residents' reaction were performed to evaluate the impacts of traffic calming devices.

Key Words: traffic calming, physical measures, comparative study, decision making process, installation policy.

1. INTRODUCTION

The most common problems reported on residential streets regarding to motor vehicles are excessive speed and traffic volume. As a result residents feel general decline in their quality of life. Noise and environmental pollution increase. Several traffic calming practices have been implemented for reducing speeds and dominance of motor vehicles through urban areas and are based on the concept of sharing all modes of users in the same space. One explanation of what traffic calming involves is given by Brindle (1994, p256): Actions to restrain traffic speed and lessen traffic impacts at the local level, where traffic volumes, levels of service and network capacity are not an issue.

2. BACKGROUND AND STUDY METHOD

Although Japan has introduced some traffic calming devices but it is not fully developed yet. Besides there is no guideline to facilitate the process. There are still some variations in designs. There is no written procedures and documented methodology used in setting priorities for traffic calming device implementation. Several traffic calming devices are installed in some areas but they are not so effective as they do not follow proper research method. Improper design of these devices is creating more problems for residents than solving as they are increasing noise and vibration levels.

This research is a comparative study of traffic calming design and decision making process, which is hoped to serve as a suitable base for future implementation for the traffic calming decision making process in Japan. If there is a framework for the decision making process, then it is too easy to install a device to anywhere of the country without much effort. A questionnaire survey of USA, some European countries and some cities of Canada was conducted regarding to the traffic calming decision making process and types of traffic calming devices currently in use on the residential local streets. Most of the questionnaires were sent to the cities for which manual of the traffic calming process was studied for clear understanding of the process. About 175 questionnaires were sent and 26 respondents replied. Reply ratio is 15%.

Japan started traffic calming during 1984 by the introduction of "Road-Pia" concept when there was no coordination between the Police and Local Government let alone the neighborhood. In case of the instigation of “Community Zone” in 1996 Local Government and Police was supposed to judge whether to install it or not, residents did not have the opportunity to propose it. In case of the new scheme named “Kurashino Michi Zone” started in 2003, residents can propose. But there is no channelize process as to how to start, how to proceed and how to define the responsible authority. There are no formal procedures for establishing the need for traffic calming measures. Standards have not been developed to ensure uniform benefits to residents of traffic calmed areas, particularly with regard to their opinions. There is no documented process as to how the residents will involve into the planning stages of the traffic calming process either. Therefore, a guideline must be set for the proper selection prior to the implementation of any traffic calming device Effective coordination of Local Government, Police and Residents has not frequently ensured in Japan. Hence Japan needs to clearly define its comprehensive traffic calming plan and to develop a formal, documented traffic calming process.

3. OBJECYIVE OF TRAFFIC CALMING

The principal objective of traffic calming is to reduce the speed and volume of motor vehicles. The following objectives can be also documented with the reduction of speed and volume:

- protecting neighborhood areas from the unwanted through traffic
- reducing the environmental pollution caused by motor vehicles
- reducing the noise caused by speeding vehicles
- ensuring road safety for all users especially for non-motorized users as pedestrians and cyclists
- reducing crash occurrence and severity.

4. TRAFFIC CALMING MEASURES

The benefits which can be gained from traffic calming depend on the choice of appropriate traffic calming measures and its implementation. Traffic calming device should be chosen based on the type of the problem of the street. They may fall under the four categories: 1) Vertical deflections, 2) Horizontal deflections, 3) Narrowings, and 4) Speed Zoning System. Vertical deflections are elevated sections of roadway that force drivers to slow down as driving in high speeds over the vertical deflection causes uncomfortable feeling. Typical measures include: speed hump, speed bump, raised crosswalk, raised intersection, speed tables. Horizontal deflections alter the street width to reduce vehicle speed and volume. These measures discourage through traffic causing reduction in vehicle volume. Typical measures include: chicanes, roundabouts, and traffic circles. Narrowings are the roadway segments narrower than the normal portion of the street. They are effective in reducing through traffic. Typical measures include: chokers, neckdowns, central island narrowings etc. Speed zoning is a speed limit of a street where the speed limit is different than the legitimate speed of that roadway. Speed zoning scheme increases safety by informing drivers' reasonable speed limit of that street. Example of speed zoning scheme is zone 30 (30 km/hr).

5. DESIGN

The success of traffic calming projects sometimes referred to as speed management or local area traffic management have been more or less depending on the level of community involvement, on the assessment of the situation, decision maker's judgment and the extent of the project.

