9.0 Safety and Accessibility

9.1 Pedestrian Safety

Pedestrian safety can be both a real and a perceived factor that influences where and how often people choose to walk. Sometimes walking conditions or situations are unsafe without the pedestrian understanding the risk and other times a condition is perceived risky when in fact is may be uncomfortable or inconvenient rather than unsafe.

"I want to live in a people city, not a car city"

Ottawa Resident

9.1.1 Safe Places to Walk

Streets without safe places to walk put people at risk. Studies in the US have shown that residential areas with no sidewalks had 23% of the pedestrian collisions but only 3% of the pedestrian traffic*(73)*. In addition, local streets without sidewalks are more hazardous. Streets with no sidewalks had 2.6 times more pedestrian collisions, and sidewalk one side only had 1.2 times more pedestrian collisions than streets with sidewalks on both sides*(74)*.

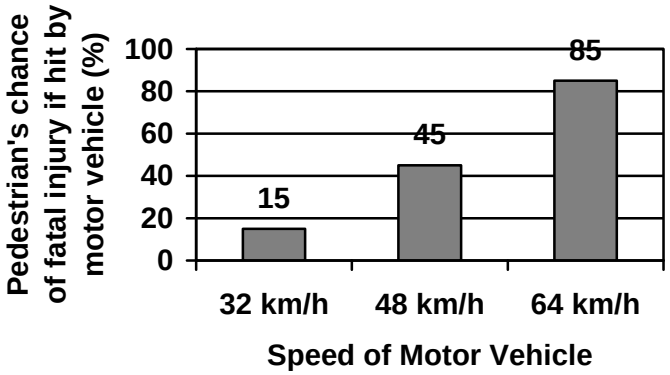
Pedestrian safety is affected by the traffic. As indicated in **Figure 9.1,** when vehicle travel speed increases the risk of injury of death if a collision occurs with a pedestrian also increases. In addition, the awareness, visibility and behaviour of both drivers of motor vehicles and pedestrians affect pedestrian safety, and this is further complicated by higher vehicle travel speeds regardless of whether or not the travel speed exceeds the posted speed. Statistics show that there is safety in numbers. A motorist is less likely to collide with a person walking if more people walk*(75).*

73 Knoblauch, R.L., Tustin, B.H., Smith, S.A., and Pietrucha, M.T., *Investigations of Exposure Based on Pedestrian Areas: Crosswalks, Sidewalks, Local Streets AND Major Arterials*, Report No. FHWA/RD-88/038, Federal Highway Administration, September 1988.

74 Ibid.

75 Jacobsen, P.L. *Safety in Numbers: More Walkers and Bicyclists, Safer Walking and Biking.* Injury Prevention 9, 205-209. 2003.

Figure 9.1
Pedestrian's chances of death if hit by a motor vehicle travelling at various speeds vehicle*(76)*



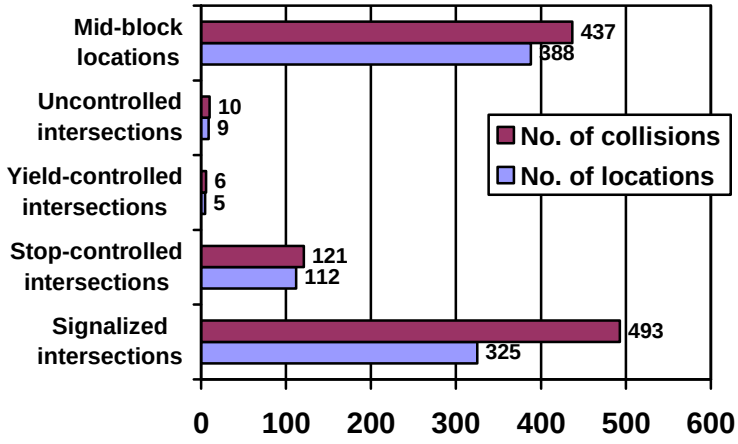
9.1.2 Pedestrian Collision Locations in Ottawa

The City of Ottawa collects collision data. The frequency was analyzed and ranked for locations involving pedestrians for the years 2004 to 2006 (3 years). The locations were categorized as signalized, stop-controlled, yield-controlled and uncontrolled intersections, and uncontrolled mid-block locations. (**Figure 9.2**) Intersection-related collisions involving pedestrians were more frequent (by 44%) than collisions occurring at mid-block locations:

- Mid-block locations – 437 collisions at 388 mid-block locations
- Intersections locations - 630 collisions at 451 intersections which included:
    - 10 collisions at 9 uncontrolled intersections,
    - 6 collisions at 5 yield-controlled intersections,
    - 121 collisions at 112 stop-controlled intersections, and;
    - 493 collisions at 325 signalized intersections.

76 Department of Transport (United Kingdom). *Killing Speed and Saving Lives*. As reported in Oregon Department of transportation, *Oregon Bicycle and Pedestrian Plan*, 1995.

Figure 9.2
Pedestrian collisions in Ottawa from 2004 to 2006 (inclusive) by location



The location in the City of Ottawa with the highest collision frequency was King Edward Avenue and Rideau Street with eight collisions involving pedestrians at this signalized intersection. Forty-two signalized intersections had a collision frequency of three or more collisions. Stop-controlled, yield-controlled and uncontrolled intersection locations had frequencies of two collisions or less.

The mid-block (non-intersection-related) location with the highest frequency of collisions was Murray Street between Cumberland Street and King Edward Avenue with five collisions involving pedestrians. Five mid-block locations had a collision frequency of three collisions involving pedestrians.

The locations with a higher frequency of collisions (three or more) involving pedestrians occurred in the following locations:

- 58 collisions occurred at 18 locations in the Ottawa Centre—28 of these collisions occurred at ten intersections on Elgin Street, Slater Street and Albert Street between O'Connor/Elgin/Somerset (an "L" shape) and 6 collisions occurred mid-block on Laurier Avenue between Metcalfe Street and Nicholas Street.
- 44 collisions occurred at ten locations in the Ottawa Inner Area— King Edward at or near Murray Street had ten collisions involving pedestrians.
- 25 collisions occurred at 6 locations in Ottawa West—11 collision at three signalized intersections on Richmond Road, Seven collision at two locations on Carling Avenue, and seven collisions at two locations on Woodroffe Avenue.
- Ten collisions occurred at three locations in Bayshore/ Cedarview.
- Nine collisions occurred at three locations in Alta Vista.
- Nine collisions occurred at three locations in Ottawa East.
- Six collisions occurred at two locations in Merivale.
- Six locations occurred at two locations in Orleans.
- Three collisions occurred at one location in Kanata/Stittsville.

9.1.3 Characteristics of Pedestrian Collisions in Ottawa

The list of 1,976 collisions involving pedestrians from the years 2002 to 2006 was sorted by location (signalized, stop-controlled, yield-controlled or uncontrolled intersection or mid-block), driver action and pedestrian action, and vehicle manoeuvre and pedestrian action. Below is a summary of those actions or manoeuvres that contributed to more than 5% of the total collisions involving pedestrians:

Etobicoke, ON

- Only 284 (14%) of the collisions involved pedestrians walking on the sidewalk or shoulder compared to 1,251 (63%) of the collisions that occurred when the pedestrian was crossing the road.
- 648 (33%) of the collisions involved pedestrians crossing the road with the right-of-way, 622 (31%) involved drivers who failed to yield the right-of-way, and 854 (43%) involved drivers driving properly.
- 461 (23%) of the collisions occurred at signalized intersections with the driver failing to yield the right-of-way, disobeying traffic control, speed too fast or lost control when the pedestrian was crossing with the right-of-way.
- 278 of the collisions involved vehicles that were turning left and 153 that were turning right at a traffic signal with the pedestrian crossing with the right-of-way (22%).
- 217 (11%) of the collisions occurred at mid-block with the pedestrian crossing without the right-of-way or running into the roadway.
- 148 collisions (8%) occurred at signalized intersections with the pedestrian crossing without the right-of-way, and 125 of these the vehicle was going ahead (not turning).

In summary, the most prevalent collisions involving pedestrians in Ottawa occur when pedestrians are crossing the roadway regardless of location or traffic control. Pedestrians are almost 5 times less likely to be involved in a collision when walking on a sidewalk or roadway shoulder than when crossing the roadway. Signalized intersections where a right, or left-turning driver is failing to yield the right-of-way to a pedestrian in the crosswalk (a pedestrian who has the "walk" or "flashing don't walk" signal) is the most common collision (431 collisions out of a total of 1535). Absolute numbers are expressed because percentages can be misleading.

"Need seats at more bus stops, standing to wait is difficult for disabled. I could use regular service if I didn't have to stand after walking to stop."
Ottawa Resident

9.2 An Accessible Pedestrian System

The Government of Ontario passed the *Accessibility for Ontarians with Disabilities Act* (AODA) in 2005, the first of its kind in Canada. The AODA provides for the development and enforcement of standards for accessibility related to goods, services, facilities, employment, accommodation and buildings. These standards will apply to businesses, public sector organizations, municipalities and the provincial government.

Pedestrians can be affected by mobility, hearing, visual, and cognitive impairments. These pedestrians can become disabled in their environment unless it is designed to be accessible. Details make a difference—sidewalk and street crossing designs are evolving to create barrier-free, walkable communities

Elements to incorporate into sidewalks and street crossings to make them accessible include the following, as published by the US Federal Highway

Administration*(77)*, providing a summary of the information found in US Access Board's *Designing Sidewalks and Trails for Access*. Note that there are currently no comprehensive national guidelines in Canada. The US Access Board has published draft guidelines*(78)* and a new guide*(79)* that shows how access can be maximized in existing streetscapes. In addition to the key elements and features of the sidewalk and transitions to crosswalks described below, there are guidelines for street furnishings such as benches and rest areas, planters, grates and utility access covers etc..

