Raised Crosswalks and Continuous Sidewalks: "Pedestrian Priority"

March 2017

Briefing Note

For up-to-date knowledge relating to healthy public policy

This document is part of a series of briefing notes documenting innovative municipal norms that have the potential to help create environments promoting safe active transportation by changing the design or organisation of public roadway networks.

Here, "municipal norms" refers to public policies that are adopted or endorsed by elected municipal officials. The technical planning and execution of the work associated with these norms is done by authorized professionals. Nothing in this document should be construed as a recommendation or opinion requiring the professional judgment of engineers, urban planners, architects, or any other professional.

This briefing note focuses on norms for raised crosswalks (or elevated crosswalk raised pedestrian crossing or raised zebra crossings) and continuous sidewalks. Both of these devices generally have the same surface height as the sidewalk. In the case of raised crosswalks, the pedestrian markings on the pavement are retained (see Figure 1). Crosswalks are installed either at intersections, both the traditional type and roundabouts, or on sections of streets between intersections.

In the case of continuous sidewalks, on the other hand, the material from which the sidewalk is constructed is extended to create a continuous surface (see Figure 2).[1] Continuous sidewalks are installed at intersections or on street sections - in the latter case at entrances to alleys, instead of curb cuts. They often serve as the gateway to a street or a sector where the speed has been limited to 30 km/h or less.

Figure 1 A raised crosswalk in British Columbia

Photo credit: Richard Durdl
Source: http://www.wikicommons.org

Figure 2 A continuous sidewalk in Stockholm (Sweden)

Photo credit: Lior Steinberg
Source: http://www.lvblcity.com

Model formulation for the norm

A raised crosswalk or a continuous sidewalk shall be the default option during the construction or reconstruction of streets or sidewalks:

- at entrances to alleys;
- on local streets, at the intersections of arterial or collector streets.

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[1] The term "continuous sidewalk" is sometimes used to describe sidewalks characterized by the absence of changes in elevation, known as "curb cuts, at the entrances to parking areas." This type of installation is not discussed here, because, although they are interesting devices, the evaluative literature available does not seem relevant to such a discussion.

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Alternative formulation

Raised crosswalks or continuous sidewalks should be considered as an option during the construction or reconstruction of streets or sidewalks:

- at entrances to alleys;
- on local streets, at the intersections of arterial or collector streets.
- in the vicinity of multi-modal transit stations or other key civic locations;
- in places where numerous pedestrians cross between two intersections.

Normative context

In Canadian municipalities, a sidewalk is normally interrupted at the point where a road intersects it. Sidewalks are also regularly lowered by curb cuts, also referred to as "curb ramps," to facilitate the entrance of vehicles into an alley or a private entrance.

The introduction of raised crosswalks or continuous sidewalks is not unprecedented in Canada. That said, there is significant potential for implementation on a large scale, subsequent to the adoption of the model norm or its alternative wording, in Canadian cities.

Desired benefits[2],[3]

Currently prevailing urban design practices have a number of impacts on the user-friendliness and safety of pedestrian travel. Sidewalk interruptions at intersections and curb cuts at entranceways force pedestrians to negotiate two changes in level. This can be particularly challenging for users with diminished cognitive or motor abilities. Moreover, in both cases, users must walk through a space designed for the passage of motor vehicles. Thus, in the case of street intersections, pedestrians often have to cross the path of vehicles, whose volumes and speeds may be high, which places them in a high-risk environment, even on local streets, where sidewalk interruptions are numerous. To illustrate, the Société d'assurance automobile du Québec (SAAQ) [Québec's public automobile insurer] estimated that, in 2015, 28% of collisions resulting in death or injury suffered by pedestrians and 14% of all collisions resulting in death or injury occurred on residential streets (Société d'assurance automobile du Québec [SAAQ], 2016).[4] The potential of raised crosswalks and continuous sidewalks to improve the

[2] The results of the studies presented in this section are detailed in Appendix 1. These results come from studies comprising both methodological limitations and strengths. Their limitations include, notably, the small number of studies found and, for some of these, the absence of long-term monitoring, of control for regression to the mean, and of control sites. Notable strengths include, for some of the studies, the use of site controls, good descriptions and illustrations of interventions. The interpretation of these results should take into consideration these strengths and limitations, along with the fact that these results are highly consistent with those concerning the broad spectrum of traffic-calming measures.