5.1 Types of Projects

Traffic calming projects can be done locally or area wide basis. If it is done locally then there is chance that drivers may change their direction and alternate routes will be congested. So traffic calming projects should be done area wide basis instead of localized treatment. This also provide users a regular announcement avoiding them becoming amazed with new designs. An extensive approach should be undertaken to solve neighborhood traffic problems. This should involve a more detailed traffic study including evaluation of the capacity and design features of the neighboring collector and/or arterial roadway network.

5.2 Trend of Used Traffic Calming Devices

Several types of traffic calming devices are currently used by different countries. From the questionnaire survey the tendency of used devices by different cities was found. The following table shows the percentage of devices exercised by different cities.

Table 1: Trend of Used Traffic Calming Devices

Province	Percentage of the devices used								
	Speed humps	Speed tables	Raised crosswalks	Chokers	Chicanes	Diverters	Circles	Round-abouts	Others
Austin, TX	14%		1%	1%	1%	1%	2%		80%
City of Concord, NH	25%	25%	25%						25%
Delray-beach, FL	30%		10%		10%	10%	40%		
City of Overland Park, KS	27%			9%	9%		27%		28%
Sacramento, CA	5%	1%	4%			1%	25%		15%
Seattle, WS	7%	0.5%	0.5%	0.5%	9%	7.5%	75%		
City of Albuquerque, NM	96%			1%		1%	1%		1%
City of Boulder, CO	50%		5%		5%	5%	25%		10%
Dover, DL	50%	10%		10%	15%		10%		5%
City of Redmond, WS	25%	25%	10%	20%			5%		80%
Largo, MD	75%	5%	5%	5%			5%	5%	25%
City of Sarasota, FL		85%	1%	5%	4%	1%	1%		3%
Vancouver, BC	3%	1%	3%	2%		14%	50%		28%
Colorado Springs, CO	25%	10%	10%	20%		20%		15%	15%
West Sacramento, CA	85%			3%			2%		10%

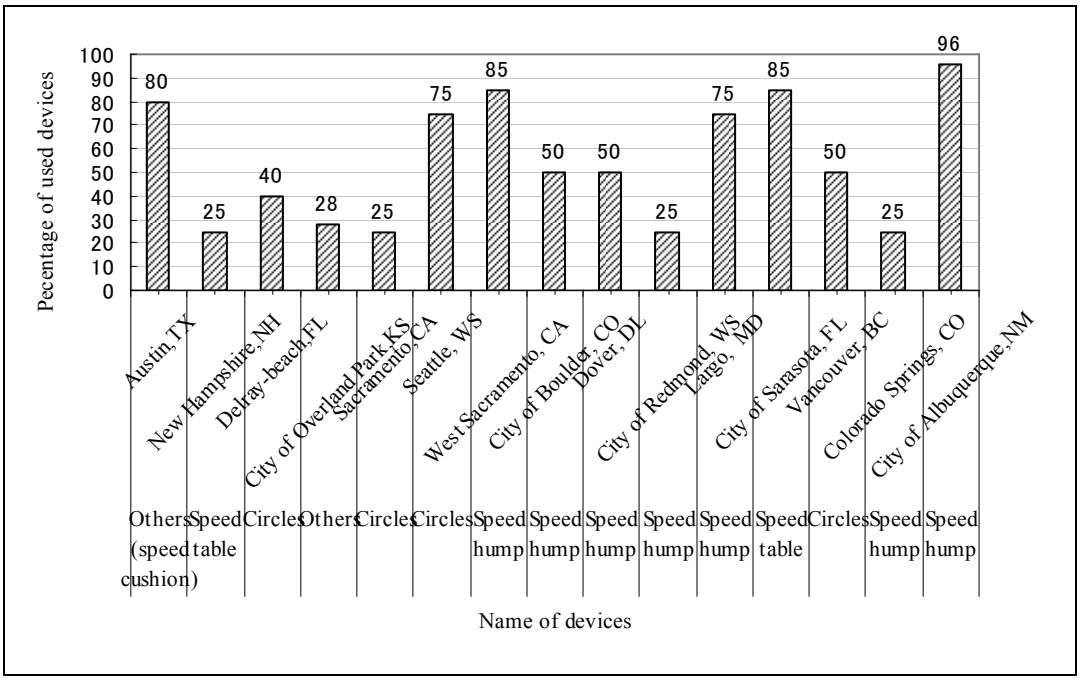

Figure1. Trend of Mostly Used Devices

Amongst the devices commonly used approach can be observed. From the survey it was found that speed humps are most widely used (46%) device. Then traffic circles (27%) are used mostly and then speed tables (13%) and speed cushions (7%) are used usually. Because of its low cost and effectiveness in reducing speed, speed hump is the most popular traffic calming devices. Following figure shows the percentage of commonly used devices by different cities.