The following is a review of key elements that affect accessibility. **Figures 9.3 and 9.4** provide a graphic representation of the guidelines described below. It is suggested that readers refer to the cited reference materials for more details and justification for suggested guideline or dimension.

9.2.1 Sidewalks

Sidewalks or the pedestrian travel zone include:

Galt, ON

- **Width**—1.5 m is required for a wheelchair to turnaround, and 1.8 m to pass other wheelchairs.
- **Grade**—a maximum of 5% is recommended, however, this can be difficult to control since sidewalks follow streets that sometimes have grades in excess of 5%. A level landing can be provided every 9 m for excessive grades (maximum of 8.3%). The landing is recommended to be 1.5 m square with a slope not greater than 2% in any direction.
- **Cross slope**—The maximum cross slope recommended is 2%. A sidewalk with a steep cross slope can be modified to provide a level area 0.9 m wide within the width of the sidewalk, or the height of the curb can be increased but with potential impacts to on-street parking and curb ramp design.
- **Surface**—concrete and asphalt provide firm, stable and fairly slip-resistant surfaces when dry. Concrete is recommended to be broom finished to increase slip resistance. Consistent colour and texture aid the visually impaired who may not be able to distinguish a change in colour or texture from a drop-off or change in level. Texture should not include more than a 6 mm rise every 75 mm for those with mobility aids. Textured surfaces can make it difficult for pedestrians with visual impairments to identify detectable warnings at the transition from the sidewalk to the street. Smooth walkways with brick trim are recommended to identify the pedestrian travel area within the overall pedestrian zone of a street or plaza.
- **Elevation**—As with texture, changes in level or vertical rises in sidewalks should not exceed 6 mm; from 6 to 13 mm the surface can be beveled with a maximum grade of 50% (1:2); and greater than 13 mm a ramp with a maximum grade of 8.3% is needed to address the vertical rise.

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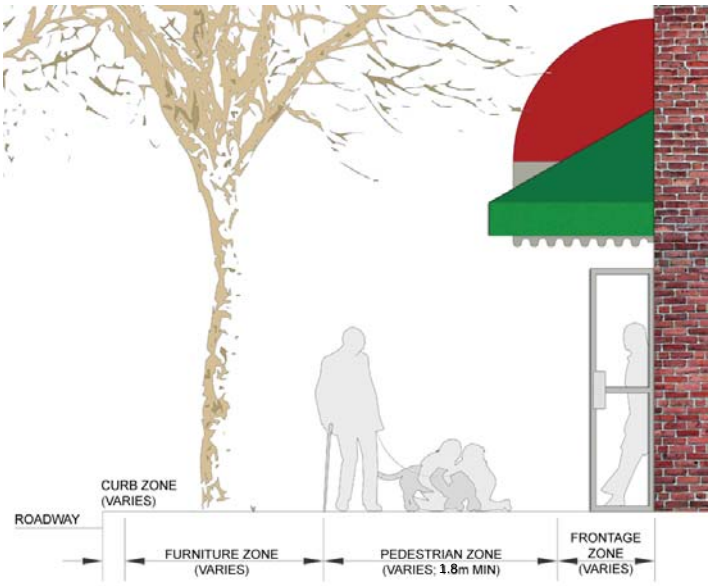
77 U.S. Department of Transportation, Federal Highway Administration, *Accessible Sidewalk and Street Crossings—An Information Guide*, HWA-SA-03-019.

78 *Revised Draft Guidelines for Accessible Public Rights-of-Way*, http://www.access-board.gov/prowac/. 2005.

79 Institute of Transportation Engineers. *Accessible Public Rights-of-Way: Planning and Designing for Alterations* shows how access can be maximized in existing streetscapes, http://www.access-board.gov/news/row-guidance.htm. August 2007.

Figure 9.3
The sidewalk corridor zone system



The sidewalk corridor zone system consists of the curb zone, furniture or buffer zone, pedestrian travel zone and frontage zone

.

Figure 9.4
Sidewalk corridor zones: Example

The concrete sidewalk or pedestrian travel zone is uniform in colour and texture with a defined edge, and contrasts with the adjacent zones.Location: Niagara-on-the Lake, ON. Source: Stantec

- **Protruding objects into the sidewalk corridor**—Objects above 2 m in height over the pedestrian travel zone are not a problem for pedestrians with visual impairments. They can usually detect objects with a long cane under 0.7 m in height. However, objects that protrude between 0.7 and 2.0 m over the pedestrian travel zone but do not extend to the ground are more difficult to detect and avoid. Objects mounted on a wall, post or side of a building should not protrude more than 0.1 m into the sidewalk corridor or pedestrian travel zone (**Figure 9.5**).
- **Sidewalks at private approaches**—The characteristics of an accessible sidewalk should continue across a commercial / retail / institutional / residential entrance, including a cross slope not greater than 2%, level manoeuvering space, changes in level not to exceed 6 mm and a maximum flare slope of 10%. Ideally the change in grade of the entrance to match the street grade occurs outside the sidewalk or pedestrian travel zone, between the sidewalk and the street. If this is not possible, the level sidewalk can be jogged away from the street providing a greater width over which to provide the entrance ramp. The treatment of the sidewalks as it crosses the private approach is provided for in the City of Ottawa standard detail drawing for sidewalks and curbs.

"More sidewalks both sides of the street."
Ottawa Resident

Figure 9.5
Protruding objects in the sidewalk zone

Objects located between 0.7m and 2.0m from the ground should not protrude more than 100mm

9.2.2 Sidewalks

Curb ramps at street crossings—these are necessary to provide access from the sidewalk to the street for pedestrians who use wheelchairs and other mobility devices. However, they can create barriers for people with vision impairments

who use the curb to identify the transition between the sidewalk and the street. Detectable warnings are installed to mark the boundary between the sidewalk and the street where the vertical edge of the curb is eliminated by the curb ramp.

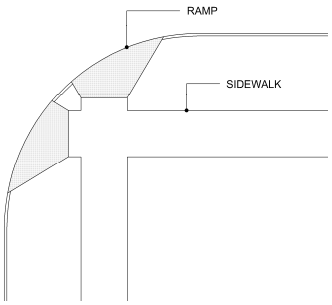
Curb ramp types include:

- **Perpendicular**—two ramps per corner aligned with the crosswalk. On small radius corners, the path of travel from the ramps through the crosswalk is straight. On larger radius corners, this path may not be straight.
- **Diagonal**—not recommended. Wheelchair users are directed into the intersection and must turn at both the top and the bottom of the ramp. Pedestrians with vision impairments can mistake a diagonal ramp for a parallel ramp and unintentionally travel into the intersection since it is not aligned with the crosswalk. If the corner radius is tight, the level landing area at the bottom of the ramp where the wheelchair user must manoeuver towards the direction of the crosswalk may be within the travel path of motorists proceeding parallel to the crosswalk.
- **Parallel**—on narrow sidewalks the sidewalk itself is ramped down to a level landing. Pedestrians on the sidewalk (not crossing) must negotiate two ramps.
- **Combination parallel and perpendicular**—the sidewalk is partially ramped to reduce the length of the perpendicular ramp to provide a level manoeuvering area at the top of the ramp. Pedestrians on the sidewalk (not crossing) must negotiate two ramps.
- **Depressed corners**—eliminate the need for curb ramps. Design details are required to prevent larger vehicles from travel onto the sidewalk when turning and to define the boundary between the sidewalk and street.

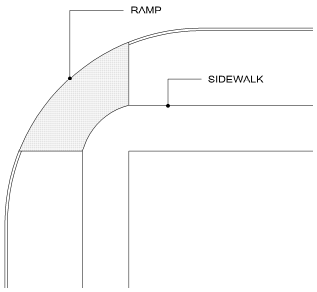
  Design elements of curb ramps include the following:

- **Ramp grade**—maximum of 8.3%, however, 7.1% is recommended to allow for construction tolerances.
- **Cross slope**—not to exceed 2%.
- **Ramp width**—minimum of 1.2 m, but 0.9 m is acceptable in restricted spaces where a ramp is being retrofitted.
- **Grade changes**—the change in grade between the ramp and the gutter/street must be 13% or less to prevent wheelchair users from being pitched forward or thrown backwards.
- **Curb ramp alignment**—align perpendicular to the curb face and parallel to the direction of travel within the crosswalk (**Figure 9.7**). This results in a straight path of travel from the top of the ramp to the roadway, through the crosswalk, to the curb ramp on the other side and to the top of that ramp.

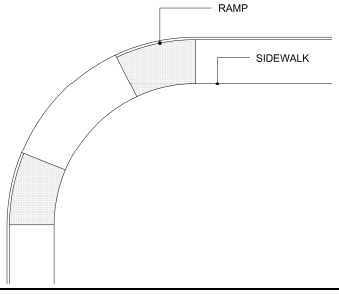
Figure 9.6
Curb Ramp Types



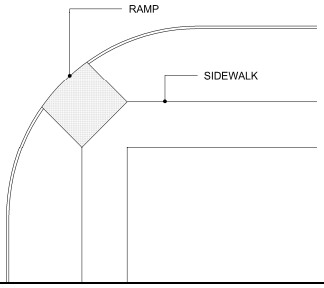
Perpendicular
(recommended)



Depressed Corner
(recommended)



Parallel
(not recommended)



Diagonal (not recommended)

Figure 9.7
Curb ramp alignments for wheelchairs .

