Apr. 2013, Volume 7, No. 4 (Serial No. 65), pp. 456-465
Journal of Civil Engineering and Architecture, ISSN 1934-7359, USA

Traffic Calming in Québec: Speed Humps and Speed Cushions

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Abstract: Speed management is an essential tool in ensuring the improved safety of users of urban roads, particularly vulnerable users. It relies on several measures: awareness campaigns, speed control, as well as the development and operation of the road infrastructure. Municipalities in Québec are increasingly resorting to the development of traffic calming measures, and are facing numerous questions concerning their installation and their effectiveness. To respond to this need, the ministère des Transports du Québec (Québec Department of Transport) has begun publishing a series of fact sheets on a variety of traffic calming measures, including speed humps and speed cushions, raised crosswalks and intersections, neckdowns, centre islands and chicanes. A general fact sheet introduces all of the measures and notably outlines the procedure for pre-implementation analysis. Each fact sheet dedicated to an individual measure outlines the implementation context, advantages and disadvantages, geometric characteristics, effectiveness at reducing speed, and maintenance requirements, including winter maintenance. Two fact sheets are already published: the general fact sheet and the fact sheet on speed humps and speed cushions. The fact sheets as well as examples of measures implemented in municipalities are available on the ministère's web site under Partenaires-Municipalités-Sécurité routière.

Key words: Traffic calming, speed management, road safety, urban streets, speed humps.

1. Introduction

The definition used by the Transportation Association of Canada [1] is based on the Institute of Transportation Engineers' work with traffic calming: "Traffic calming is the combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver behaviour and improve conditions for non-motorized street users".

Traffic calming measures aim primarily to reduce the speed of drivers in urban areas, but can also be used to meet traffic reduction objectives. Benefits are apparent on multiple levels: speed control not only contributes to increase road safety, but also to better coexistence for all users, a better quality of life for residents and more user-friendly neighbourhoods, which in turn promotes active transportation.

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1.1 The Issue of Speed in Urban Areas

Speed is one of the primary factors behind accidents. Higher driving speed increases the risk and severity of accidents. This risk is particularly high for vulnerable users, including pedestrians and cyclists, who are presented in large numbers in urban areas. When the impact speed in a collision is 30 km/h, a pedestrian's likelihood of being fatally injured is approximately 10%, at 50 km/h, it jumps to over 75% (Fig. 1).

It is therefore important to properly manage speed, which calls for a variety of actions. The first, of a legal nature, consists in setting an appropriate speed limit. The Québec Highway Safety Code prescribes a speed limit of 50 km/h in urban areas, with the option for municipalities to set a different limit on their road network.

Speed is limited to 50 km/h on the vast majority of urban streets. However, with increasing attention drawn to concerns about road safety, the environment and active transportation, a trend is developing across Québec and in other countries to set reduced limits

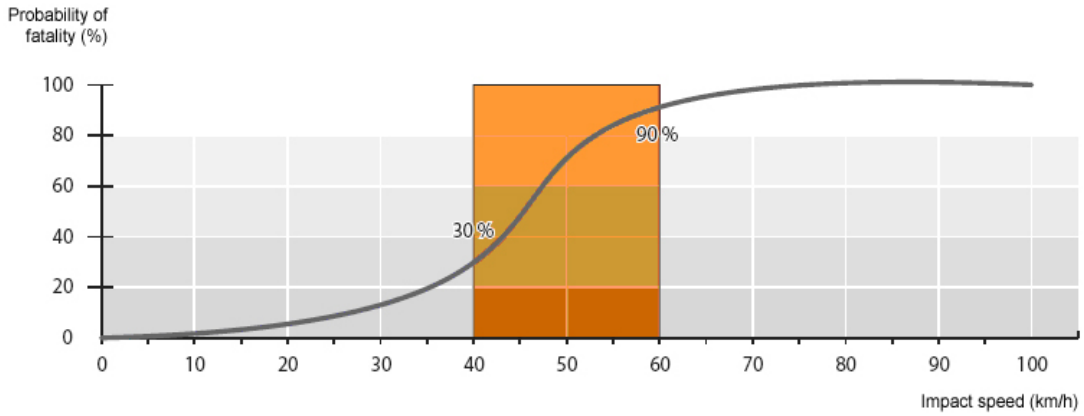

Fig. 1 Likelihood of pedestrian fatality, according to impact speed [2].