5.3 Speed Humps

A speed hump is a raised area in the roadway surface extending transversely across the street section. Humps can be parabolic, sinusoidal, flat-topped, and round or circular in shape.

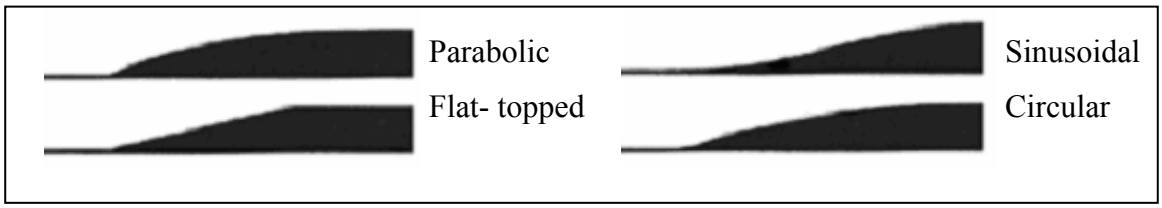

Figure 2. Shape of Humps

The standard or Watts profile hump, developed and tested by Britain's Transport and Road Research Laboratory, is the most common speed control measures. In USA Speed humps normally have a height of 3 to 4 inches (76-100mm) and a length of 12-14 feet (3.6-4.2m), although there are large variations in shape depending upon the desired speed reduction effect. The hump has a design speed of 25 mph (40kph). The Seminole County speed hump designed by Seminole County Florida is the most popular alternative to Watts hump. Seminole hump is 22 feet long and 6 foot ramps on either side of a 10 foot flat top.

Flat-topped speed humps are called speed tables, raised crosswalk or pedestrian crossings. Its effectiveness depends on the rise, the slope of the ramp and the distance between adjacent humps. Sinusoidal humps are more comfortable for ride because of its initial rise is slower.

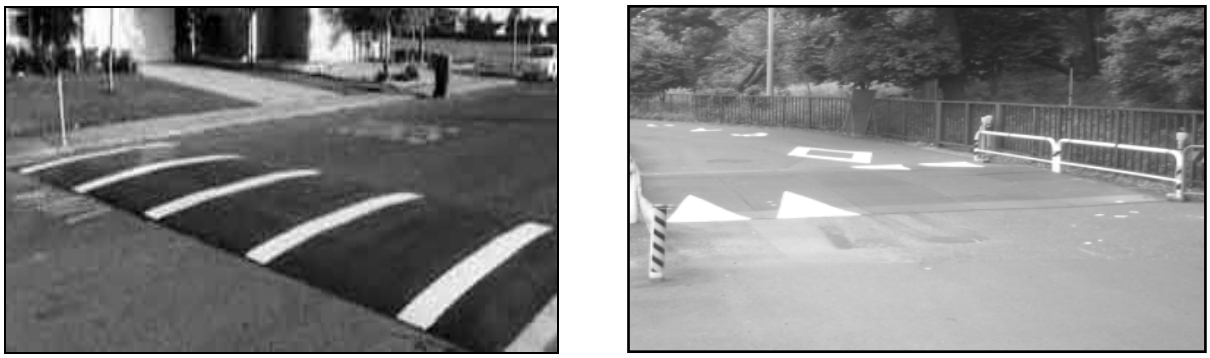

Figure 3. Speed Humps

Speed humps should be installed in series rather that single because drivers may increase speed between humps if the distance between humps is too long.

5.4 Potential Disadvantages

There may be some disadvantages caused by the installation of traffic calming.

- It affects emergency response time
- Redirection of traffic to other residential streets
- Sometimes it increases in trip lengths
- May be expensive to construct and maintain
- Affect drainage issues
- Due to traffic calming there may be lose of parking.

But if the benefits are experienced then the few disadvantages can be neglected to some extent.

6. IMPACTS OF TRAFFIC CALMING

A before and after study of traffic speed, volume, accident level, residents satisfaction and environmental features are measured for traffic calming impacts. The data shown in the table below is based on results of a number of before and after studies.

6.1 Traffic Speed

Reducing vehicle speed in residential streets is the primary goal of traffic calming. For determining a speeding problem on a specific roadway, the 85th percentile speed is often used because it is usually seen as approximately the high end of the "normal" speeds traveled by motorists on a given roadway. 85th percentile speed is that speed below which 85 percent of all traffic units travel, and above which 15 percent travel. From the table below speed reduction effect of different devices can be seen.