The curb ramp alignment is such that the wheelchair user is directed outside the crossing area in order to access it. Curb ramps must be perpendicular to the curb and should align with the crosswalk Source: www.pedbikeimages.org / Dan Burden

- **Detectable warnings for vision-impaired pedestrians**—A 600 mm wide tactile detectable warning strip is utilized at ramps indicate to the visually impaired pedestrian, the transition from the sidewalk to the street (see subsequent sections).
- **Transition points**—Less than a 13 mm change in level between adjacent curb ramp surfaces.
- Sidewalk approach width—minimum of 1.2 m.
- **Level landing**—required at the top and bottom of the curb ramp, 1.2 m by 1.2 m in size and a cross slope of not more than 2% in any direction. The absolute minimum landing width is 0.9 m however, the slope of the curb ramp flare must not exceed 8.3% in order to allow wheelchair users to travel over a portion of the flare to move between the ramp and the sidewalk.
- **Drainage**—adequate drainage is required to prevent water and debris from accumulating at the bottom of the ramp. The pavement elevations along the curb return/radius at in intersection should be designed and

constructed such that a low point is **not** located at the crosswalk/curb ramp. Refer also to Chapter 10 for a discussion of sidewalk maintenance.

- **Detectable warnings**—standardized surface feature built in or applied to walking surfaces to warn visually impaired pedestrians of potential hazards. In particular, detectable warnings are placed at the bottom of curb ramps, at depressed intersection corners, raised crosswalks and intersections, the edge of transit platforms, and railroad tracks that cross sidewalks. In the US, the only approved detectable warnings consist of a surface of truncated domes aligned in a grid pattern—dome base diameter 23 to 26 mm, top diameter 50 to 60% of base diameter, height 5 mm, centre-to-centre spacing of 40 to 60 mm, and visual contrast of light on dark or dark on light with adjacent walking surfaces (**Figure 9.8**).
- Grooves in curb ramps are specified in the Ontario Provincial Standards but are not allowed in the US for they have been deem undetectable and confusing. Pedestrians cannot always detect them underfoot and can confuse them with sidewalk expansion joints and cracks.
- Testing of the installation and maintenance of truncated dome surfaces is on-going by various jurisdictions. In particular, testing by the Vermont Agency of Transportation considers the durability of truncated domes under winter maintenance conditions.

Figure 9.8

Example of cast-in-place truncated dome panels in a curb ramp.

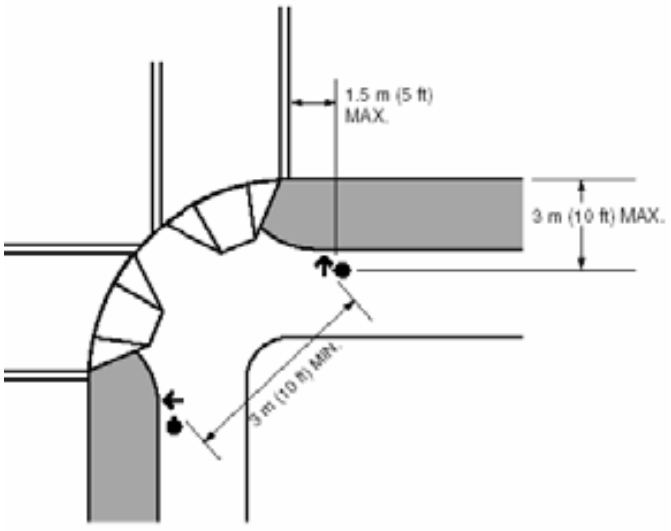
Source: Vermont Agency of Transportation

- **Accessible pedestrian signals** (APS—Refer to **Figure 9.9**) provide information about the status of the pedestrian signal (walk, don't walk) by audible tones or speech messages. The design and placement of pedestrian signal devices must also be accessible, including:

- Locate the push button as close as possible to the curb ramp without interfering with clear space and so it can be operated from a level of landing.
- Mount the device no higher than 1.0m above the sidewalk with the control face of the button parallel to the direction of the crosswalk.
- One button per pole separated by 3.0m is preferred, located no closer than 750mm to the curb and no more than 1.5m from the crosswalk.
- The button diameter should be a minimum of 50mm and capable of being activated by a force no greater than 15.5N.

Figure 9.9

Recommended location of Accessible Pedestrian Signal pushbuttons at a two ramp crossing



Source: US Manual of Uniform Traffic Control Devices

Additional guidance on accessible street crossings is provided in the next section.

Recommendation 9.1

It is recommended that the City:

Review design elements of sidewalks and street crossings to ensure that they meet accessibility and safety guidelines presented in the Pedestrian Plan and include consideration of pedestrian signal activation devices on pedestrian islands.

9.3 Pedestrian Street Crossings

Pedestrians want and need safe access to all destinations that are accessible to motorists. Pedestrians must be able to cross streets at regular intervals and should not be expected to go out of their way more than is necessary in order to take advantage of crossing locations. As a general rule, a diversion to reach a good street crossing location should not exceed approximately 100m.

9.3.1 Pedestrian Crosswalks

The Ontario *Highway Traffic Act* (HTA) defines crosswalks:

a. That part of the highway at an intersection that is included within the connections of the lateral lines of the sidewalks on opposite sides of the highway measured form the curbs or, in the absence of curbs, from the edges of the roadway, or
b. Any portion of a roadway at an intersection or elsewhere distinctly indicated for pedestrian crossing by signs or by lines or other markings on the surface. *(80)*

9.3.2 Pedestrian Cross-overs

Pedestrian cross-overs differ from crosswalks and are also defined in the HTA as "any portion of a roadway, designated by by-law of a municipality, at an intersection or elsewhere, distinctly indicated for pedestrian crossing by signs on the highway and lines or other markings on the surface of the roadway." The HTA does not permit pedestrian crossovers on highways with speeds in excess of 60 km/h.

The HTA regulates "where portions of a roadway are marked for pedestrian use, no pedestrian shall cross the roadway except within a portion so marked."

The HTA is silent on the protection of pedestrians crossing a roadway without traffic control whether at an intersection or mid-block. In other words, motorists are only required to yield to pedestrians where any of the following forms of traffic control are present: traffic signal, intersection pedestrian signal (IPS), pedestrian cross-over (PXO), school crossing guard or a stop sign. Drivers have no statutory requirement to yield to pedestrians in crosswalks at "uncontrolled" locations. Providing crosswalks at uncontrolled locations may mislead pedestrians into thinking they have right of way over traffic.

The pedestrian cross-over (PXO) was first introduced in the Ottawa area in 1963. In 1991 the former Region of Ottawa Carleton made the decision to discontinue the use of PXO's and directed staff to remove them in a phased manner and replace them intersection pedestrian signal (IPS) crossings. Today there are no PXO's remaining in the City of Ottawa. (*81*)

Alternative Treatments for At-grade Pedestrian Crossings(82) documented the state of the practice in innovative treatments for pedestrian accommodation for intersection and mid-block crossings. The report represents an inventory of over

80 Ontario Highway Traffic Act . R.S.O. 1990.

81 http://ottawa.ca/calendar/ottawa/archives/rmoc/Transportation/21Oct98/Warrafnl.pdf .

82 Lalani, Nazir and the ITE Pedestrian and Bicycle Task Force, *Alternative Treatments for At-Grade Pedestrian Crossings,* Institute of Transportation Engineers, 2001.

70 pedestrian measures. The pedestrian measures included both "controlled" crossings (where pedestrians have the right of way) and "uncontrolled" (where approaching vehicles have the right of way). The report concludes:

"Recreational paths should not connect straight into sidewalks without clear delineation."
Ottawa Resident

- Installing marked crosswalks, especially at uncontrolled locations, by striping two lines across the roadway and posting a single sign in advance of and at the crossing does not afford pedestrians effective protection from being struck by a vehicle while crossing in the marked crosswalk. This is especially the case on high-volume, multilane facilities.
- There are a number of higher-cost geometric design features, such as curb extensions (also commonly referred to as bulb-outs) and pedestrian refuge islands, that can be used to improve the safety of marked crosswalks, especially those on high-volume, multilane major streets.

9.3.3 Intersection Crossings

Signalized intersections are one of the most complex parts of the road network for pedestrians. Improvements to pedestrian crossings at intersections can be achieved by introducing intersection design elements that shorten pedestrian crossing distances, increase pedestrian and vehicle visibility, simplify the crossing task, control vehicle speeds and control vehicle paths*(83).* Although conceptually simple, implementing these design elements, particularly in retrofit as opposed to new construction, may result in significant planning, engineering, operations and maintenance requirements and effects.

Attributes of good intersection design for pedestrians include*(84):*

- **Clarity**—It should be obvious to motorists that there will be pedestrians present and obvious to pedestrians where best to cross the intersection.
- **Predictability**—The placement of crosswalks should be predictable and intersection crossings should be more frequent where pedestrians volumes are higher.
- **Visibility**—The location and illumination of the crosswalk, and location of other obstructions allows pedestrians to see and be seen by approaching traffic while crossing.
- **Short wait**—The pedestrian does not have to wait unreasonably long for an opportunity to cross.
- **Adequate crossing time**—The time available for crossing accommodates pedestrians of all abilities.
- **Limited exposure**—Conflict points with traffic are minimized, and the distance to cross is short of divided into shorter segments with refuge islands.
- **Clear crossing**—The crosswalk is free of barriers, obstacles, hazards, and is accessible. Pedestrian crossing information is in accessible formats.

Intersections should be designed as compact as practical in urban areas. Design features that can enhance the safety and functionality if intersections (signalized and unsignalized) are described below.

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83 Traffic Engineering Council Committee TENC-5A-5*, Design and Safety of Pedestrian Facilities: A Recommended Practice of the Institute of Transportation Engineers*, Institute of Transportation Engineers, Washington, D.C., March 1998.

84 *Guide for the Planning, Design, and Operation of Pedestrian Facilities*, American Association of State Highway and Transportation Official, July 2004.