(40 km/h or 30 km/h) on residential local streets and in school zones.

In order to speed limits to be respected, limits must be consistent with the environment as well as the characteristics of the road and the sides of the road. When rectilinear urban grids or wide street designs encourage speeding, complementary measures are often necessary. Municipalities are resorting to enforcement, awareness campaigns or the implementation of traffic calming measures. They are also looking to control speed when designing new streets, for example, by reducing the width of streets, or by introducing smaller curb radii at intersections.

1.2 Traffic Calming in Québec

According to a survey conducted in June 2009 with over 250 municipalities in collaboration with the Union of Québec Municipalities, approximately 50 of them have implemented traffic calming measures. A complementary survey to which approximately 30 municipalities replied in fall 2009 further documented the types of measures most often implemented (Table 1). These measures are used alone or in combination with others.

In addition to an analysis of the most recent documentation [3-10], the results of this survey have allowed to update the information available to Québec municipalities and to adapt it to meet their needs and concerns. A series of fact sheets are currently being developed to disseminate the information. A general fact sheet presents the main results from the survey on traffic calming in Québec and suggests a procedure for implementing measures. It will be accompanied by fact sheets describing each type of measure.

The following information is included in each fact sheet describing traffic calming measures:

- the implementation context for the measure;
- advantages and disadvantages;
- geometry;
- signage;
- effectiveness at reducing speed and road safety;
- costs;
- references.

1.3 Implementation Context for Traffic Calming Measures

According to the survey, most traffic calming

Table 1 Types of measures most often implemented in fall 2009, Québec.

Number	Traffic calming measures most commonly used in Québec
1	Speed humps
2	Raised and/or textured crosswalks
3	Raised intersections
4	Reduction of the width of a street
5	Curb extensions at and between intersections (neckdowns and chokers)
6	Center islands
7	Chicanes
8	Roundabouts[a]
9	Landscaping

[a] Roundabouts have been discussed in a previous guide [11].

measures (63%) have been installed in the past five years, but nearly 20% have been in place for over 10 years. More than half of all measures are implemented on collector roads, serving through traffic as well as residential property access, and one third are on local roads, where the primary function is property access. The presence of traffic calming measures on arterial roads destined mainly for through traffic is less common. It is possible to treat all categories of roads (arterial roads, collector roads or local roads) to control speed, but the choice and geometry of measures varies depending on the category [12].

The types of treated roads most often are residential roads (39%) or mixed-use residential and commercial roads (35%), and school zones (16%). Municipalities will often test the first traffic calming measures in school zones.

The speed limit on treated roads is 50 km/h in 76% of cases and 30 km/h in 16% of cases. In general, residents living on streets where traffic calming measures have been implemented are satisfied (88%), although that percentage falls to 62% for through-traffic users.

1.4 Winter Conditions

The speed issue is a bit different in the winter. The authors generally presume that drivers are more careful and that driving speeds decrease in the winter, particularly when roads are snow covered, which is relatively often in the case of residential local streets. In fact, complaints regarding excessive speeding in residential streets are less numerous in winter.

One of the primary concerns for Québec municipalities regarding traffic calming measures has to do with winter conditions, removing snow from traffic calming measures and the risks of deterioration associated with maintenance operations. The survey reported that several municipalities installed temporary traffic calming measures that can be removed in the winter.

In 92% of cases where the measure is permanent, it remains as effective at slowing speeds in the winter as in the summer. In 79% of cases, there was no deterioration resulting from winter conditions or snow removal. In 71% of cases, snow removal did not pose any problems.

In general, winter conditions do not present constraints for the installation of traffic calming measures. Distinctions are made, however, in the fact sheets outlining each type of measure. One example is that the design must account for winter-related constraints: less restrictive measures may facilitate snow removal operations.

Whether completed in-house or entrusted to a third party, snow removal methods often require adjustments, including using smaller or modified equipment and specific snow removal procedures, and organizing work (for example, assigning the same operators to a given itinerary so they become familiar with the distinctive features of the measures implemented). Snow removal operations may take longer and thus increase maintenance costs.

1.5 Implementation Procedure

A structured analysis procedure enables a municipality to determine, as objectively as possible, whether it is appropriate to install traffic calming measures on a given street or in a given neighbourhood, and what types of measures should be used to achieve the desired objectives in terms of speed reduction and increased safety. Several municipalities have adopted policies or guidelines to formalize and harmonize their actions. In other cases, a complaint management system, including a decision-making process, has been implemented. The various stages of a structured procedure can be summarized as follows.