Table 2. Before and After Speed Counts (Source: Traffic Calming Manual, City of Sarasota, 2003)

Method	Roadway	Segment from	Segment to	Posted speed limit, mph	Pre-mph	Post-mph
Speed humps	Shade Avenue	Browning Street	Hatton Street	25	34.08	24.53
Speed tables	Orange Avenue	Bahia Vista Street	Loma Linda Street	30	44.27	33.88
Diverter	Irving Street	Osprey Avenue	Yale Street	25	37.68	23.00
Neck-Out Bulb-Out	Hyde Park Street	Lime Avenue	Shade Avenue	25	41.42	29.09
Median	Ringling Boulevard	Lime Avenue	Shade Avenue	25	38.38	32.64

6.2 Traffic Volume

Reducing through traffic volume in residential streets is another primary objective of traffic calming. Traffic volume reduction on traffic calmed streets depends on the availability of alternative routes and on the devices installed. From the table below the effectiveness of speed humps in reducing traffic volume can be seen along with its spacing.

Table 3. Volume Impacts of Speed Humps for Local Streets (Source: Canadian Guide to Neighborhood Traffic Calming, 1998)

Traffic Volume (Vehicles/day)		Number of Speed Humps	Spacing (m)	Location
Before	After			
5615	3840*	2 pairs + 1	137-160	Scarborough, ON
2500	2125	4	120-170	Sherbrooke, QC
1200	1000	9	60-78	Toronto, ON
800	1600	9	68-95	
2200	1600	7	65-77	
800	540	2	104	Bellevue, WA
3685	2930	2	122	

*Traffic volume on adjacent streets increased by the same amount as this reduction.

6.3 Safety Performance

Traffic calming measures reduce the traffic volume and speed and thereby reduce the accident frequency and severity. Circles are most effective in reducing accidents. A review of 600 traffic calming schemes in Denmark has indicated that there has been a reduction of 43% in casualties compared with untreated areas (T Pharoah and John Russell, 1989).

6.4 Environmental Impacts of Traffic Calming Measures

Environmental impacts of traffic calming measures are described for the indicators of noise and air pollution.
Due to fewer and slower vehicles traffic calming can reduce noise in residential streets. In the traffic calmed area of Esslingen, Germany noise levels dropped by up to 4 dB(A), with the largest reductions occurring in those streets in which the number of vehicles fell the most (Anon, 1992a).
In Buxtehude, Germany, monitoring of vehicle emissions before and after the implementation of traffic calming indicated a reduction in Carbon Dioxide levels of 20%, a reduction in Hydrocarbons of 10% and a reduction in Nitrogen Oxide of 33% (T. Harvey).

6.5 Residents' Satisfaction

Acceptance of traffic calming by the local community is the most important issue for success of the scheme. Surveys before and after the implementation of a scheme in the German town of Buxtehude found 46% of car drivers and 49% of residents opposed to the project prior to its construction, and yet three years later 67% of car drivers and 76% of residents were in favor (T Pharoah and John Russell, 1989).

7. TRAFFIC CALMING DECISION MAKING PROCES

7.1 Involvement of the Public in the Traffic Calming Process

No traffic calming devices should be installed permanently without seeking comments and opinions of residents directly affected by the proposed measures. There are several reasons for involving the public in planning and implementation of traffic calming process. First of all residents are well aware of the problems in their area as they observe it over an ample period of time. Traffic calming strategies in general require alteration in road users' behavior so it is necessary to convey the message to the residents from the early stages of the planning process. There are several ways to involve the public in a traffic calming process -meetings, walkabouts, leaflets; public events are the ways of communication between residents and city staff. However, the methods for including citizens in the traffic calming process are quite varied. Furthermore, in the case of financial constraints, if there is strong neighborhood support for the traffic calming proposal then they are more likely to be funded by residents. Community involvement is critical to the success of any traffic calming project. The Canadian Guide to Neighborhood Traffic Calming states that:

Examples of groups of people to be considered in the 'public involvement' except general residents are: the fire services, police, emergency services, maintenance services, schools, environmental action groups, delivery services and handicapped people.

7.2 Opinion of Community

It is important to know the community opinion during planning process of traffic calming to determine the potential support and opposition of a traffic calming scheme as to gauge it is not just a small number of voicing residents. If there is more opposition of the scheme then there would be a strong dissatisfaction among the residents after installation which may cause to remove the device. The percentage of community support for installation of a traffic calming device varies from community to community. This issue of deciding which households to include as voters on traffic calming initiatives is critical.

7.3 Criteria for Selecting a Project

Sometimes there is increasing requests for traffic calming by residents to do something about traffic problems. These requests are likely to exceed available resources. Ranking system is used by different cities to prioritize projects and to implement decisions for the traffic calming requests. Neighborhood traffic problem involves high speed of vehicles, high volume of vehicles and accident frequency. So these criteria are weighted vitally in the ranking. Residential density affects general traffic conditions as higher densities such as parks, schools, shopping centers tend to generate more pedestrian and vehicles. Sites shall be ranked based on the cumulative total points. A site with the greatest number of total points shall be considered to have the highest priority.