The Transportation Association of Canada provides guidelines for the design of intersections in their *Geometric Design Guide for Canadian Roads*. The focus of these guidelines is accommodating motor vehicles. There is a lack of guidance provided regarding design elements for, and/or affecting pedestrians. The development of guidelines for pedestrian on Canadian roads is needed.

9.3.4 Crosswalk Markings

Crosswalk markings should only be provided in locations (generally intersections) where motor vehicle traffic is controlled by a traffic control signal, stop sign, yield sign or school crossing guard.

A traffic control signal does not necessarily provide safety for a pedestrian obeying the signal, especially when the pedestrian is crossing a lane with a permitted vehicular crossing movement, such as a permissive left turn on a green light or a right turn on a red light. Studies completed by the Region of Waterloo*(85)* determined that:

- A crosswalk that is poorly defined can result in 4 to 10 times more vehicle/pedestrian conflicts.
- When drivers can see the crosswalk better, they seem more likely to respect the crosswalk as pedestrian space.

Not all crosswalks are visible to both pedestrians and motorists. Examples of the visibility of crosswalks are illustrated in **Figure 9.10**.

85 Button, N., *Crosswalk Visibility and Pedestrian Safety,* Region of Waterloo Report E-05-069, June 14, 2005.

Figure 9.10

The pedestrian and motorists' view of various crosswalk treatments.

What the pedestrian sees...

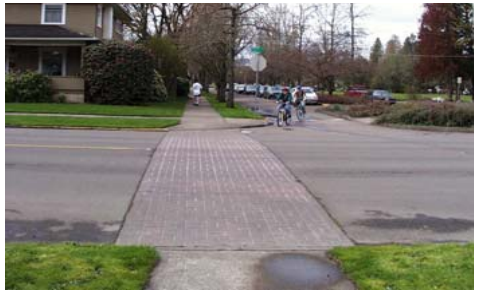
What the motorist sees...

Duratherm installation (Region of Waterloo) - Not Recommended

What the pedestrian sees...

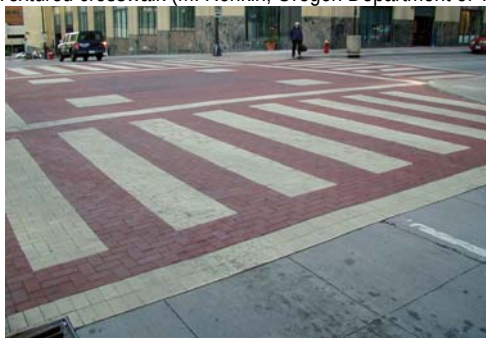
What the motorist sees...

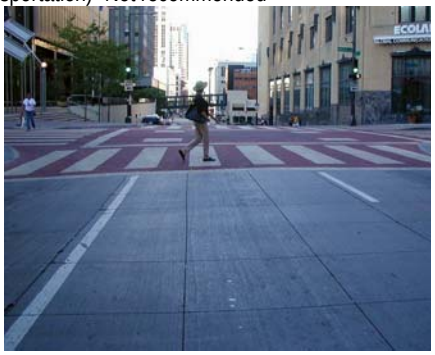
Coloured concrete (M. Ronkin, Oregon Department of Transportation)—Not recommended



Textured crosswalk (M. Ronkin, Oregon Department of Transportation)- Not recommended

Inlaid durable pavement marking, ladder pattern (Region of Waterloo)—Recommended





High contrast, textured crosswalk with ladder pattern (M. Ronkin, St. Paul, MN)—Recommended

The literature is consistent in recommending white horizontal lines (zebra, ladder or continental striping) as a means to make a crosswalk more visible. In New York City, the replacement of double line crosswalks with "ladder" markings reduced vehicle/pedestrian collisions by 42%.

The ladder crosswalk pavement marking consists of 60cm by 2.5m blocks spaced 60 cm outlined by 15 cm wide, transverse crosswalk lines. The *Ontario Traffic Manual* provides details for intersection and school zone crossings, which consist of two -15cm transverse lines spaced 2.5 to 5.0m apart. The ladder crosswalk includes the transverse lines but is more visible to drivers and has been shown to reduce vehicle/pedestrian conflicts.

In addition, they provide the following benefits:

- More visible to pedestrians with low vision by providing a larger area of contrast.
- Smoother surface for the mobility impaired to negotiate.
- More easily maintained than pavers. Pavers can heave because of settling or freezing. The asphalt abutting the concrete cradle is more likely to fail because of the different strengths of materials and water infiltrating between the concrete and the asphalt.
- More flexibility in the appropriate placement of inductive traffic loops. Loops cannot be placed under interlocking brick because of the concrete cradle.
- Easier to place around utility covers and values. To install pavers, a concrete cradle must be poured around utility covers and values. The concrete affects aesthetics and maintenance. The pavers may heave but the concrete will not creating tripping hazards.
- More easily installed, with minimal disruption to motorists. Installation of pavers requires each lane to be closed for 3 to 4 days. Installation of ladder crosswalks requires each lane to be closed for a few hours.
- Lower cost. The cost to install pavers at an intersection is around $50,000. The cost to install inlaid durable ladder pavement markings plus stop bars at an intersection is approximately $25,000.

Crosswalk treatments other than pavement markings must include the transverse crosswalk lines made from a retro-reflective material. Alternatively, the crosswalk pattern can incorporate a high-contrast ladder pattern with the retro-reflective transverse crosswalk lines. Ladder crosswalks are recommended for use where the pedestrian volumes warrant higher visibility of the crosswalks such as in downtowns and village centres, adjacent institutional campuses, and transit stations. They also may be used at intersections with high pedestrian collisions (minimum of 3 pedestrian collisions in 5 years). In addition, they are recommended at roundabouts to improve the visibility of crosswalks.

Currently in the City of Ottawa, zebra crosswalk pavement markings are applied only where field observations have identified a high frequency of conflict between pedestrian and motorists, such as in right-turning cut-off lanes at urban intersections. The purpose of these markings is to warn motorists that they are approaching a significant pedestrian crossing and, in many locations, that they should prepare to yield to pedestrians. Where the warrant criteria for the installation of zebra crosswalk pavement markings are not met, such as at intersections of residential roads, the implementation of such markings is strongly discouraged as the overuse of zebra markings may cause their effect on driver behaviour to become diminished.

Recommendation 9.2

It is recommended that the City:

Improve measures to reduce risks and improve accessibility for pedestrians passing through road construction zones including advanced signing for construction activities, temporary conditions that are fully accessible and pedestrian specific detours where appropriate.

9.3.5 Raised Pedestrian Crosswalks

The raised pedestrian crosswalk consists of a platform with an elevation approximately half way between that of road surface and nearby sidewalk. They serve as traffic calming measures by effectively extending the sidewalk across the road, and help to reduce vehicle speeds specifically where pedestrians will be crossing a street.

Experience shows that raised crosswalks should not impede transit service or scheduling. However, the location must take into consideration whether it is use as a primary emergency response route, and they may generate some noise from vehicle decelerating and accelerating.

Consideration for visually impaired persons dictates not placing the raised crosswalk at the same elevation as the sidewalk. Though the crosswalk is raised from the street surface, a pedestrian should also be able to tell when they are entering an area shared with automobiles. Appropriate curb ramps, detectable warning devices and visible crosswalk markings must be included in the design.

9.3.6 Curb Return Radii

The design of the curb return at intersections revolves around the choice of design vehicle (frequent or infrequent larger vehicles), the dimensions that make up the approaching and receiving lanes, and the curb radius itself *(86)*. Inadequate curb return radii should be avoided where large vehicles frequently turn that could potentially travel across the curb into the pedestrian waiting area at the intersection corner.

Current best practices include:

"More areas where older walkers would have services (i.e. washrooms) so they could go farther and longer"
Ottawa Resident

- 1.5 m radii at intersections in urban areas where no vehicles turn.
- 3 to 5 m radii at intersections where:
    - Pedestrian volumes are high.
    - Turning vehicle volumes are low and consist mainly of passenger cars.
    - The width of the receiving intersection approach can accommodate a turning passenger car vehicle without encroaching into the opposing lane.
    - Bicycle and parking lanes create additional space to accommodate the "effective" turning radius of vehicles.

86 *Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities: An ITE Proposed Recommended Practice*, Institute of Transportation Engineers, 2006

- Occasional encroachment of turning school bus, moving van, fire truck or oversized delivery truck into the opposing lane is acceptable, as radii less than 5m can be challenging for larger vehicles.
- Larger curb radii, determined based on the design vehicle effective turning radius, are required where:
    - Occasional encroachment of turning school bus, moving van, fire truck or oversized delivery truck into the opposing lane is not acceptable.
    - Curb extensions or bulb outs are proposed—the design of the curb extension is such that it narrows the adjacent travel lanes resulting in tighter turning radii that may not accommodate the design vehicle that the intersection was originally designed to handle.
    - The receiving lane is less than 3.65 m in width and is not adjacent to on-street parking or a bicycle lane.
- Consideration should be given to the installation of a channelized right-turn lane if the corner radius exceeds 15.0m, or implementation of 2 or 3-centred compound curves to accommodate large trucks (*87*). Note that TAC recommends 2 and 3 centred curves for large trucks and channelized right-turn lanes for larger corner radii but a threshold, such as 15.0m, is not provided.

9.3.7 Roadway Narrowings

Road narrowings, sometimes also referred to as “bulb-outs” are horizontal intrusions of the curb into the roadway. The reduction in the path of travel width for vehicles can improve the pedestrian environment and improve driver behaviour.. Narrowings reduce pedestrian crossing distance, improve sight distance and sight lines for both pedestrian and motorists, prevent parked cars from encroaching on the crosswalk, and create additional space for curb ramps and landings where the existing sidewalk space is narrow. Research also suggests that narrowings can reduce vehicle speeds by 2 to 5km/h*(88.).* Curbs can be extended on one or both sides of a roadway to reduce its width to as little as 6.0m for two-way traffic.