1.5.1 Initiation

Most often, the process begins with a request from residents concerning a school zone, a residential street or a neighbourhood. A variety of concerns may be raised: excessive speed, excess traffic, unsafe conditions for pedestrians and cyclists, noise pollution, impairment to quality of life, etc.. Considering the

complexity of concerns as well as objective and subjective facets, a thorough analysis is often required. In some communities, a minimum number of petitioners must express concern before the process can begin.

1.5.2 Technical Analysis

The goal is to assess the problem and confirm that excessive speed is the issue. Traffic and speed studies should be conducted. The analysis should also look at accidents as well as the geometric characteristics of the road and its function (type of users, transit artery, bus route, residential local road, commercial street, etc.). A public consultation is the last step in the analysis and allows residents to express their thoughts and concerns.

Even if the original request concerned only a portion of a road, it is preferable to assess the problem at a neighbourhood-wide scale in order to account for all impacts and eventually plan for the entire neighbourhood. One can assume that implementing traffic calming measures throughout a neighbourhood will more easily modify drivers' behavior and reduce speed in the long term.

1.5.3 Analysis of Possible Scenarios

If the technical analysis concludes that the issue really is speed related, now is the time to select the traffic calming measure(s) best suited for the affected area. It is at this stage that the advantages and disadvantages of the various types of measures are studied, as well as costs. It is important, for example, not to penalize through traffic or buses on arterial or collector roads, and to evaluate the risk of diverting traffic to neighbouring roads.

1.5.4 Public Consultation

A public consultation is necessary to define the best adapted and most accepted solution for everyone. The various municipal or regional services must be involved, particularly emergency services, police forces, maintenance services and public transit corporations. Those responsible for winter maintenance may be able to highlight eventual snow removal difficulties and suggest changes at the design phase.

Residents and affected users must also be included in the process, their cooperation is a key factor in the success of traffic calming measures. Some municipalities also seek pre-approval from affected residents before installing traffic calming measures.

1.5.5 Choice of Actions and Implementation

When traffic calming measures require a substantial budget, the municipality must establish a schedule for work that spans multiple years, according to the priority of actions. The municipality may take advantage of other infrastructure work already scheduled for a street and install traffic calming measures at the same time.

Prior to permanently implementing a traffic calming measure, it may be useful to introduce a temporary measure using street furniture or signage, as changes can easily be made to the design if necessary. Lastly, the municipality must be sure to install the necessary signage that is required for certain traffic calming measures. Markers or vertical signage is generally useful for snow removal operators.

1.5.6 Follow-up

Follow-up allows municipalities to evaluate the impacts of traffic calming measures in terms of safety, traffic, maintenance, as well as acceptance by users and residents, and in turn, improve its implementation procedure for future projects.

2. Speed Humps and Speed Cushions

2.1 Description

A speed hump is a raised portion of a road that creates a vertical motion for vehicles and discomfort

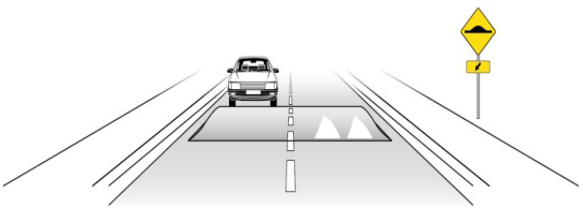

Fig. 2 Speed hump-preferred.

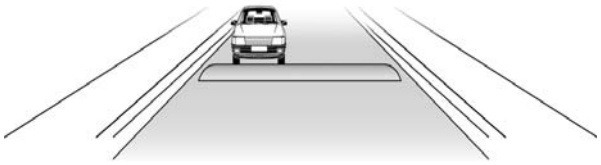

Fig. 3 Speed bump, avoid using on public roads.

that leads the driver to slow down (Fig. 2). Its length is greater than the wheelbase[1] of vehicles and the slope is gradual. These characteristics distinguish it from the speed bump which is more aggressive and not recommended for public roads (Fig. 3). The centre portion of a speed hump can be rounded or flat.