7.4 Case Study-Project Ranking System for Pennsylvania

For Pennsylvania, USA points are assigned for projects on the basis of 1) Speed, 2) Average daily traffic volume, 3) Reported crashes within past 3 year, 4) Elementary or Middle school, 5) Pedestrian generators, and 6) Pedestrian facility.
Pennsylvania gives weight as 30% for extent by which 85th percentile speed exceed posted speed limit, 25% on average daily traffic volume, 10% for crash reported within past 3 years, 10% for the presence of Elementary or Middle school, 15% for pedestrian generators and 10% for pedestrian facility for project priority.

Table 4. Project Ranking System for Pennsylvania

Criteria	Points	Basis for point assignment
Speed	0-30	Extent by which 85th percentile speed exceed posted speed limit; 2 points assigned for every 1 mph
Volume	0-25	Average daily traffic volume(1 point assigned for every 120 vehicles)
Crashes	0-10	1 point for every crash reported within past 3 years.
Elementary or Middle school	0-10	5 points assigned for each school crossing on the project street.
Pedestrian generators	0-15	5 points assigned for each public facility (such as parks, community centers, and high schools) or commercial use that generates a significant number of pedestrians.
Pedestrian facility	0-10	5 points assigned if there is no continuous sidewalk on one side of the street; 10 points if missing on both sides.
Total points possible	100	

7.5 Case Study-Project Ranking System for City of North Vancouver, Canada

Priorities are determined based on a number of criteria, described below. For each criterion, a rating of 1 through 5 is applied to each neighborhood, where 5 indicate the highest priority. Each rating is then multiplied by a weighting factor, which indicates the relative importance of various criteria. The criteria are: reported collisions, vehicle speeds, traffic volumes, known problems, neighborhood interest, and pedestrian and cyclist activity. Current neighborhood priorities are summarized in the following Table.

Table 5. Neighborhood Priorities

	Priority Evaluation						
	Quantitative Criteria			Qualitative Criteria			
N-hood	Collisions	Traffic Volumes	Traffic Speeds	Known Problems	N-hood Interest	Ped/Bike Activity	Total Score
	Weighting factor						
	x 2.0	x 1.5	x 1.5	x 1.0	x 1.0	x 0.5	

7.6 Case Study-Eligibility for Traffic Calming

Traffic calming study may be initiated by residents, city staff or by some neighborhood associations. Upon receipt an application, criteria is evaluated whether the street is eligible for traffic calming or not.
The minimum criteria to be used to determine if a street is eligible for traffic calming for city of Livermore California is as follows:

Speed- 85^{th} percentile speed (critical speed) is at least 33 mph
Volume- Average daily traffic is at least 1000 vehicles

For district of North Vancouver a screening process for candidate for traffic calming is outlined for ranking these projects based on objective criteria such as traffic volume and speed with a maximum of 25 points assigned for each. The scores for the projects are totaled out of 50 points, for projects scoring less than 25 points are eliminated for the consideration.

7.7 Case Study-Traffic Calming Process for City of Calgary, Canada

For city of Calgary, Canada the traffic calming study process begins once a community or isolated location is identified as the highest priority according to the evaluation process. City staff and Community Traffic Committee members jointly determine the most appropriate traffic calming measures to address the identified issues. The table 4 summarizes the steps involved in the community traffic study process.

Table 6. Process for Conducting Community Traffic Studies

Stage	Activity
Stage 1 Problem identification	• Establish Traffic Committee • Identify traffic concerns • Collect and analyze traffic and safety data • Establish study goals and objectives
Stage 2 Traffic Plan	• Identify potential solutions • Develop proposed Traffic Plan • Determine community support for traffic
Stage 3 Trial measures	• Present Traffic Plan to Standing Policy Committee on Transportation, Transit and Parking for approval, if necessary • Implement traffic calming measures for a trial period. • Monitor traffic conditions during the trial period; assess benefits and impacts to the neighborhood and transportation network
Stage 4 Project completion	• Review Traffic Plan and identify changes as appropriate • Present the final version of Traffic Plan to community for approval • Forward Traffic Plan to Standing Policy Committee on Transportation, Transit and Parking for approval, if necessary

7.8 Case Study-Traffic Calming Process for Denmark

One of the most common speed management tools are know as traffic calming in Denmark. At the beginning of the process, a statement on safety problems, traffic data and the transport

system must be done as a whole. The problems and their causes and factors affecting them are determined in this step. Setting targets clarify the objectives and help decide responsibilities for all actors involved. Furthermore, targets make the established basis for the evaluation process. In the stage of formulating the speed management strategy, funding, time frame, policies, cost/benefit, use of different speed management techniques are taken into account. Activities include: Road and Speed Classification, Speed Management Techniques, Draft Design, Involving the public, Priority and Detailed Design. Final step in the process is to carry out an evaluation program to determine whether or not the set target has been reached, and if not, why? The evaluation program should as a minimum include evaluations on safety, speed, traffic flow, etc. A general framework for speed management is shown in the flow diagram.