[3] The following expressions were used to locate the evaluative literature: "traverse piétonne surélevée," "trottoir continu," "trottoir traversant," "elevated crosswalk," "continuous sidewalk." We used the INSPQ's 360 meta search engine to query the following databases: Ageline, BiomedCentral, PudMed, Ovid Medline, Medline Complete, CINAHL, EBM Reviews Full Text- ACP Journal Club, Cochrane DS and DARE, Embase, ERIC, Érudit, Health Policy Reference Centre, Highwire Press, ipl2, MetaPress Complete, Nature Journals, OAIster, Political Science Complete, Psychology and Behavioral Science, PsycInfo, Public Affairs Index, Science Direct, SocIndex. We also queried Google and Google Scholar. The references to articles and guides thus identified were consulted. To be retained for the purposes of this document, an evaluation's methodology had to be explicit enough to be evaluated or the study had to constitute a literature review.

[4] It is generally recognized that the vast majority of collisions occur at intersections. Nevertheless, clearly there are currently no sidewalks on a portion of the local streets in many municipalities in the country. The proposed norms can only be effective where there are sidewalks, and thus, their potential cannot be extended to the entire set of local streets.

safety and comfort of pedestrians crossing the street is thus significant.

EFFECTS ON SPEED

One of the main mechanisms of action of these devices is moderation of the speed of motorized vehicles. This is, indeed, one condition for reducing the level of risk of injury and improving environmental conditions tied to user-friendliness (perceived safety, noise, etc.). With regard to speed, several studies suggest that crosswalks and continuous sidewalks have the potential to reduce traffic speeds to 40 km/h, 30 km/h, or even 20 km/h, depending on their characteristics, such as their height or their use in conjunction with a speed hump located at a greater or lesser distance in advance of the crosswalk, etc.(Gitelman, Carmel, Pesahov, & Chen, 2016; Huang & Cyneki, 2001; Johansson & Leden, 2007; Ziolokowski, 2014).

These results are, in fact, consistent with many studies concerning speed humps, a similar type of device (Bellefleur & Gagnon, 2011). The results are also highly consistent with those concerning the effects of raised crosswalks on safety and user-friendliness that are reported in the studies identified, and that are examined here.[5]

USER-FRIENDLINESS

The user-friendliness of streets for those engaged in active transportation is a multi-dimensional concept. We have divided the results of studies into two categories: (1) pedestrians' perceived safety when crossing the street and (2) pedestrians' crossing speeds.

(1) The studies suggest that raised crosswalks tend to improve pedestrians' perceived safety when crossing the street. Indeed, the installation of these devices seems likely to encourage drivers of motorized vehicles to yield to pedestrians. As for pedestrians, they seem more inclined to cross at crosswalks. It also appears that pedestrians often turn their heads less to monitor the approach of motor vehicles. Children asked about their perception of the safety of new crosswalks also reported feeling safer at these crosswalks than at a control site.

(2) The studies suggest that raised crosswalks tend to reduce pedestrians' crossing times. Indeed, pedestrians seem to have less of a tendency to stop before crossing. In one case where waiting times were measured, a reduction was observed, which, however, was not statistically significant: from 0.04 seconds before to 0 seconds afterward.

SAFETY

The studies that examined pedestrian-vehicle conflicts all observed a reduction in the number of conflicts where this type of device was present. The only study that examined collisions reported a 70 percent reduction in collisions of all types combined following the installation of raised crosswalks, which compares favourably with other devices evaluated in the same study, such as roundabouts (-57%) and various signalling devices (-46%). This same study reveals that collisions resulting in injury were reduced by 80% following the installation of raised crosswalks.

Potential drawbacks

Blind or visually impaired persons use changes in the sidewalk's level to help them distinguish street space from pedestrian space. Removing the change in level deprives them of this cue. Existing information briefs or practice guides generally recommend installing assistive devices at intersections for such persons (Trussart & Janssens, 2008; Billard, Hiron, Murard, Loubet-Loche, & Seguin, 2010).