Speed hump is one of the most effective and most widely used traffic calming measures in Québec [3, 13]. Many have also been implemented in North America and in Europe in the last decades [1, 5, 14, 15]. They have been in place long enough to establish a fairly precise definition of the conditions in which these measures can reduce speed while minimizing potential disadvantages. Distinctive features specific to Québec were also identified in the survey conducted in fall 2009 as well as several follow-up consultations.

Speed cushions have been used in Europe for quite some time [14] and have more recently been implemented in North America [16]. A speed cushion is a raised area on a road, similar to a speed hump, but which does not cover the entire width of the road. Speed cushions are usually configured two or three across depending on the width of the road. The width of each cushion is designed intentionally so that the wider axle of emergency vehicles can pass unaffected but that smaller passenger vehicles must ride over the raised area. This configuration addresses one of the main concerns with speed humps: the fact that emergency vehicles are also forced to slow down.

Permanent speed humps and speed cushions are generally made of asphalt. Rubber models are temporary and can be removed for the winter.

2.2 Implementation Context

Because of their restrictive nature, it is preferable to consider traffic calming measures that modify visual fields and road width prior to investigating speed humps and speed cushions. For new or redesigned roads, proper design can sufficiently control speed. Speed humps and speed cushions are recommended in the following locations:

- Urban areas, i.e., streets with closed drainage (storm sewer) and curbs. Some municipalities install speed humps on roads with open drainage and no curbs, but it is necessary to prevent drivers to avoid them and drive on the shoulder, by example by installing bollards;
- Streets with little through traffic that are not regular public transit, emergency vehicle or trucking routes. These are mainly local roads and occasionally collector roads with two lanes of traffic;
- Residential streets, school zones and playground zones;
- Sectors where the speed limit is 50 km/h or less;
- Sectors where low speeds are desired (around 30 km/h).

Speed humps and speed cushions should be avoided in the following locations:

- On arterial roads, roads with through traffic, roads frequently traveled by public transit, trucks or emergency vehicles, and roads with four or more lanes of traffic;
- Sectors where the 85th percentile speed[2] is above 70 km/h;
- On approaches to intersections;
- In curves or approaches to curves, on roads with a particularly pronounced slope (slopes greater than 8%) or locations where traffic calming measures would not be sufficiently visible or could surprise drivers. The minimum stopping sight distance must be

[1] The distance between the front and rear wheels.

[2] Speed below which 85% of drivers travel.

maintained[3];

- Before a driveway.

When the aim is to reduce speed on relatively long roads, speed humps or speed cushions may be used in succession. This configuration prohibits drivers from regaining too much speed after passing one measure.

2.3 Advantages of Speed Humps and Speed Cushions

Speed humps and speed cushions present the following advantages:

- Proven, It is lasting effectiveness at reducing speed (see the effectiveness section);
- Speed cushions do not present any notable disadvantages for emergency vehicles;
- At an intersection, a speed hump can serve as a raised crosswalk. When it extends across an entire intersection, it acts as a raised intersection;
- Some models are removable and so able to control speeds when the problem is more important, i.e., when it is not wintertime;
- Good effectiveness at moderate cost is compared to other traffic calming measures (see the costs section).

2.4 Disadvantages of Speed Humps and Speed Cushions

Certain disadvantages are linked to the presence of speed humps and speed cushions, but may be avoided if the traffic calming measures are properly implemented:

- Speed humps and speed cushions have little effect on speed for two-wheel motorized vehicles that, like cyclists, can pass in the flat area on the edge of the curb. In the case of speed cushions, there is a risk that cyclists alter their trajectory to pass between the cushions in the middle of the road;
- Increased noise as a result of vehicles decelerating and accelerating. This disadvantage can be minimized if speed is controlled on the entire road or throughout the neighbourhood;
- Depending on the type of soil, there is a risk that vibrations from passing heavy vehicles can be felt in residences. On local roads where there is very little heavy vehicle traffic, this is a minor disadvantage;
- There is a risk of diverting traffic to neighbouring roads, however, studies aimed at quantifying the impacts on traffic congestion are not conclusive [18]. It is recommended that implementation be planned for the entire neighbourhood;
- Speed humps negatively affect emergency vehicles (increasing response times by up to 10 s per speed hump). This disadvantage can be eliminated by installing speed cushions in place of speed humps, or minimized by using speed humps on residential local roads that are not preferred routes for emergency vehicles.