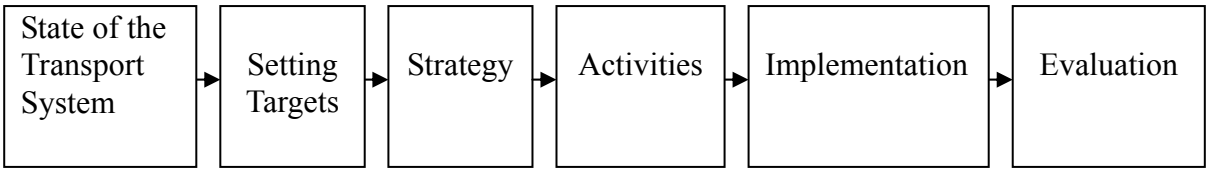

Figure 4. Flow Diagram for Speed Management

7.9 Typology for "How Do You Prioritize the Projects?"

From the questionnaire survey it was found that about 61% of the projects were prioritized by point scoring system, 14% of the projects were prioritized by engineering judgments, 10% of the projects were prioritized by combination of both point scoring system & engineering judgments, 10% of the projects were prioritized by first come first serve basis and 5% of the projects were prioritized by lottery.

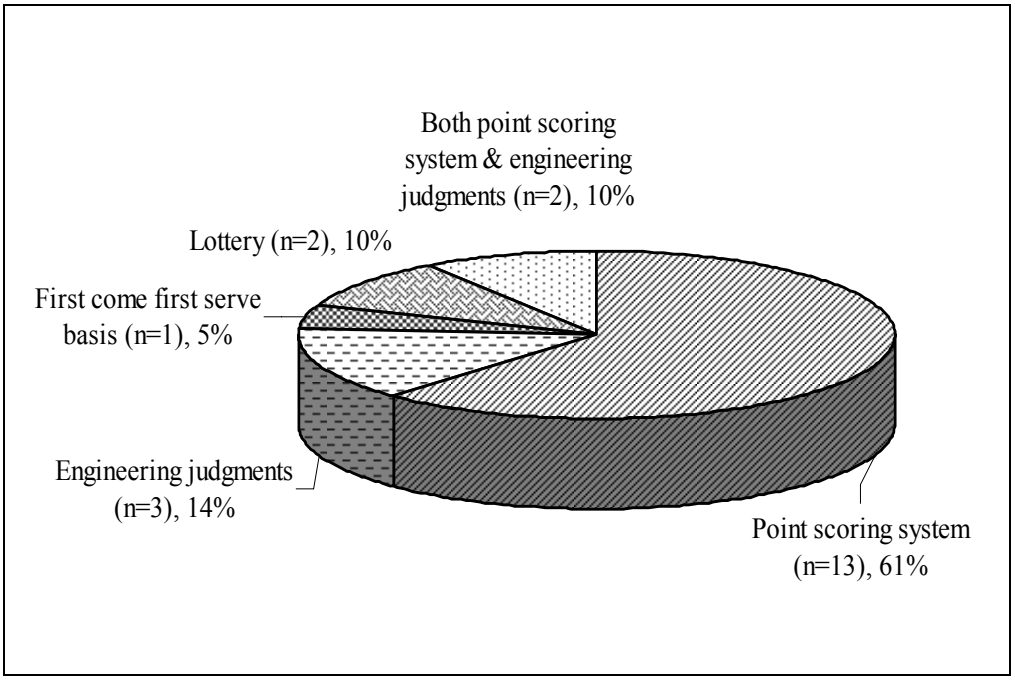

Figure 5. Typology for Project Prioritization

7.10 Typology for "Who Initiates a Traffic Calming Project"

A written request from any individual will initiate a traffic calming study. From the questionnaire survey mentioned above there were 3 categories concerning who initiates a traffic calming project. They are as follows: a) Type I: percentage of projects initiated by city staff, b) Type II: percentage of projects initiated by residents, and c) Type III: percentage of projects initiated by neighborhood association.
From the questionnaire survey it is seen that about 35% projects are initiated by residents in along with neighborhood association, 26% projects are initiated by residents, 26% projects are initiated in combination of city staff, residents and neighborhood association, 9% projects are initiated in combination of city staff and residents and 4% projects are initiated by neighborhood association.