The model formulations proposed here apply to local streets. Therefore, the noise generated by trucks passing over these devices should not be a significant drawback, seeing as there are generally low volumes of this type of vehicle on local streets.

Implementation context

The model norm suggested above is a simplified version of the one included in the street design guidelines for the City of San Francisco (USA), which is worded thus:

"Raised crosswalks should be considered:

- As a standard treatment at alleys and shared public ways

[5] For ease of reading, we have presented here an analysis of the trends revealed in Appendix 1, rather than inserting specific references.

- Where low-volume streets intersect with high volume streets, such as at alley entrances, neighborhood residential streets, and local access lanes of multi-way boulevards;
- Where a street changes its function or street type. For example, a commercial throughway may become a neighborhood commercial or residential street as the land uses along it change
- At key civic locations."[6]

The norm cited above provides specific details about several locations where it could potentially be relevant to install raised crosswalks or continuous sidewalks. As indicated, it indeed seems reasonable to consider these devices relevant at the intersections between arteries or collector streets and streets where it is considered appropriate to reduce speeds to 30-40 km/h or less. Similarly, these devices would seem to be a valid option when a public roadway changes function at a specific point, as for example when an main arterial or collector street becomes a local residential or collector street.

The installation of raised crosswalks on local streets, at their points of intersection with arterial and collector streets, was recently announced by authorities in the Montréal borough of Rosemont–La Petite-Patrie.[7] Such devices can also be installed, following the same principles, in roundabouts: they are not reserved for "traditional" intersections.

Moreover, as the announcement by the Rosemont–La Petite-Patrie borough indicates, raised crosswalks can also be installed elsewhere than at intersections, to encourage mid-block crossings. It is also on mid-block sections that it could be relevant to "continue" sidewalks to lessen, if not eliminate, changes in levels caused by curb cuts (New York City, 2013).

Precedents

One can find continuous sidewalks or raised crosswalks installed in all of the situations identified above within Canada. One can easily find examples of their installation on local streets, whether residential or collector, in many Canadian municipalities, particularly in Montréal, Toronto, Vancouver, Surrey, and Calgary.

Moreover, these devices are also included in the "toolbox" of many municipalities in the country, such as Surrey[8] or Calgary.[9] In the studies reviewed, we found no example of a municipal norm in Canada that establishes these devices as the default option or even encourages professionals to consider them systematically, in the way that the formulations proposed at the beginning of this document do. However, it remains possible that such a norm exists.

Facilitators

The norms applying to street and street network design are evolving significantly in many Canadian municipalities at this time, in ways that enhance the safety and user-friendliness of active modes of travel. In fact, several cities have begun by taking advantage of the margin of manoeuvre contained in provincial guides and in the federal guide to revise several of their norms with a view toward such improvements. In addition, the National Association of City Transportation Officials (NACTO) in the United States has published several guides that support the development of street design practices, in general, and of intersection designs, in particular, that encourage safe active transportation. Moreover, one of these guides supports the intent of the model and alternative formulations for a norm proposed in this document.[10]

Obstacles

Street design practices more focused on the circulation of motor vehicles than on safe active transportation remain a reality in Canadian municipalities, although some practices integrating the devices discussed in this brief are emerging. Also, street redevelopment cycles and the costs of

[6] See: http://www.sfbetterstreets.org/find-project-types/pedestrian-safety-and-traffic-calming/traffic-calming-overview/raised-crosswalks/ (Retrieved on June 9, 2016).

[7] See: http://journalmetro.com/local/rosemont-la-petite-patrie/actualites/963183/larrondissement-securise-des-passages-pietonniers/ (In French only: retrieved on June 9, 2016).

[8] See: http://www.surrey.ca/city-services/780.aspx (Retrieved on December 21, 2016).

[9] See: http://greenfield.calgaryregion.ca/tools/greenfield_design_trafficCalming.pdf (Retrieved on December 21, 2016).

[10] See: http://nacto.org/publication/urban-street-design-guide/intersections/intersections-of-major-and-minor-streets/ Retrieved on December 21, 2016).

installing raised crosswalks – which vary depending on a number of contextual factors – are probably the greatest obstacles to the rapid implementation of this type of device.

