



BRITISH
COLUMBIA

B.C. Community ROAD SAFETY TOOLKIT



Module 2:
Safe Roadway Designs to Protect All Road Users

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Disclaimer: This toolkit is designed to consolidate and disseminate knowledge about proven and promising road safety designs, strategies, and devices, rather than to provide technical knowledge. A strong effort was made to find and incorporate the most valid and reliable research about the various strategies in the toolkit. However, the nature of road safety research is such that knowledge on road safety continues to change, and therefore any claims drawn from the research should be approached with a critical mind. Local road authorities wishing to implement any designs, strategies, and devices in this toolkit should do so under the guidance of trained and professionally-certified engineers and experts.

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Module 2: Safe Roadway Designs to Protect All Road Users

Safe Roadway Designs to Protect All Road Users

This is the second module of the three-part BC Community Road Safety Toolkit. This module builds on the first by introducing roadway designs and traffic engineering strategies to improve the safety of all road users, including pedestrians, cyclists and motor vehicle occupants.

This module has a strong focus on roadway designs and strategies that help reduce driver speeds. Managing driver speed is critical because it is one of the basic risk factors affecting road safety. At faster speeds, drivers have less control and less time to react to other road users and hazards. When a crash does occur, the consequences are more severe due to the greater impact forces.

The module also focuses on intersection safety. According to data gathered by police, 27% of all motor vehicle crash deaths in British Columbia between 2006 and 2015 occurred at intersections. During this time, the annual number of road fatalities occurring at non-intersection locations has decreased steadily, while the number of fatalities at intersections has remained relatively steady. By making stronger efforts to build new safely-designed intersections and improving existing ones using a number of proven methods, the risk of serious injuries and fatalities at intersections can be reduced significantly.

Finally, this module introduces some designs and strategies to help improve safety for motor vehicle occupants and vulnerable road users, including pedestrians and cyclists, in road corridors.

In order to use this module, please see the Resource Kit section, which contains:

- Defined terms;
- Evidence of effectiveness for each safety design, strategy, or device in Module 2; and
- Further resources containing additional information on each item in Module 2.

This module should be read alongside *Module 1 – Protecting People Walking and Cycling*, which contains roadway designs that will complement those contained in this document and will help in improving safety for people walking and cycling.



Reducing Driver Speeds

Reducing driver speed is one of the most effective ways to improve road safety outcomes. By reducing speeds, the roadway designs and strategies contained in this section can help give road users more time to react safely to one another, provide drivers with greater control and reduce kinetic forces when crashes do occur.



Lowering of Speed Limits

Description

Reducing posted speed limits is one of the simplest and most cost-effective ways of reducing travel speeds. Speed limits of 50 km/h on most residential streets where there are pedestrians or cyclists are not consistent with research findings on safe speeds, or with best practices for speed management.

In many cities around the world, communities and road safety authorities have acknowledged that 50 km/h speed limits in these situations are unsafe. For example, “20’s Plenty for Us” is a non-profit organization in the United Kingdom that has successfully campaigned for 20 mph (32 km/h) default speed limits on residential and urban streets. Canadian cities such as Edmonton, Montreal, and Toronto have recently made systematic efforts to implement 30 km/h speed limits across wide zones.

Reducing Speed Limits in BC Municipalities

Under the provincial *Motor Vehicle Act* (MVA), the default speed limit for urban municipalities is 50 km/h, and 80 km/h for highways outside municipalities. This means that, unless otherwise posted, drivers must follow the default speed limits.

Under Section 146 of the MVA, municipalities may enact a bylaw that sets a different speed limit from the statutory default. The MVA requires that a speed limit sign be posted on each road with a reduced limit.

Evidence of Effectiveness

There is strong evidence that 30 km/h, speed limits in urban and suburban areas, where cars mix with pedestrians or cyclists, reduces motor vehicle crashes, fatalities, and injuries, and reduces injury severity when crashes occur. A study on reduced speed limits in London, England, found that after adjusting for other underlying trends over a 20-year period, 20 mph (32 km/h) speed limits resulted in 41.9% reduction in road casualties.

The positive effect was greatest in younger children. A study on speed management in European countries confirmed that speed limit reductions can significantly reduce speeds and crashes. A study in the United States also found a significant increase in motor vehicle crashes and fatalities following interstate highway speed limit increases in 23 states. The road form and function should be consistent

with the change in speed limit, otherwise there could be a net deterioration in safety if lower speed limits are not reasonable, resulting in higher level of non-compliance.

Typical Implementation Considerations

In the absence of added enforcement, some drivers may not reduce their speeds following speed reductions. More consistent speed reductions can be achieved through applying physical speed reduction counter-measures, such as the ones found in this toolkit, including **chicanes**, **speed humps**, and **narrowed lanes and roads**. This measure may also be combined with **speed reader boards** to improve compliance with speed limits.



Narrowed Vehicle Lanes

Description

Vehicle lane widths in urban areas are commonly set between 3.3 to 4.0 metres. Reducing urban vehicle lanes widths to between 2.75 to 3.0 metres, however, has numerous safety and practical benefits.

How It Works

Narrower lanes influence drivers' perception of their margin of error, causing them to slow down. Reducing speeds, meanwhile, increases the objective margin of error, while also making crashes less severe when they do occur.

Reducing lane width can also help create space for the implementation of other road safety measures.

Evidence of Effectiveness

A study by Mbatta and his colleagues found that changing the outer lane width of a multi-lane urban road led to a CMF that has the following functional form noted below, where $x_{outside}$ is the new outer lane width (in feet). This function is applicable to all crash types and severity levels.

$$CMF = e^{-0.36(x_{outside}-12)}$$

Several studies have found that narrower roads and lanes lead to slower vehicle travel speeds.