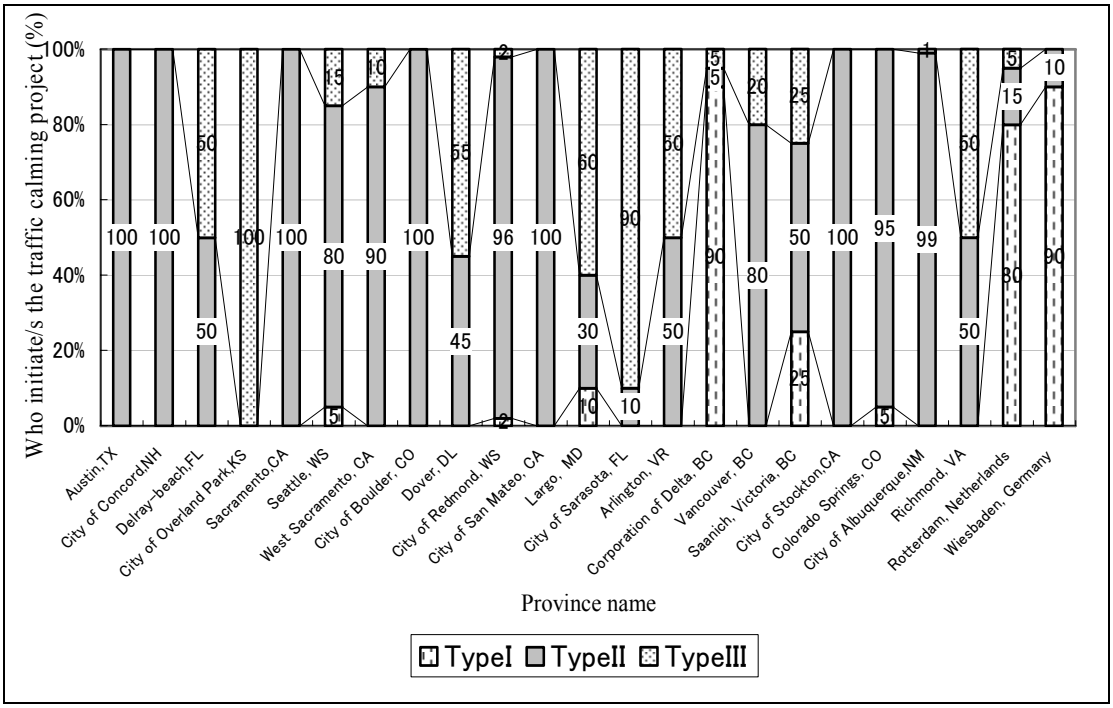

Figure 6. Initiation of Traffic Calming Projects by Different Cities

7.11 Typology for "Who Pays the Budgets for Traffic Calming?"

From the questionnaire survey mentioned above there were 4 categories concerning who pays the budgets for traffic calming project. They are as follows: a) Local Governments b) Residents, c) Neighborhood association, and d) Others.
It can be seen from the survey that 64% projects were funded by Local Governments, 12% of the projects were funded by Local Governments along with other sources, 8% of the projects were funded by Local Governments along with residents, 4% of the projects were funded by Through Traffic Impact Fees/Developers, 4% of the projects were funded by State department of Transportation, 4% of the projects were funded by Gas Tax and Transportation Sales and 4% of the projects were funded by state funds (secondary highway system).

7.12 Typology for "How likely do you Get Support for Installation of Traffic Calming Measures from Residents?"

From the questionnaire survey it is found that about 100% of the cities included neighborhood in the planning stages of traffic calming project.
The potential support of traffic calming from residents varies from 50-90% and the potential opposition to traffic calming from residents varies from 10-50%. Whereas some cities require overall residents acceptance for the projects.