2.5 Geometry

The primary geometric characteristics of speed humps and speed cushions are the height, the length, and the shape of the slope. Speed cushions are also characterized by their width. When used in succession, the spacing between measures also influences their effectiveness at controlling speed [1, 4, 6, 14, 18, 19].

In Québec, the most commonly used height is approximately 80 mm. The most recent technical guidelines recommend this height as it offers the best compromise between effectiveness at reducing speed and acceptance by users.

Length (measured in the direction of travel) can vary. Inside and outside Québec, there are two main types of measures: some of 3.5 m to 4 m long, which are mainly used on local roads (Fig. 4), and others of approximately 7 m long, which have a flat centre of approximately 3 m and are better adapted to collector roads (Fig. 5). Based on the experience of several Québec municipalities, both types provide good results.

[3] When travelling at a given speed, the distance required to bring the vehicle to a complete stop which the driver should notice something on the road. See Ministère des Transports, Ouvrages routiers, Normes de conception routière, Volume I, Chapter 7 [17].

As for the slope of the measure, a sinusoidal shape is preferred over a circular or parabolic shape because it provides a more gentle transition and is easier for winter maintenance operators and cyclists to negotiate[4].

The optimal width for speed cushions is approximately 1.8 m, which is narrow enough to allow emergency vehicles to pass unaffected but wide enough to maintain the desired slowing effect for passenger vehicles. The space between the cushions and the curb should be approximately 0.6 m, which is narrow enough so that drivers can not avoid the cushions but wide enough for the tires of emergency vehicles to pass (Figs. 6 and 7). If only two cushions are installed, one in each direction, the distance between them must be at least 1 m so that heavy vehicles do not pass too close to one another.

When speed humps or speed cushions are installed in succession, the spacing that technical guidelines recommend, and which several Québec municipalities have followed, is between 80 m and 150 m, depending on the desired maximum speed on the stretch between traffic calming measure. One speed hump is sufficient on a road measuring less than 150 m between intersections.

Experience has also proven that several elements must be factored in when designing and constructing speed humps and speed cushions:

- The sides of traffic calming measures must also be sloped. It is recommended to leave approximately 0.6 m of space at the street curb to make it easier for cyclists to pass and to ensure good road drainage;
- Lighting is important, speed humps and speed cushions must always be clearly visible;
- When traffic calming measures are built of asphalt, geometric specifications are difficult to accurately achieve in the field, especially the sinusoidal shape. Particular attention must be paid to construction, and it is recommended that a template be used. The process to build asphalt speed cushions is almost entirely manual and is more delicate than building asphalt speed humps;

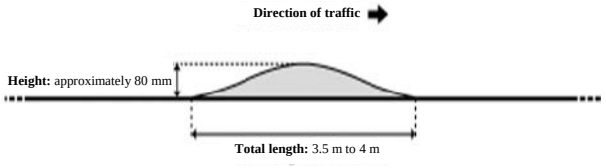

Fig. 4 Typical geometry of a speed hump without a flat centre.

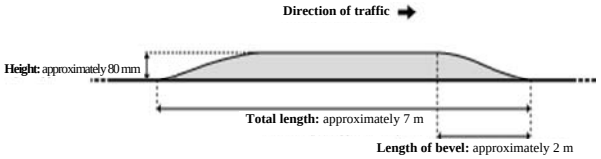

Fig. 5 Typical geometry of a speed hump with a flat centre.

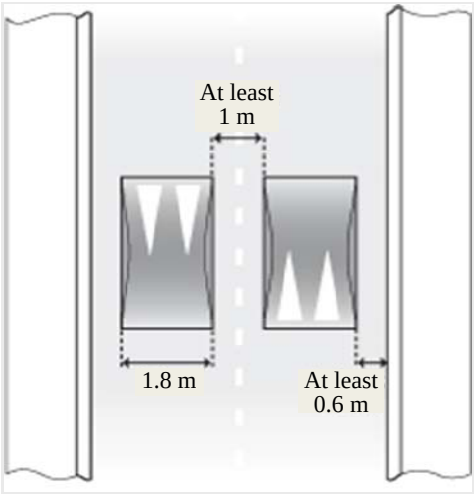

Fig. 6 Two-cushions configuration—narrow road.