The City of Ottawa *Area Traffic Management Guidelines* recommend several types of narrowings that can be implemented. These include intersection narrowings, mid-block narrowings, and centre island narrowings (centre medians). Intersection narrowings in particular, are applicable at intersections on roadways with on-street parking. Provided that it does not obstruct sight lines for pedestrians or motorists, low level landscaping can be provided to make them more conspicuous. Care must be taken to design the curb return radii to fit the path of the design vehicle so that the rear wheels of large vehicles do not track into the pedestrian space. This is especially important when applying narrowings on major roadways, particularly in proximity to signalized intersections and locations with significant vehicle turning movements.

87 *Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities: An ITE Proposed Recommended Practice*, Institute of Transportation Engineers, 2006

88 *Canadian Guide to Neighbourhood Traffic Calming*, Transportation Association of Canada and Institute of Transportation Engineers, 1998.

9.3.8 Channelized Right-turn Lanes (Ottawa's Urban Smart Channel)

In looking for an alternative design for channelized right-turn lanes that are more pedestrian friendly and support improved traffic operation, the City is currently piloting an Urban Smart Channel concept. This concept varies from traditional channelized right–turn lanes that are more sweeping, have higher free flow speeds and have a low adjacent road entry angle.

Within this pilot the desired objectives of the Urban Smart Channel are to;

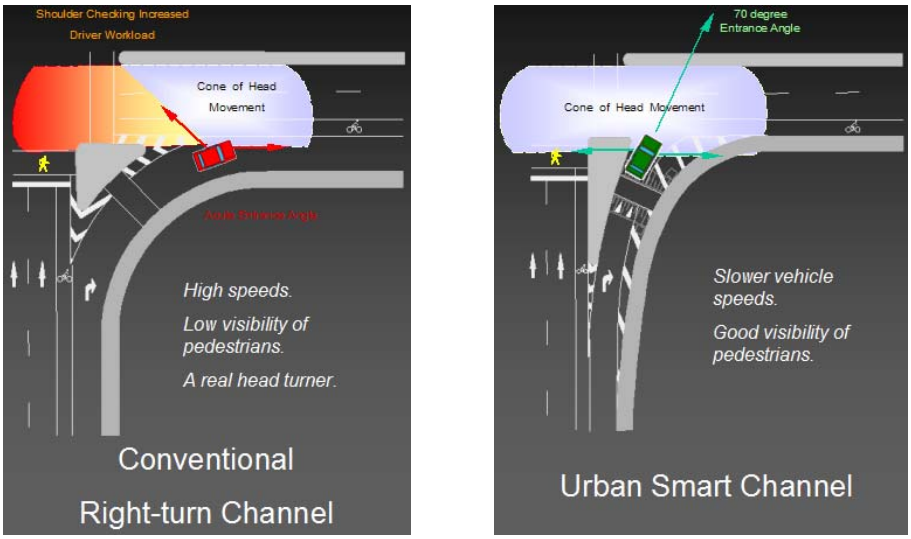
- Reduce driver workload by reducing the angle of shoulder check and entry,
- Improve visibility of pedestrians by reducing viewing angle, and
- Reduce turning speed to be more consistent with yield conditions that may require a full stop.

Channelized right-turn lanes at signalized intersections are implemented to increase intersection efficiency and reduce unnecessary delay and idling emissions where higher right-turn traffic volumes exist. An incorporated pedestrian-friendly design can reduce the pedestrian crossing distance under signal control resulting in shorter exposure distance, shorter signal cycles, and reduced potential for pedestrians to be in conflict with vehicles.

The Smart Channel concept was derived from a proposed right-turn slip-lane design identified in a Federal Highway Administration (FHWA) Research and Development study report entitled Pedestrian Facilities Users Guide (Report No. FHWA-RD-01-102). This report identified a modified channel design that responded to pedestrian issues. Further to this design concept, raised pedestrian crossings in the channel and yield and crossing markings and geometrics that are inline with roundabout design, were incorporated and are included in the pilot for evaluation.

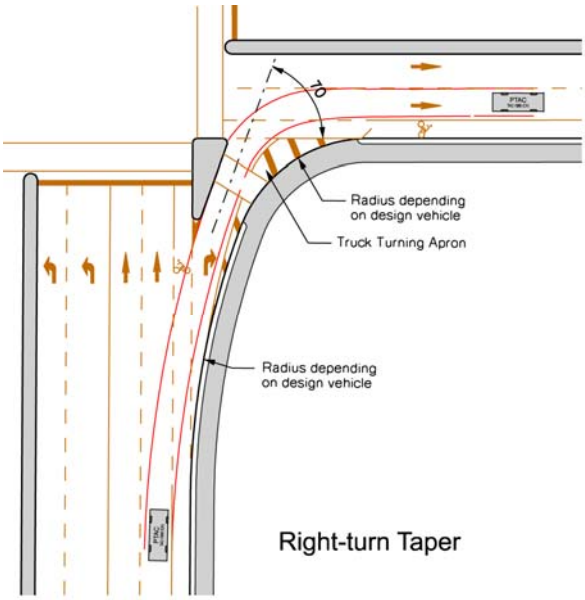
The Urban Smart Channel as designed for slower vehicle speeds, improved entry angle sight lines, improved visibility of pedestrians and pedestrian crossing improvements, is illustrated in **Figures 9.11 and 9.12**.

Figure 9.11
Channelized right-turn lane designed for pedestrians compared to the conventional design



Source: City of Ottawa

Figure 9.12
Details of the pedestrian-friendly channelized right-turn lane



Source: City of Ottawa

9.3.8.1 Auxiliary Left and Right-Turn Lanes

Studies have shown that left-turn lanes can reduce collisions at intersections. Both right- and left-turn lanes are implemented to improve traffic flow based on volume warrants. The addition of right- or left-turn lanes to an intersection will

also increase the pedestrian crossing distance and exposure. The application of multi-right or left-turn lanes can further increase the pedestrian crossing distance. However, signal phasing can be utilized to establish a separate "protected" pedestrian phase offering greater benefit to pedestrian safety. Multiple–right and left-turn lanes should be used with discretion and opportunities for utilizing signal timing for the advantage of pedestrian movement should be maximized. The "urban smart channel" can be implemented, as previously discussed, when right-turn traffic voumes are high.

9.3.9 Traffic Signal Phasing

Traffic signal phasing methods can be utilized to address conflicts experienced by pedestrians crossing within the right of way. Two signal timing phases have been considered and include:

"The timing of lights at intersections. They are timed for cars not pedestrians."
Ottawa Resident

- Where there are conflicts occurring between crossing pedestrians and left-turn traffic, provide a **protected (exclusive) left-turn signal phases only**, i.e., left-turning traffic can only proceed on the "GREEN ARROW" signal and are not permitted during the "GREEN BALL" phase. The pedestrian phase is not permitted during the protected left-turn phase. Some delay is experienced by the pedestrian waiting for the protected left-turn phase to end before crossing and by the left-turning driver not permitted to proceed during the "GREEN BALL" phase. However, the conflict with left-turning traffic during the pedestrian phase is eliminated.
- Where there are conflicts occurring between crossing pedestrians and right-turn traffic, provide a **leading pedestrian interval (LPI)**, i.e., the pedestrian is allowed to begin crossing before motorists on the parallel street are given the "GREEN BALL" phase. Two case studies in the US*(89)* indicate that the LPI increased the visibility of pedestrians crossing the crosswalk, and conflicts were virtually eliminated for pedestrians departing during the start of the "WALK" phase and reduced during the remainder of the "WALK" phase. The reduction of the pedestrian/motorist conflicts during the beginning of the "WALK" phase improved the vehicular level of service despite the decrease in green time for vehicles. Warrants would be required to determine when the application of an LPI is appropriate.
- Where the volume of pedestrians is so high that it blocks turning traffic during the entire "GREEN" signal phase, an exclusive pedestrian phase can be introduced. During this phase, all vehicles are stopped on all approaches to the intersection, allowing pedestrians to cross the intersection either diagonally or conventionally. Commonly referred to as a "Pedestrian Scramble" signal, this type of phasing may require the addition of pavement markings and signs to communicate that crossing diagonally is permitted. Pedestrian signal heads are installed facing the diagonal crossing direction. A case study in Beverly Hills, CA *(90)* indicated that pedestrians and motorists became accustomed to the new phasing quickly, the level of service at 6 of the 8 intersections tested remained within acceptable levels, and collisions between vehicles and pedestrians decreased from 18 to 6. The City of Toronto recently implemented a pilot pedestrian scramble at a very busy intersection in the midtown area and are studying the benefits and drawbacks of this

89 http://www.walkinginfo.org/pedsafe/casestudy.cfm?CS_NUM=65 and http://www.walkinginfo.org/pedsafe/casestudy.cfm?CS_NUM=66

90 http://www.walkinginfo.org/pedsafe/casestudy.cfm?CS_NUM=23

type of pedestrian crossing. Although it provides for more efficient crossing for most pedestrians, some users such as the visually impaired report some concerns as the path of travel is not as clearly defined as with a more conventional pedestrian crosswalk.

9.3.10 Pedestrian Countdown Signals

Pedestrian countdown signals (**Figure 9.13**) provide a numeric countdown display that indicates the number of seconds remaining for a pedestrian to complete the crossing of a street. The countdown marks the length of time between the current "WALK" signal and the solid "DON'T WALK" signal (during the flashing "DON'T WALK" signal).