That said, these redevelopment costs appear to be more or less similar to those of installing curb extensions under the same conditions. As in other cases, integrating these new designs into existing municipal redevelopment cycles can significantly reduce costs.

Implications for practice

First, although these specific potential effects have not, to our knowledge, been the subject of evaluations, raised crosswalks and continuous sidewalks could be of particular interest to certain categories of persons who find it particularly difficult to negotiate the changes in surface level introduced by typical designs. These might include the elderly, those using wheelchairs or those pushing children in strollers. Such persons and the groups representing their interests could prove to be important allies for public health actors interested in promoting these norms and safe walking environments in general.

Finally, the formulation of these norms limits installation of these devices to local streets, whose traffic volumes and speeds are generally limited. However, two of the studies synthesized in this brief focus on crosswalks installed on collector streets and even, in two cases, on arteries. It seems relevant to monitor the evolution of these practices on collector streets and arteries, because the safety records for these types of streets are particularly worrisome. For example, the SAAQ report mentioned previously indicates that, in 2015, arteries were the scene of 33% of all collisions resulting in injuries in Québec, and 44% of those collisions in which the victims included a pedestrian (SAAQ, 2016).

Related norms or regulations

The height of crosswalks and sidewalks; the installation of preceding speed humps; speed limits on local streets; raised bicycle crossings.

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Appendix 1 Summary table of evaluations of raised crosswalks

Reference	Speed	Safety	User-friendliness
Cafiso, García Garcia, Cavarra & Rojas (2010). Spain. Two raised crosswalks (North site 10 cm, and South site 7.5 cm), with zebra markings, and in combination with speed humps (60 m from the North site crosswalk, and 200 m from the South site). Several phases of implementation and evaluation, but we have synthesized here only the results from before the 1st phase and after the last phase.		Pedestrian risk index (PRI - index resulting from a calculation incorporating stopping time, reaction time, speed of the motor vehicle and deceleration) calculated before and after the intervention with and without pedestrians at the crosswalk. North crosswalk: reduction of PRI from 1607 to 219 (-87%) without pedestrians, and from 2207 to 197 with pedestrians (-91%). South crosswalk: reduction of PRI from 904 to 283 (-69%) without pedestrians, and from 818 to 342 (-58%) with pedestrians.	
van der Dussen (2002), in Turner, Makwasha, Pratt, & Beecroft (2014). Netherlands. Synthesis of the literature on various speed reduction devices. The reported study devoted to raised crosswalks focused on 82 intersections in the same city, including 10 that included raised crosswalks. Intersections with AADT of 3000-6000. Before-after analysis of installed measures.		70% reduction in the number of collisions at intersections with raised crosswalks, compared to 57% for roundabouts and 46% for signalling. 80% reduction in the number of collisions with injury.	

Reference	Speed	Safety	User-friendliness
Gitelman, Carmel, Pesahov, & Chen (2016), Israel. 8 sites each comprising two raised crosswalks which include, notably, zebra markings, a flashing light and a speed hump 15 to 20 m before the crosswalk. Two-lane arterial and collector streets, speed limited to 50 km/h, and pedestrian activity of, at least, 25 pedestrians/h. Devices of varying heights, and varying volumes of pedestrian and motorized traffic. Before-after analyses (at two "after," times; i.e., immediately afterward, and two months afterward).	Tendency toward a reduction in driving speeds (at all sites except 1). More significant reductions at 10 crosswalks whose height was greater. Sites 1-4 and 8: average speed before of 42-58 km/h; average speed after 2 months of 22-30 km/h. V85 of 50-65 km/h before; 28-37 km/h after. Reductions in average speed of 19-30 km/h and in V85 of 20-30 km/h. Greater reductions were seen where the speeds had been higher before. Sites 5-7 (except northbound at site 5): average speed before of 41-52 km/h; average speed after 2 months of 31-37 km/h. Reductions in average speed of 12-17 km/h and in V85 of 7-17 km/h. Site 5, northbound: average speed before of 31 km/h; average speed after of 32 km/h. V85 before of 39 km/h; after of 39 km/h).	Tendency toward a reduction in the percentage of vehicle-pedestrian conflicts. Reduction in 5 cases. Increase in 3 cases, none of which were statistically significant.	Tendency toward a reduction in the percentage of pedestrians who stop before crossing. Reduction in 9 cases and increase in 6 others, 3 of which were not statistically significant. Tendency toward an increase in the percentage of pedestrians checking whether vehicles are arriving before crossing. Increase in 10 cases, 3 of which were not statistically significant. Reduction in 2 cases. Tendency toward an increase in the percentage of drivers in the first of the two lanes yielding to pedestrians. Increase in 9 cases, 4 of which were not statistically significant. Tendency toward an increase in the percentage of drivers in the second of the two lanes yielding to pedestrians. Increase in 9 cases, 2 of which were not statistically significant. Reduction in 1 case. Tendency toward an increase in the percentage of pedestrians crossing within the boundaries of the raised crosswalk. Increase in 12 cases, 1 of which was not statistically significant. Reduction in 2 cases. Tendency toward an increase in the percentage of pedestrians crossing within the boundaries of the raised crosswalk. Increase in 11 cases, 4 of which were not statistically significant. Reduction in 3 cases.