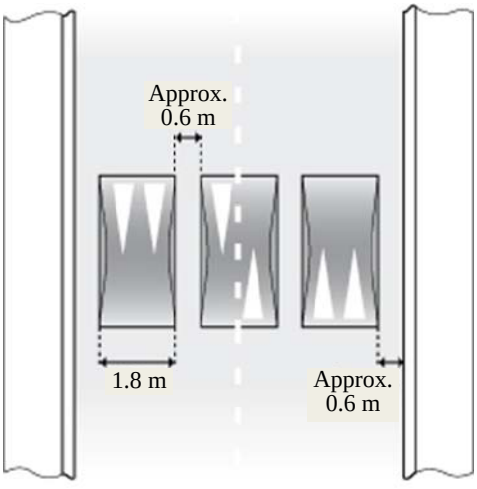

Fig. 7 Three-cushions configuration—wider road.

[4] For more information about the shape [1, 18].

• Removable speed humps must be carefully affixed to the road to prevent them from being ripped off.

Prior to constructing permanent speed humps and speed cushions of asphalt, rubber models may be used temporarily to gauge effectiveness and the reaction of users and residents.

2.6 Signage

Speed humps and speed cushions must be visible to drivers at all times. In this context, Québec signage standards have recently been adopted for speed humps[5]. The primary elements are:

• Markings on speed humps. These markings are mandatory (Fig. 8);

• A D-361 sign, accompanied by a D-240-P-10 tab sign, installed at the location of the speed hump, aligned with the centre of the highest part of the speed hump;

• A D-361 sign, accompanied by a D-245-P-2 tab sign, installed upstream of the speed hump at the distance indicated in the standard (Fig. 9);

• If there are several speed humps in close proximity along the same roadway, the D-361 sign, installed upstream of the speed humps, must be accompanied by the D-250-P-2 distance tab sign.

Markings make speed humps more noticeable, especially when there are cars parked along the side of the road. Because of winter maintenance operations, it may be necessary to replace the markings annually. Vertical signage is important to ensure the traffic calming measure visibly in the winter.

2.7 Effectiveness

Speed humps and speed cushions have long been recognized as very effective and durable measures for reducing driving speeds. They also have a positive impact on road safety.

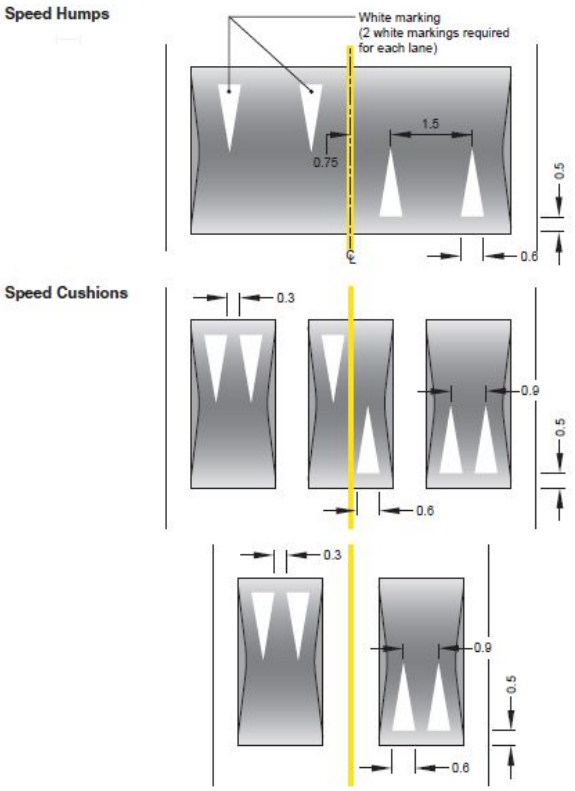

Fig. 8 Québec signage standard—markings (all dimensions are in m).