In October 2008, Council approved the installation of pedestrian countdown signals at new traffic control signals and pedestrian signals being rehabilitated as part of a capital reconstruction projects. The ultimate goal of this initiative is to install pedestrian countdown signals at all signalized intersections over a period of 10 years. Priority will be given to locations where there are at least four lanes of traffic and/or at locations where a high percentage of the pedestrians are children, seniors, or mobility challenged. *(91)*

91 http://www.ottawa.ca/calendar/ottawa/citycouncil/occ/2008/10-22/trc/ACS2008-PWS-TRF-0027.htm

Figure 9.13
Pedestrian countdown signal

Pedestrian countdown signal head with the flashing "DON'T WALK" hand above the seconds remaining until the solid "DON'T WALK Location: Guelph, ON. Source MMM Group

Two cases studies in the US*(92)* note that most people misinterpret the meaning of the flashing "DON'T WALK" hand of the signal. According to previous studies, most people think that it means to hurry up or to turn back to the sidewalk, instead of not to initiate crossing if not already in the crosswalk. In Monterey, CA, of those pedestrians interviewed, 87% said that having the pedestrian countdown device helped in understanding the pedestrian signals. The countdown signal was found to discourage some pedestrians from crossing with few seconds left. In San Francisco, CA, 78% found them helpful compared to 34% who found the conventional pedestrian signals helpful. The number of pedestrians who finished crossing on red dropped from 14 to 9% at 8 intersections, the number pf pedestrians running or aborting their crossing decreased from 13% to 8%, and observed vehicle/pedestrian conflicts dropped from 6% to 4%.

The City of Toronto reported in 2007*(93)* that pedestrian countdown signals were installed at more than 250 intersections in the city and another 540 intersections will be equipped with the signals over the next nine months.

92 http://www.walkinginfo.org/pedsafe/casestudy.cfm?CS_NUM=62 and http://www.walkinginfo.org/pedsafe/casestudy.cfm?CS_NUM=63

93 http://www.toronto.ca/city_initiatives/cityupdate2007.htm

It was noted by the City of Toronto and the City of San Francisco that the incremental cost of adding pedestrian countdown signals when replacing pedestrian signals with more energy-efficient LED (Light Emitting Diode) versions is very small.

9.3.11 Intersection Pedestrian Signals

The intersection pedestrian signal (IPS) provides a device to assist pedestrians crossing major streets. The IPS includes:

- Standard traffic signal indications to control traffic on the major street.
- Standard pedestrian "Walk" and "Don't Walk" indications, activated by push buttons, for pedestrians wishing to cross the major street.
- Stop signs for vehicles approaching the intersection from the minor street.

The IPS system is distinctly different from a standard traffic signal in two ways:

1. The traffic signal poles and pedestrian indicators are all located on one leg of the intersection and pedestrians are only permitted to cross at that location.
2. The traffic approaching from the side streets is controlled by a STOP sign, as opposed to a traffic signal.

Vehicles approaching from the side street will be permitted to turn onto the main street only when it is clear and safe to do so, yielding the right-of-way to both pedestrians crossing the main street as well as vehicles traveling along the main street.

The IPS is a more positive and effective pedestrian crossing device than a pedestrian crossover (PXO). It is also significantly less expensive to install and maintain compared to a full traffic signal. Although widely used in Western Canada, the IPS is relatively new to the Province of Ontario. The Ministry of Transportation of Ontario has allowed the use of IPS's across Ontario.

The City of Ottawa undertakes investigations of intersections and mid-block sections to determine the need for pedestrian signals if the minimum warrants are satisfied as defined in the Ontario Traffic Manual. An eight hour pedestrian and cyclist survey is conducted and collision data is reviewed. Pedestrians and cyclists are counted by type of person (child, youth, senior) and by delay to these persons in crossing the subject roadway. The highest six hours of collected data is tested against the pedestrian signal warrants*(94)*.

Both of the following warrants must be fully satisfied before a location can be recommended for a pedestrian signal.

1. **Minimum Pedestrian Crossing Volume Warrant:** The total of the highest six-hour pedestrian volume crossing the major road at an intersection or mid-block location meets or exceeds the minimum value required based on the 12-hour vehicular traffic volume on the major road.
2. **Minimum Pedestrian Delay Warrant:** The total of the highest six-hour volume of pedestrians experiencing delays of 10 seconds or more in crossing the road meets or exceeds the minimum value required based on the six hour volume of pedestrian crossing volume of the volume warrant.

The process to install a pedestrian signal includes consultation. The Ward Councillor is consulted for all locations that prove warranted. If roadway modifications are required, public notification/consultation is conducted as set out

94 http://ottawa.ca/residents/onthemove/driving/traffic/programs/ped_signal_program/index_en.html

by the Ontario Municipal Act. Subsequent public consultations will be held if geometric changes to the intersection or an impact on local traffic movements are anticipated Council approval, through the capital budget process, is required for all installations.

9.3.12 Pedestrian Refuge Islands

Pedestrian refuge islands are medians that are placed in the centre of the roadway separating opposing lanes of traffic (**Figure 9.14**). They allow pedestrians to cross one direction of traffic at a time, with a location in the centre of the roadway to wait for a gap in traffic for the other direction. They are well suited for roadways with four or more lanes of traffic, since pedestrians (particularly young children and older adults) can have difficulty selecting a suitable gap in traffic for broad, multi-lane roads as compared to roads with only two lanes of traffic.

A number of jurisdictions have implemented Pedestrian Refuge Islands. The following are two specific examples to illustrate some principles being used to determine their location and design.

The Region of Waterloo has prepared design guidelines and warrants for pedestrian refuge islands *(95)*. Two warrants are used:

- **Locations requiring road widening to accommodate the island**—for urban roadways where the nearest controlled crossing is more than 500 m away, and seniors or school children (JK to G8) are crossing the roadway. The Ontario Traffic Manual justification for pedestrian signals is used as the basis for the pedestrian refuge island warrant.
- **Locations that do not require road widening**—when the asphalt width and lane configuration can accommodate the island. Typical locations include T-intersections where there is a “runout” lane opposing the left-turn lane, and roadways with a two-way, left-turn lane or a painted median. The warrant for the pedestrian refuge island is based on the presence of a pedestrian-related land use such as a school, seniors' facility, hospital, transit stop, shopping mall or pathway crossing, and the island not blocking driveways or interfering with turning movements on the roadway.

The City of Toronto’s warrant for a pedestrian refuge island on roadways that are more than 16.4 m in width and less than five travel lanes is more than 100 pedestrians in 8 hours.

Guidelines for the typical design elements for a pedestrian refuge island are as follows *(96)*:

- Islands are typically a minimum of 6 m in length.
- Island width should be at least 1.8 m wide, but 2.4 m is preferred to accommodate wheelchairs in a level landing 1.2 m wide plus 0.6 m wide tactile warning devices on each side. The 2.4 m width will also accommodate bicycles in the refuge.
- Curb ramps are provided to allow access to the roadway and island for wheelchair users, and detectable warning devices (0.6 m in width) are required at the bottom of the curb ramps.

95 Region of Waterloo, *Transportation Engineering Practice: The Blue Book*

96 Traffic Engineering Council Committee TENC-5A-5*, Design and Safety of Pedestrian Facilities: A Recommended Practice of the Institute of Transportation Engineers*, Institute of Transportation Engineers, Washington, D.C., March 1998.

- The pathway on the island is constructed of concrete, not asphalt. The visually impaired can better detect the change in texture and contrast in colour supplemented by the detectable warning devices to locate the refuge island.
- Appropriate tapers are required to diverge traffic around the island based on the design speed of the roadway.
- The pathway on the island can be angled so that pedestrians are able to view on-coming traffic as they approach the crossing.
- Illumination should be provided on both sides of the crossing.
- Signage associated with the pedestrian refuge island includes “Keep Right” and “Object Marker” warning signs installed on the island facing traffic, and “Pedestrian Crossing Ahead” warning signs installed on the roadway approaching the crossing. “Wait for Gap” warning signs can be installed on the far side of the crossing and on the refuge island if pedestrians are failing to cross in a safe manner.
- Crosswalk markings are not provided unless the crossing is at an intersection controlled by signals, stop, yield or controlled by a school crossing guard.
- Railings on the island to control pedestrian access are not recommended because they are a hazard in potential collisions (spearing of driver or pedestrian). Some pedestrians will walk in front of or behind the island to avoid the railings, a less safe refuge location than on the island.

Figure 9.14
Raised median island on a residential collector

Raised median island on a residential collector street at a pathway crossing and park access Location: Guelph, ON. Source: Stantec

9.3.13 Freeway Ramps

The intersection between freeway ramps (entrance and exit ramps) and urban streets can create opportunities for conflict between pedestrians and vehicles. These intersections are often designed for high-speed, free-flow movements to/from the freeway. As with intersections, design features should be

implemented to slow traffic and increase visibility to facilitate convenient and safe pedestrian crossings. Through dialogue with the Ministry of Transportation (MTO), “Smart Channel” design principles could be considered at freeway ramp locations in Ottawa that are under MTO jurisdiction. This aspect of pedestrian-vehicle conflict is not well studied..

9.3.14 Roundabouts

Roundabouts are a form of circular intersection with yield controls for entering traffic, and geometric design features that slow traffic approaching and traveling though the roundabout. There are many benefits to single-lane roundabouts (replacing all-way stop-controlled intersections) and multi-lane roundabouts (replacing signalized intersections) such as reduced vehicle speed through the intersections, reduced starts and stops and increased capacity.

Ottawa has implemented several Roundabouts in both urban and rural areas (see Ottawa.ca).