Reference	Speed	Safety	User-friendliness
Huang & Cyneki (2001). United States. **Raised crosswalks** 3 experimental sites, 3 control sites, paired. Two-way streets, one lane in each direction. Crosswalks at intersections and mid-block. One of the crosswalks was equipped with a flashing light. **Raised intersections** 1 site, before-after measurement. Raised intersection with zebra markings.	**Raised crosswalks** V50 measured at each pair of sites (experimental-control): 1. 33 km/h (experimental site) – 40 km/h (control site). 2. 19 km/h – 38 km/h. 3. 35 km/h – 39 km/h.		**Raised crosswalks** The frequency with which cars yield to pedestrians was evaluated for two of the three pairs of experimental-control sites: 1. 79% (experimental site) – 31% (control site). 2. 1%-1%. **Raised intersections** The frequency with which pedestrians used the device increased from 12% before to 38% after. The crossing wait time decreased from 0.04 seconds before to 0 seconds after (not statistically significant).
Johansson & Leden (2007). Sweden. 2 experimental sites, 2 control sites. Changes to the road code and raised intersections at 2 experimental sites, but several other changes as well, carried out in several stages (see article for details).	Reductions at two experimental sites both in average speeds and in V90: 1. From 49 km/h to 32 km/h (V90 57 km/h – 41 km/h). 2. From 39 km/h to 26 km/h (V90 32 km/h after). 3. Reduction at control site from 52 km/h to 47 km/h.		As cars approached the experimental sites, pedestrians turned their heads toward them less. Experimental sites: 1. From 87% to 44% (null effect if no car). 2. From 70% to 44% for children. Control site: no change. Pedestrians stopped less at the sidewalk-crosswalk junction at the experimental sites. Reduction at the control site, but less significant. The frequency with which cars yielded to pedestrians increased at all sites. The highest frequencies were observed at a raised intersection (a control site), and the greatest increase at another raised intersection

Reference	Speed	Safety	User-friendliness
			(an experimental site). Pedestrians cross less at crosswalks with markings, at all sites. At all sites with a raised crosswalk, children felt safer. The perceived safety was greater at the experimental sites than at the control site.
Ziolokowski (2014). Poland. Tests of 7 roundabouts (mini and conventional) with varying geometries and characteristics. One included a raised intersection, another a raised crosswalk. At three approaches, speed humps were added; at one, a speed cushion was added; and a raised median was added at the last.	In roundabouts with vertical deflections, speed was reduced by 31% on average. Average speed of 19 km/h at the raised intersection and of 22 km/h at the raised crosswalk; of 17, 21 and 20 km/h for the speed humps and 29 km/h for the speed cushion. Motor vehicles slowed down the earliest at the approach to the raised intersection (105 m) and they slowed down the latest at the median (52 m).		

Note: Raised crosswalks were among the measures implemented in "zone 30" type sectoral traffic calming strategies in London. The evaluations of these strategies by Grundy (2008) showed significant reductions in vehicle speeds and collisions of all types. These studies are not represented in the tables above because they included other measures besides raised crosswalks; therefore it would not be possible to attribute effects to raised crosswalks alone based on these.

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