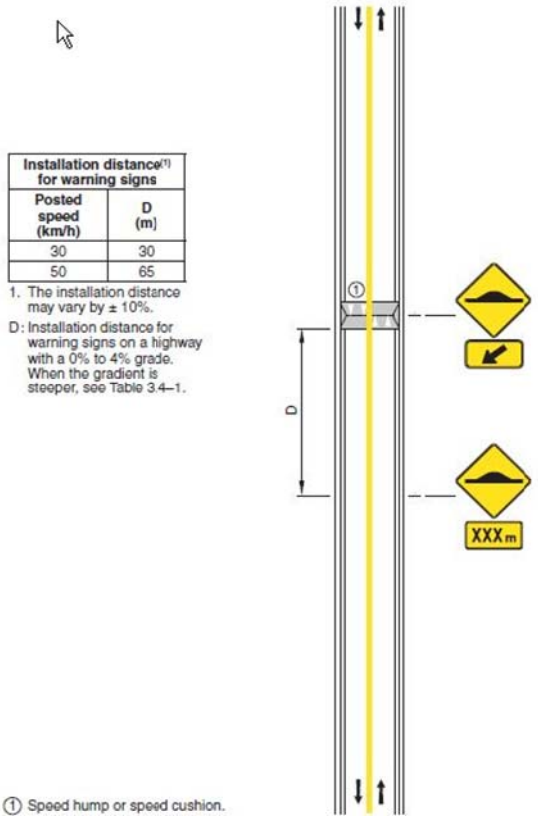

Fig. 9 Québec signage standard—D-361 sign.

[5] Ministère des Transports du Québec, Ouvrages routiers, collection Normes, Volume V, Traffic Control Devices, Chapter 3, Section 3.44.2 and standardized drawing 028; Chapter 6, Section 6.11.13 and Appendix H.

2.7.1 Reduced Driving Speeds

The speed at which vehicles travel over a speed hump depends on the length and height of the hump. The presence of a flat centre section permits vehicles to cross at a higher speed. According to data collected in Québec and the studies consulted [1, 4, 18], for 80 mm high speed humps without a flat centre section (approximate length: 4 m), the 85th percentile speed is between 30 km/h and 35 km/h, and with a flat centre section (approximate length: 7 m) that speed may reach 50 km/h.

Along a road where multiple speed humps have been installed in succession, the results depend on the spacing and the speed that can be regained between humps. This speed varies between 40 km/h and 50 km/h when speed humps are spaced between 80 m and 150 m apart.

Experience in the United States [16] has shown that speed cushions exhibit similar effectiveness in terms of controlling speed as speed humps of equal height and length.

The presence of speed humps and speed cushions, however, has little effect on controlling the speed of two-wheel motorized vehicles, which can pass between speed cushions or between a speed hump and the curb. The presence of speed cushions also has no effect on the speed of emergency vehicles, therefore not increasing response times.

2.7.2 Improved Road Safety

Speed control has a positive impact on road safety. According to studies published in the United States, the implementation of speed humps on local roads in urban areas decreased the number of injury accidents by an estimated 40%, however, with a standard error of 20%, the precision of this estimation is rather low [20].

2.8 Maintenance in Winter Conditions

A consultation with municipalities that had installed speed humps for many years reported that winter conditions and winter maintenance generally do not cause major problems for the majority of municipalities studied: speed humps maintain their ability to control speed, exhibit little deterioration and cause few problems for snow removal operations. This has also been reported by a variety of Canadian provinces and US states. Certain precautions must be taken, however.

The design of the speed hump plays a significant role. A progressive slope with a sinusoidal shape is easier for snow removal vehicles to negotiate. Operators must adapt their methods, properly positioning the blade of their equipment and taking the time to remove snow from the areas on and around the speed hump where it tends to accumulate.

The blade must be raised slightly in order to avoid damaging speed humps, but care must also be taken to remove all of the snow and ice that has built up. Removing snow from speed humps therefore requires adjusted methods and possibly additional time.

Snow removal for speed cushions is more difficult because of the space between the cushions and the possibility that snow can accumulate.

2.9 Costs

According to the Québec municipalities surveyed in 2009, the average cost of a speed hump was less than $5,000. The cost varies depending on the dimensions of the measure, the type of material (asphalt or rubber) and the installation procedure.

3. Conclusions

In urban areas, traffic calming measures are used to improve the safety of road users, particularly vulnerable users, and to make neighbourhoods more user-friendly. With a variety of traffic calming measures available to use individually or in combination, and a structured implementation procedure, it is possible to design the solution best adapted to each situation.

In order to provide municipalities with up-to-date information adapted to their needs and concerns, the

ministère des Transports du Québec has begun publishing a series of fact sheets on speed control.

The first published fact sheet presented the primary traffic calming measures as well as an analysis procedure for the implementation of such measures [21]. The second fact sheet specifically addresses speed humps and speed cushions, and outlines their characteristics as well as important factors to consider [22].

Both fact sheets are available on the ministère's website [23] under Partenaires-Municipalités-Sécurité routière. Examples of implementation procedures for traffic calming measures and speed control measures will also be outlined in order to share expert information on the matter.

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