The Hierarchical Planning of Traffic Calming in Opening Residential Areas

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Abstract. Opinions on Further Strengthening the urban planning and construction management, which states that in principle, construction of residential areas are no longer closed. And residential areas have been built should be gradually opened to public, in order to resolve road network layout problems and promote economical use of land. On the one hand the opening residential areas maybe relieve the traffic press, on the other hand a large number of though traffic into the residential areas will reduce the quality of life for residents of concerns about safety, noise and pollution. How to ease the contradiction between the two is a serious problem. Traffic calming which can alleviate the adverse effects of motor vehicle use, should be used in opening residential areas to reduce occurrence of excessive speeding and through traffic. Many countries have sophisticated and organized methods to carry out the measures, and have achieved some results. While our country does not have well defined and systematic study process to facilitate traffic calming measures, and the "people first" concept of traffic calming is not popular. After illustrating the advantages of traffic calming device in other countries, the objective of this research is to investigate and analyse the effects of some measures which used in opening residential areas, the aim is to establish traffic calming device selection process guiding principles to be introduced in China.

1. Introduction
With the popularity of opening residential areas, it attracts a large number of through traffic. At the same time, the influx of cars reduce the quality of community living environment. How to rationally arrange community transport, to create a favorable living environment for residents will be more attention. The spirit of "people-oriented, environmentally-oriented" design concept of the traffic calming technique should penetrate to the city traffic organization, in order to solve the traffic problems within the opening residential areas. Traffic calming is able to create a green, environmentally friendly, harmonious urban community.

2. The concepts and benefits of traffic calming
The Institute of Transportation Engineers (ITE) provides the following definition for traffic calming:“Traffic calming is the combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver behavior, and improve conditions for non-motorized street users[1].”

The common traffic calming measures can be classified into the following five different groups:
- Signs, such as speed limit signs, pedestrian crossing signs and so on;
• Vertical deflections, such as speed humps, speed tables, raised crosswalks and raised intersections;
• Horizontal deflections, such as roundabouts, chicanes;
• Narrowing, such as neckdowns, chokers, central island narrowing;
• Route modification measures, such as full and half street closures, diverters and turn restrictions.

The principal objective of traffic calming is to reduce the speed. Because the excessive speed is a common problem in the opening residential areas and studies also suggest that some traffic calming measures do effectively in reducing speed. In the report of Traffic Calming: State of the Practice, after analyzing several traffic-calming devices used and the impact they had on the speed, researchers found that average 85th percentile speed reduction ranged from 1% to 23% after calming[2]. Hernán Gonzalo-Orden analyzed 22 streets which distributed on six zones of the city, found that some traffic calming measures such as raised crosswalk and lane narrowing were effectively in lowering the speed while other measures like pedestrian push-buttons signals don’t reduce the speed by themselves[3]. The traffic calming measure is also used to reducing the volume of through traffic on residential areas. In City of San Diego, CA, traffic volumes before and after the implementation of traffic calming indicated a reduction from 14% to 63%. [4]. In fact, traffic calming measures also can help to increase the comfort and security for non-motorized street users. For establishing traffic calming measure selection process guiding principles in Japan, Farzana RAHMAN analyzed effectiveness of traffic calming devices and came to the conclusion that speed humps were suitable for various types of street issues such as speeding, high volume of cut through traffic, crashes, pedestrians safety concerns[5]. In Canada, the study found that annual collision frequencies and insurance claims both decreased by about 40%[6]. Rune Elvik analyzed the safety effects of traffic calming and found that area-wide measures reduces the number of accidents by about 15%[7].

3. Methodology
The aim of this research is to provide a method which make traffic calming measures can be applied in opening residential areas according to the characteristics of roads. For the purpose, a hierarchy for community roads by function was created, including a range of roads such as, arterial around the community, residential boulevards, residential collectors, local residential streets and alleys. All roads have their own functions, arterial streets services for direct and rapid trips of vehicles. Residential boulevard services for the neighboring communities travel, and residential collectors are collector-distributor roads of community, while local residential streets and alleys provide a place for neighborhood interaction and rest. According to the functional difference of the various roads, three hierarchies were divided, arterial streets which are distributed around the community were taken as first hierarchy, residential boulevard and residential collectors which are distributed within the community were taken as second hierarchy, while local residential streets and alleys which are penetrated to the living areas were taken as third hierarchy.

The purpose of traffic calming is to restore residential streets to their intended function and correct motorist behaviors. The benefits which can be gained from traffic calming depend on the choice of appropriate traffic calming measures and its implementation. The first step in selecting which traffic calming device(s) to use is to identify what the existing problems are and which problem(s) can be addressed through traffic calming. Once the problem is clearly defined, the next step is to identify which measure are best suited for the problem, and the desired objective and the advantages and disadvantages of the devices. The last step is to consider which devices are appropriate for a specific street. In a word, Traffic calming device should be chosen based on the type of the street.