The vehicles approaching the crosswalk at a roundabout are under yield control. The design of the roundabout includes the following features to facilitate the pedestrian crossing:

- The roundabout is designed to slow the speed of approaching motorists.
- Splitter islands on each approach to the roundabout provide a pedestrian refuge between crossing the entering and exiting traffic. The splitter island design must include the same features as pedestrian refuge islands, i.e., curb ramps, detectable warning devices, minimum width at the refuge area, concrete pathway through the island, signage and illumination.
- The crosswalk and splitter island pedestrian refuge are located one passenger car length behind the yield line at the roundabout.
- The crosswalk and curb ramps are situated perpendicular to the outside curb of the entry and exit approaches.
- Motorists and cyclists have a clear view and can easily see pedestrians at crosswalk locations.
- Crossing may be easier and safer as crossing distances are shorter, and pedestrians have to cross one direction of traffic at a time
- The crosswalk may be marked with the ladder pavement marking to increase its visibility to motorists.

Even though pedestrians have the right of way at the entry and exit points for roundabouts, there are still concerns with compliance of motorists particularly for pedestrians with visual impairments at multi-lane entry / exit roundabouts (*97*). In January, 2009, the Region of Waterloo launched its “*2009 Roundabout Education Campaign”,* which focuses on educating pedestrians on the correct way of crossing at roundabouts. The Region of Waterloo currently has 11 roundabouts on Regional roads, plus two more approved for 2009, and have have carried out pilot sites with new “yield to pedestrian signs” and are report some positive initial success with these.

Two other types of circulatory intersections include:

97 http://www.region.waterloo.on.ca/web/region.nsf/$All/4E8F02481CB1BAA98525754C00793B0C?OpenDocument

- The old-style rotaries, similar to the one at Prince of Wales Drive and the NCC laneway (before design modifications), often are large in radii and operate based on the "yield to the right" traffic rules, i.e. circulating traffic yields to entering traffic. These are unpleasant for pedestrians to cross because entering traffic not only travels at higher speeds but does not yield upon entering or existing. The pedestrian must select a large gap in traffic to cross the approach. Many are being replaced by modern roundabout designs.
- Neighbourhood traffic circles are typically installed at the intersection of local streets to slow traffic and replace two-way and four-way stop controlled intersections. Unlike rotaries, traffic yields before entering the intersection to traffic already in the intersection (circulating the central island). If implemented in series, these can have an effect of lowering overall traffic speeds through a neighbourhood, while stop signs tend to lead to a "sudden stop, speed up" behaviour. With the lower operating speeds comes the associated lower risk to pedestrians. Crosswalks can be provided at the yield signs on each approach.

It is more difficult for pedestrians with visual impairments to choose a gap in traffic at roundabouts, particularly ones with multiple lane entries and exits. The US Transportation Research Board is conducting a project to identify a range of geometric designs, traffic control devices, and other treatments that will make pedestrian crossings at roundabouts and channelized turn lanes useable by pedestrians with vision impairment*(98)*.The research is expected to be completed by 2009.

9.3.15 Grade-separated Crossings

Grade-separated crossings allow pedestrians to cross motor vehicle flows at a different level, eliminating pedestrian/vehicle conflicts. These structures can also reduce delay for vehicle operators, pedestrians and cyclists. Grade-separated crossings consist of pedestrian pathway overpasses or bridges, and pedestrian tunnels or underpasses, but also elevated walkways or skywalks and underground walkways.

Ottawa

Most pedestrians will seek to cross a highway at-grade unless a grade-separated facility is perceived to be more convenient and direct than the nearest at-grade-separated crossing. The degree to which a grade-separated crossing is used depends on the walking distance and convenience of the facility*(99)*. For example, 95% of pedestrians would use an underpass and 70% would use an overpass if the travel time were equal to the crossing time at-grade. However, if it took 50% longer to cross than at grade, very few pedestrians would use the grade-separated facility. As a result, the construction of grade crossings should be limited to locations where traffic volumes provide insufficient gaps to permit safe crossing of the highway, or where the presence of roadway cuts or fill make construction of a pedestrian crossing both less expensive and more convenient for use.

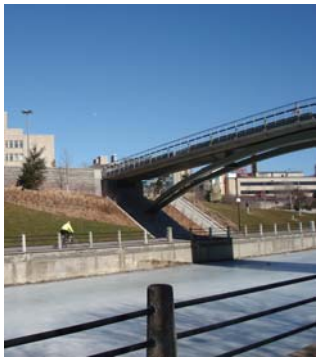
The warrants in **Table 9.1** *(100)* can guide designers on locations where pedestrian structures should be provided on **existing highways**. On new

98 Transportation Research Board, National Cooperative Highway Research Program, *Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities*: NCHRP Project 3-78.

99 Moore, R.I. and Older, S.J., Pedestrians *and Motors are Compatible in Today's' World*, Traffic Engineering, Institute of Transportation Engineers, Washington, D.C., September 1965

100 *Pedestrian Compatible Planning and Design Guidelines*, New Jersey Department of Transportation

highways, greater opportunities are available for adjusting roadway grades to facilitate overpass or underpass construction. The warrants are, therefore, inappropriate for new construction or major reconstruction which includes substantial grading work.



Ottawa

Table 9.1
Warrant for pedestrian over or underpass on existing highways

Facility Type	Pedestrian Volume Total for 4 Hours	Vehicular Volume	
		Same 4 Hours	AADT[1]
Freeway	100	7,500	25,000
Arterial	300	10,000	35,000

1. AADT = Average Annual Daily Traffic

Pedestrian over or underpasses may also be warranted where either the vehicular or pedestrian volume is slightly less than the amount shown, but the other volume is substantially greater. In addition, a grade-separated pedestrian crossing is justified any time that a safety evaluation of a pedestrian crossing has determined that erection of a fence to prohibit pedestrian crossings is required. A warrant (criteria) would be required to determine where the application would be appropriate.

Whenever designers feel that measures must be introduced to discourage at-grade pedestrian crossings, a companion project should be programmed to provide an alternative safe crossing on an expedited schedule.

In most situations, a pedestrian structure should not be constructed if a reasonable at-grade crossing is available within 180 meters. A reasonable at-grade crossing could be a signal controlled intersection, a mid-block location with a signal control, or another grade-separated crossing. A grade-separated crossing may still be appropriate despite the availability of a nearby crossing if the pedestrian demand is substantially greater than the minimum required for the warrant, or if grade differences make installation of an over or underpass especially convenient. Grade-separated crossings would be especially appropriate on college or university campuses, at crossings linking recreation areas and schools, at major activity centres, adjacent to transit terminals and major stops, and unique sites having very high and concentrated pedestrian flows.

The design of the grade-separated crossing must take into account accessibility requirements, specific site conditions, and design elements to enhance safety and security such as lighting, aesthetics and ease of use.

9.3.16 Audible Pedestrian Signals

Audible pedestrian signals (APS) provide a service to the visually impaired pedestrian who find it difficult to cross roads at signalized intersections. They provide users with information on when they have the right-of-way to cross a street, and in which direction they may cross an intersection.

The visually impaired pedestrian has to determine *(101)*:

1. Am I at an intersection?
2. What controls traffic flow at this intersection?
3. Has the pedestrian (WALK) interval started?

101 The Canadian National Institute for the Blind, *CNIB Position for Accessible Pedestrian Signals in Canada,* October 15, 2003

They rely on the sound or sense of traffic to identify a time when traffic has stopped and crossing the street is possible. This is difficult when traffic volumes are low or there is an advance green signal phase is provided for left-turning traffic. They may also delay the start of their crossing, relying on the surge of traffic as a cue, and not complete the crossing within WALK/Flashing DON'T WALK interval.

The ideal intersection geometry and operational characteristics for someone who is visually impaired is:

- Four legs;
- Intersecting at right angles;
- No more than two lanes in each direction, and;
- Crosswalks free of any obstacles.
- Signals that operate in a fixed time mode with two-phases and no advance turn phases, and
- A surge of traffic moving through the intersection at the beginning of each phase.

The geometry and operation of signalized intersections can vary greatly from one location to another. The City of Toronto has identified issues that affect the ability to install APS *(102)*. Operational issues include sound pollution due to malfunctioning APS's, complex signal phasing (two-phase crossings, split phase, leading pedestrian interval, pedestrian scramble phase), wide intersections, right/left-turn phasing, intersection construction, and controller/cabinet limitations. Geometric issues include right-turn channelization, skewed intersections, multi-leg intersections, median islands, pedestrian crossing prohibitions, and pushbutton and pole location/orientation.

Although solutions to some of these issues exist, there will always be intersections that will be difficult for installing APS. Some intersections may require major design and reconstruction and/or revised signal operational approach. Some locations may not be able to accommodate APS.

There are currently 313 intersections in the City of Ottawa equipped with APS and this number increases yearly. There are two different sets of signals: bird sounds; and bells and buzzers. The bells and buzzers are gradually being phased out and being replaced with the bird tones, a "cuckoo" for north-south crossings and a "peep peep" tone for east-west crossings. Pedestrians must push and hold the pedestrian signal activation buttons located on the poles for 5 seconds in order to activate the audible portion of the pedestrian display. This delay feature is designed to minimize complaints from nearby homeowners regarding noise generated by the devices. Intersections equipped with APS are listed on the City's web site*(103)*.

Canadian National Institute for the Blind (CNIB) recommends that the installation of APS be a priority at signalized intersections with the following characteristics:

- Pedestrian-activated WALK signal;
- Lead pedestrian phase;
- Advance left-turn phase;
- Mid-block crossings, and;

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102 Lee, Linda, *Toronto's Experience with Audible Pedestrian Signals: Operational and Design Challenges*, CITE 2007 Conference Abstracts.