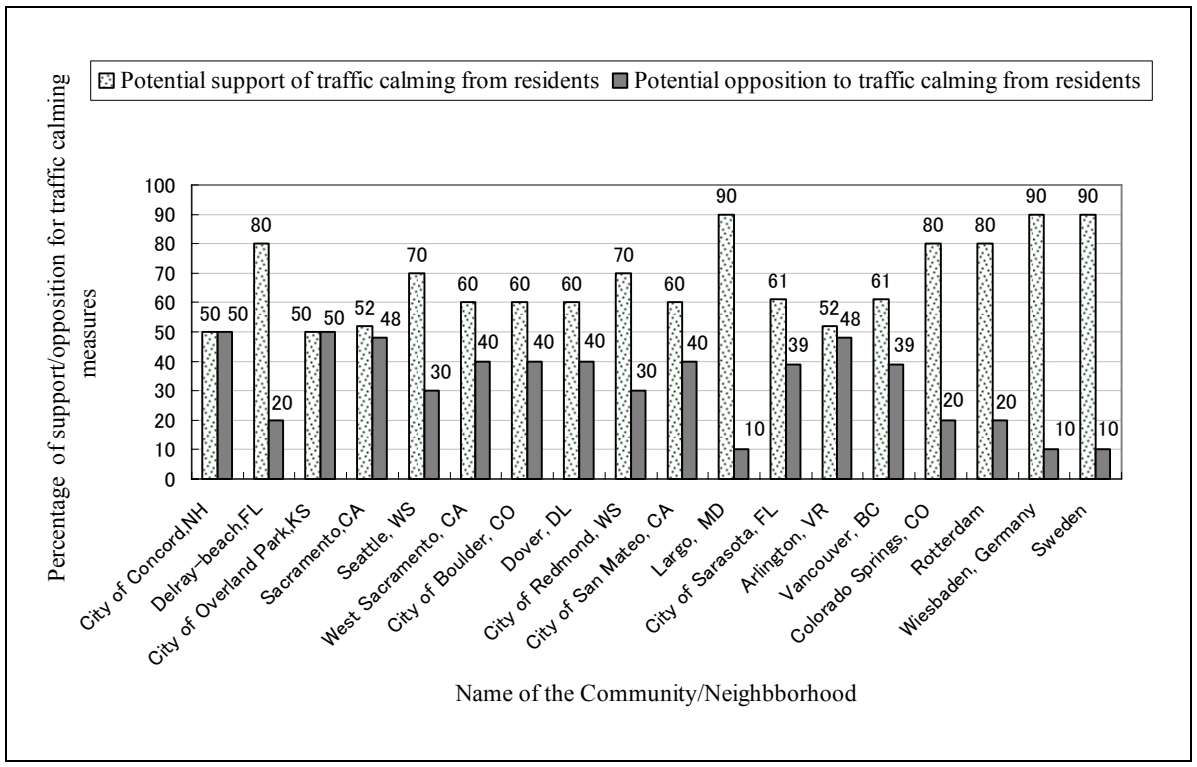

Figure 7. Typology for Residents Support/Opposition for Traffic Calming Measures

7.13 Typology for "How Often Do You Accept Requests From Same Community/Neighborhood for Traffic Calming?"

From the questionnaire survey mentioned above there were 5 categories concerning the acceptance of requests from same Community/Neighborhood for traffic calming. They are as follows: a) 0-3 months, b) 3-6 months, c) 6-9 months, d) 9-12 months, and e) 12 months or more. About 23% of the respondents replied they accept requests from same Community/Neighborhood for traffic calming within 12months or more, 19% of the respondents replied they accept request within 9-12months, 19% of the respondents replied they do not have time limit for accepting requests, 4% of the respondents replied they accept requests within 0-3 months and for 35% of the respondents the answer didn't match the categories or they replied not applicable. Sometimes the cities have a neighborhood traffic calming request database and when residents call them about a problem street, they add it to the list. So it is an ongoing process. If funding is available, they select neighborhoods at once for traffic calming study.

8. CONCLUDING REMARKS

Effective traffic calming programs require a carefully planned process which includes clear strategies, goals and guidelines. Such practices may not be the same in all communities but they usually have similar aim as to help residents and city engineers resolving traffic problems efficiently and to structuring the traffic calming process.

If there is a standard guideline and set procedures for traffic calming it would be easier to apply the devices without much diversity. Based on the literature reviewed in this paper, it is apparent that citizen involvement is crucial for an effective traffic calming program. However, the methods for including citizens in the traffic calming process are quite diverse. Ottawa is an example of a community-based planning which considers the public, including residents and business people, to be the experts when it comes to voicing their concerns, needs and solutions. In turn the engineering professionals act only as a facilitator, who gather, input, analyze, and gather the planning process.

The evaluation and prioritization process ensures that the most serious and most extensive issues are addressed first. It ensures that traffic calming funds are allocated where they will provide the greatest benefit and it ensures that all areas of the city are treated equally and fairly.

In this research it has been seen that during the preparation of a traffic calming scheme it is too important to develop a good working environment between the neighborhood and the city staff. It is also important to make the residents understand the process. Another observation is the variation in the minimum percentage of citizen support necessary needed to advance a traffic calming request to the study stage. A range of 50 – 90 % has been noted in this research. The issue of deciding which households to include as voters on traffic calming initiatives is critical especially in cities with a new system to be introduced. From the examples of traffic calming regulations and process in cities outlined above (and others not mentioned here), it is clear that for an effective implementation of a traffic calming program, guiding principles are needed. These guidelines should empower citizens to involve themselves in a collaborative process to make neighborhoods more livable.

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