In order to better implement traffic calming, these measures were divided into three levels:

3.1. Level I traffic calming
The primary aim of level I is typically to reduce delay and congestion rather than to slow down traffic. These measures are relatively easy to implement, having less impact on the emergency situation and
capacity. The arterial streets are intended to carry higher volumes of traffic and accommodate a large vehicle mix, the results of the traffic calming measures on these roads is to lessen traffic crashes, but traffic capacity are maintained or enhanced. So it is important to maintain the capacity of these roads for their operation. Traffic calming devices can be used on these streets, however, they should generally be less aggressive in design and application than those used on local streets, and should be used to address very specific, localized problems. Speed applications should be used carefully as they can impact roadway capacity. For example, neck downs can be used on arterial streets to enhance pedestrian safety and aesthetics with minimal impact to the capacity or operations of the roadway. And turn restrictions, either signed or constructed, curb extensions and landscaping can all be used to improve safety and aesthetics with little or no negative on capacity. Speed applications should be used carefully as they can impact roadway capacity. But devices that are designed to accommodate the posted speed while eliminating the very high end speeds can be effectively used on arterial streets at locations that have safety related speed problems. For example, speed limit signs can be combined with “green wave” to regulating speed. When the motor is faster than standard speed limit, it can not through the adjacent intersection without stopping. The idea is that regular road users would soon realize the benefits of driving at the appropriate speed, so as to achieve the purpose of slowing down vehicle speed. Therefore level I traffic calming includes: enforcement, landscaping, neck downs, gateways/entry ways, signed turn restrictions, truck restrictions, barrier medians, street furniture, signing and marking, in-vehicle speed governors, medians, special paving treatment, pedestrian crossing signs and so on.

3.2. Level II traffic calming
The aim of level II is to restrict traffic speed and lessen traffic volumes and lessen traffic impacts on corridors and traffic routes (district or sub-arterial roads). The primary function of residential boulevard or residential collector is to gather traffic from the local residential and deliver it to the closest arterial. It balances access and mobility and provides a necessary connection between the local roads where people begin their daily trips and the roads that carry commuters to their jobs. And it provides both local access to adjacent properties and mobility for vehicles and other modes of transportation. Collector streets provide alternative routes and additional circulation within the area circumscribed by thoroughfares. They combine the functions of the traffic distribution and servicing community residents. In these areas, implementation of traffic calming is to achieve these objectives:

- reduce the speed of vehicles to improve safety;
- discourage cut-through traffic to improve living environment;
- take into account the requirements of public transport modes.

So for roads in the second hierarchy, Level II traffic calming can be used, they can play a certain role in limiting speed, but not so severe, and it has less impact on public transport. Horizontal deflections which is a method to changing the road width to reduce vehicle speed and volume can be used to discourage through traffic, and cause reduction in vehicle volume. Typical measures include: chicanes, roundabouts, and traffic circles. Traffic circles effectively slow traffic, and it appears to have an additional benefit of reducing angle collisions and improving overall intersection safety. Narrowing which is the roadway segments narrower than the normal portion of the street can also be used to reduce cut through traffic. Typical measures include: chokers, neck downs, central island narrowing etc. Minimal lane widths can not only reduce vehicle speeds, but also reduce pedestrian crosswalk distances, and maximize the space available for bicycle lanes and sidewalks. Some of vertical measures can also be involved in level II traffic calming, for example, speed cushion, raised crosswalk, raised intersection.

3.3. Level III traffic calming
The aim of level III is to restrict traffic speed and lessen traffic impacts at a local level. The first listed objective is that of reducing the speeds of motor vehicles. They are mainly vertical measures which are the most restrictively. Streets of the third hierarchy penetrate to the residential areas where regular
public transport doesn’t go through, and the main function of these roads is public service. These streets are key determinants of neighborhood livability. They provide a place for human interaction: a place where children play, neighbors meet, and residents go for walks and bicycle rides, where residents can walk along and cross the street relatively easily and safely, and where vehicles move slowly. In these roads, pedestrians have the right-of-way at intersections whether crosswalks are painted on the street or not. So in such local streets, it requires the vehicles to driving at walking speeds, and it refuses cut-through traffic. For this reason, Level III traffic calming which is mainly vertical measures and diversion devices is applicable to the local residential streets and alleys. 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, and speed tables. Diversion devises used raised islands and curb extensions to preclude particular vehicle movement. These devices include: full closures, half closures, diagonal diverters and so on. They are very effectively in reducing the speeds of the fast drivers.

It must be clear that: In planning process, traffic calming devices suit last layer can be implemented in the next layer, however, the next have to be carefully implemented in the last.

4. The case study of opening residential areas

To show the effectiveness in reducing the negative effects of motor vehicle of traffic calming, field measurements were done on various community calmed streets where were selected from an opening residential areas in ChangSha. While other same no-calmed streets of similar characteristics were taken to compare. And a questionnaire about traffic volume, speed, noise and environment was calculated for the comparison. The basic idea of the analysis was to compare performance of traffic calming before and after the intervention on the opening residential areas.

Some streets that were calmed were selected, one arterial roads with level I traffic calming measures, two residential collector roads with level II traffic calming measures and several residential streets with level III traffic calming measures. While same streets without traffic calming measures were taken to compare. From the figure 1, before and after average 85th percentile speed (See figure 1) were compared, and the 85th percentile speed of the roads decrease about 11% in the Xiaoxiang road, about 7% in the Lusan road and about 12% in the Lushan south road, the speed of residential streets decrease most, about 41%.

This survey explored the effectiveness of traffic calming devices. The results of the public opinion (see figure 2) survey showed that 69% of the respondents who lived on streets treated with traffic calming perceived a reduction in traffic volumes and 74% in speed. And 46% approved that due to fewer and slower vehicles, traffic calming can reduce noise in residential streets. For pollution, 35% residents think it is better than before.
5. Conclusion
It is an important issue to determine which traffic calming devices is implemented. According to the hierarchical characteristics of urban road network, hierarchical planning of traffic calming was used to determine the application of traffic calming measures. The results show that well designed traffic calming devices can be considerably advantageous. It can reduce the negative effects of motor vehicle use, it also can help to reduce vehicle-related conditions that adversely affect the environment including traffic congestion, air pollution, accidents, and noise, and improve conditions for non-motorized street users, create a favorable living environment for residents.

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