103 http://www.ottawa.ca/residents/onthemove/driving/road_safety/ped_cycle/audible/index_en.html

- T-intersections.

The CNIB also supports an implementation strategy that includes APS in all new and rebuilt traffic control signal installations.

The Transportation Association of Canada (TAC) is currently undertaking a project *Accessible Pedestrian Signals—National Guidelines for the Understanding, Use and Implementation*. The current Canadian standard for APS was adopted in 1991 by TAC in the *Manual of Uniform Traffic Control Devices for Canada*. The objective of this project is to update the current national guidelines for the use and installation of accessible pedestrian signals. The guidelines are expected to be completed in 2007. There are currently over 300 intersections equipped with APS in the City of Ottawa. The City currently installs APS at all newly signalized intersections, as well as at existing signals where major road rehabilitation projects are taking place. As a result, approximately 30 new signals are installed every year. In addition, approximately 10 intersections are retrofitted each year with audible pedestrian indicators. These are located where specific requests have been made for an audible signal. Through the *City of Ottawa Municipal Accessibility Plan*, the implementation and design strategies for APS will continue to progress to create pedestrian crossings that are fully accessible to the visually impaired.

9.4 Pedestrian Safety in Work Zones

Ottawa

Planning for the safety and movement of pedestrians through construction zones is as important as planning for vehicular movement, and should be considered an integral part of the construction staging and traffic management plan for any project. The Institute of Transportation Engineers' (ITE) manual for *Design and Safety of Pedestrian Facilities (104)* and the American Association of State Highway and Transportation Officials' (AASHTO) *Guide for the Planning. Design and Operation of Pedestrian Facilities (105)* provide guidelines for the development, management and monitoring of pedestrian walkways through construction zones. The *Ontario Traffic Manual Book 7: Temporary Conditions* provides guidelines and requirements in the Ontario context and is used by the City of Ottawa.

The plan details for safe pedestrian movement through or along side active construction zones vary depending on the proximity of the pedestrian route to the active construction zone, the type and duration of construction and the volume of pedestrian traffic expected. Three important principles must be considered in the development of an appropriate plan:

- Separate pedestrians from conflicts with work site vehicles, equipment and operations.
- Separate pedestrians from conflicts with the main flow of vehicular traffic moving through, around or along side the work site.

104 Donaldson. G.A., in *Design and Safety of Pedestrian Facilities: A Recommended Practice of the Institute of Transportation Engineers*, March 1998.

105 American Association of State Highway and Transportation Officials. *Guide for the Planning, Design and Operation of Pedestrian Facilities*, July 2004.

- Provide pedestrians with a safe, accessible and convenient route that duplicates as nearly as possible the most desirable characteristics of sidewalks or pathways.

Completely closing the sidewalk/pathway and forcing pedestrians to use the opposite side of the street should be considered as a last resort. The following are some details to be considered when designing for pedestrians through work zones:

9.4.1 Temporary Sidewalk/Temporary Route Design

- Temporary sidewalks/temporary routes should be clearly identified, safe, accessible and convenient.
- If a parking or travel lane next to a worksite will be temporarily out of service during construction, pedestrians can be directed to use this space provided that the temporary route is clearly defined and properly separated from adjacent vehicular traffic (**Figure 9.15**).
- The wide ranging needs of pedestrians must be considered when developing plans for the temporary sidewalk/temporary route through or along side construction zones (i.e. various levels of mobility, visual and hearing impairments etc.).
- The temporary sidewalk/temporary route must be protected from motor vehicle traffic, be as level as possible, and free from pedestrian hazards such as holes, debris, obstacles abrupt changes in grade, standing water and mud.
- Where additional materials are required to create the temporary route, pedestrian volume and the anticipated length of the construction period should be considered when making selections. Typical materials include properly compacted earth, gravel, asphalt, concrete, wood, or steel plates. Slip resistance should be considered when selecting a temporary surface material.
- Objects that are a potential trip hazard should be clearly marked and detectable with a cane.
- A minimum width of 1.5m should be provided (1.8m is desireable). Where pedestrian volumes are high, a wider temporary sidewalk/temporary route is necessary.
- During winter months, temporary sidewalks/routes must be maintained to a 1.8m width.
- If it is not possible to accommodate the pedestrian route on the same side of the street as the construction (i.e. where the pedestrian sidewalk/pathway is/was prior to construction), then pedestrians should be directed to use the opposite side of the street. In this case, signing should be placed in advance of the intersections closest to either end of the construction zone, allowing pedestrians to cross at an intersection prior to entering the construction zone. It is not reasonable to assume that a pedestrian will retrace their steps back to an intersection to cross; More often than not they will attempt a mid block crossing, which may be especially inappropriate on busy multi-lane roads.

Figure 9.15
Designated pedestrian travel route through an active construction zone

Location: Toronto, ON. Source: Stantec

9.4.2 Barriers and Barricades

- Simple pedestrian barricades to separate pedestrians from the work area are acceptable so long as they are not also being used for vehicular traffic control, then traffic cones, markers, flexible drums, barricades or barriers would be required as per OTM Book 7. It is necessary to ensure that the barricade is clearly marked and detectable by a cane.
- Ensure that there are no objects protruding into the walkway zone (i.e. from scaffolding, signs etc.). This is especially important for objects at eye level/head height.
- For long duration construction sites in areas of high pedestrian traffic a lit, canopied walkway should be considered, especially if the danger of falling objects and debris from overhead work is a possibility.
- Protective barriers may be needed to prevent pedestrians from entering into the work site. This is especially important near schools where children may be tempted to take short cuts and/or enter construction sites to satisfy curiosity. Protective barriers should be sturdy and non-climbable. High fencing (2.4m or greater) should be installed in areas of high pedestrian activity to separate pedestrians from construction activity.
- There are no regulatory requirements in OTM Book 7 on pedestrian barricades. It only recommends that the pedestrian pathway should be clearly defined, and the top of the pedestrian barricade be approximately 1.0m above the surface on which it is installed.

9.4.3 Monitoring

- The designated route/walkway must not be used for storage of construction equipment, materials, or vehicles. Furthermore, stopping or parking of work vehicles along side the pedestrian pathway /walkway

should be discouraged as this may indirectly encourage the movement of workers, materials and equipment across the pedestrian path of travel.

- Crossings of the pedestrian route/walkway should be minimized. Where construction accesses must cross the pedestrian path of travel, signals, traffic control persons or police officers should be considered as a means to control movements. This is most important in high volume pedestrian zones and near locations that children and seniors frequent.
- Daily inspection of the pedestrian route/walkway is required. Modifications should be made to adapt to changes in the nature of the construction site, to further direct pedestrian movement where the route is not functioning as planned or where unanticipated conflict points are observed. Good engineering judgment should always be employed.

Recommendation 9.3

It is recommended that the City:

Review road and sidewalk maintenance standards, as an initiative under the City Strategic Plan, with a specific focus on levels of service and maintenance classifications based on the sidewalk's transportation role.

9.5 Using The Pedestrian Planning and Design Tools

The Ottawa Pedestrian Plan presents an array of tools that can be used at various stages of the planning and design continuum. Generally speaking these include the following

- The Community Design Plan Process.
- Community Pedestrian Improvement Process process and Methodology proposed in the Ottawa Pedestrian Plan.
- The Ottawa Pedestrian Plan Design Guidelines (recommendation 8.4).
- The Ottawa Pedestrian Plan Pedestrian Networks as illustrated in Schedules 1 through 17.
- Other Pedestrian Design Guidelines such as ITE's Promoting Sustainable Transportation Through Site Design.
- Walkability Audits, Checklists and Scorecards
- Ottawa's Sidewalk Design Guidelines.
- Ottawa's New Sidewalk Links Program.

Table 9.2 illustrates how each of these tools can be used either as a core resource or a supporting resource at various stages in the design continuum that spans wide scale community and land use planning through to the details of reconstruction of individual elements of the pedestrian network once they reach their lifespan.

Table 9.2
Using the pedestrian planning and design tools

	Pedestrian Planning and Design Tools							
Planning and Design Continuum	Community Design Plans	Community Pedestrian Improvement Process (process and Methodology	Ottawa Pedestrian Plan Design Guidelines	Other Guidelines (i.e. ITE, Promoting Sustainabel Transporation Through Site Design)	Walkability Audits Checklists and Scorecards	Ottawa Pedestrian Plan Network	New Sidewalk Links Prorogram	Ottawa Sidewalk Design Guidelines
Community and Land Use Planning	✓	●	●	●	●	✓	◆	◆
Subdivision Planning and Approvals	✓	✓	✓	●	●	✓	●	✓
Site Planning and Approvals	◆	●	✓	●	●	✓	●	✓
Development of the Ottawa Pedestrian Plan Netwtork	◆	◆	●	◆	◆	✓	✓	●
Construction and/or Reconstruction of City Roads	NA	✓	●	●	●	✓	✓	✓
Rehabilitation of Pedestrian Network Elements	◆	◆	✓	●	●	✓	●	●
Reconstruction of Pedestrian Network Elements	◆	✓	✓	●	●	●	●	✓
✓ = Primary resource		● = Secondary or supporting resource			◆ = Indirectly related			

9.6 Summary of Recommendations

It is recommended that the City:

9.1 Review design elements of sidewalks and street crossings to ensure that they meet accessibility and safety guidelines presented in the Pedestrian Plan.

9.2 Review warrants for ladder markings at pedestrian crossings for their application at locations such as school crossings, roundabouts (particularly multi-lane) and multiple right-turn and left-turn lanes.

9.3 Review road and sidewalk maintenance standards, as an initiative under the City Strategic Plan, with a specific focus on levels of service and maintenance classifications based on the sidewalk's transportation role.