One study found that where lanes had been narrowed from 12 feet (3.66 metres) to 9 to 11 feet (2.75 to 3.36 metres), there were fewer fatal and injury crashes, or that the number of fatal and injury crashes remained unchanged.

A study commissioned by the City of Surrey found that the reduction of travel lane widths on some of the city's arterial roads resulted in 13 to 20 km/h reductions in speed. The narrower lanes did not adversely affect drivers' lane control, meaning cyclists and other vulnerable road users were not placed at greater risk of crashes with errant vehicles.

Typical Implementation Considerations

Narrowing or removing vehicle lanes can provide more space for implementing other measures, such as **protected bicycle lanes, reduced pedestrian crossing distances, smaller corner radii, or wider sidewalks**. Municipalities may also install 2.10 to 2.75 metres demarcated parking lanes to help indicate to drivers how close they are to parked vehicles.



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Chicanes

Description

A chicane, also known as a serpentine, is a series of two or more curb extensions staggered from one another on opposite sides of a road. Chicanes narrow the roadway for drivers, while increasing space for things like landscaping, street furniture, bicycle parking, etc. Chicanes are a type of traffic calming measure.

A two-lane chicane allows vehicles to remain in the right lane. A one-lane chicane extends the curb halfway into the road so that only one vehicle may pass the chicane at once.

How It Works

Chicanes use 'horizontal deflection' in order to force a vehicle to maneuver left and right as it passes through the chicane. This typically causes drivers to reduce their speed in order to comfortably negotiate the deflection. Chicanes also create a visual narrowing of the roadway, which generally causes drivers to reduce their speeds.

Chicanes can deter shortcutting, thereby reducing vehicle volumes on residential streets. This has safety benefits due to reduced exposure, and can also result in reduced noise and air pollution within a neighbourhood.

Evidence of Effectiveness

No CRF was available for chicanes. A study from Massachusetts found a 6% reduction in 85th percentile speeds and a 15% reduction in vehicle volumes on roads where a chicane was built. A study of chicane application in Seattle, United States found that this measure reduced 85th percentile speeds by as much as 6 mph (13 km/h) in the vicinity of chicanes. This measure also reduced vehicle volumes on streets where the measure was applied by as much as 48%.

Typical Implementation Considerations

Chicanes are suitable on local and collector streets with speed limits of 50 km/h or less, and at mid-block locations. One-lane chicanes are most effective when traffic volumes are similar in both directions.

Two-lane chicanes may cause drivers to pass over the centreline to maintain a straight line. For this reason, collector streets should only be treated with two-lane chicanes. In addition, municipalities may consider installing a narrow central island to prevent drivers from crossing into the opposite lane.



Speed Humps

Description

Speed humps are raised asphalt or concrete protrusions placed across the pavement in the path of motor vehicles. They are typically 7.5 to 10.0 centimetres in height and 3.7 to 4.3 metres in width. They can slow down vehicle speeds to 30 km/h at each hump.

Speed humps are different from speed bumps, which typically have a height of 7.5 to 15 centimetres and are 0.3 to 1.0 metre wide, and cause vehicles to slow down to 8 to 10 km/h. For this reason, speed bumps are commonly used in driveways and parking lots.

How It Works

This measure makes use of ‘vertical deflection.’ At speeds that are too fast, vertical deflection creates a small but uncomfortable jolt for vehicle occupants, which drivers avoid by slowing down.

For the greatest effect, a series of speed humps should be distanced apart on a road segment. This prevents drivers from speeding up after passing an individual hump. Humps placed 150 metres apart can ensure 85th percentile speeds of 40 to 48 km/h. They may result in even slower vehicle speeds if placed closer to one another.

Evidence of Effectiveness

Speed humps have a CRF of 50% for urban and suburban roads and for all injuries. They are effective in reducing vehicle travel speeds, and have a positive effect on reducing crash injuries. In many cases, speed hump installation can divert traffic away from residential streets.

They do, however, have a CRF of -28% for vehicle/bicycle crashes (i.e., a 28% increase in crashes), and therefore should be avoided on popular cycling routes.

Typical Implementation Considerations

This measure may slow down emergency vehicles. Prior to installing speed humps, planners should consult with local emergency services to determine if the measure would negatively impact emergency routes. Speed bumps may cause an increase in noise levels.

In geographic parts of the province where snow is common and where collector streets are snow plowed, speed humps should be accompanied by signage to ensure that plow drivers are made aware of their presence when they are buried in snow.



Speed Reader Boards

Description

A speed reader board is an interactive sign that detects and electronically displays the speed of approaching vehicles. Speed reader boards can be installed permanently on a post/pole adjacent to a roadway, or temporarily as a portable trailer. Permanent boards are installed where speeding is a chronic problem, whereas portable boards can be placed in response to requests from the public or near temporary construction zones.

How it Works

Speed reader boards are generally placed near a regulatory speed limit sign to indicate to motorists whether they are respecting or exceeding the posted speed limit. They enhance compliance by drawing drivers' attention to their speed, and creating the sense that their speed is being monitored. Some designs flash lights toward vehicles that are exceeding the speed limit in order to draw drivers' attention to the board. As drivers slow down, their awareness of pedestrians, cyclists, or of a high-risk area nearby improves.

Evidence of Effectiveness

Speed reader boards have a CRF of 5 to 7% for all crash types and severities on two-lane horizontal curved roadways. There has been little research on the effects of speed reader boards on speed-related crashes. However, studies have shown that boards generally reduce speeds, with the reductions varying from significant to small depending on the application and location of the speed reader board.

For speed reader boards used in school zones, a Canadian study by Hildebrand and his colleagues showed a sustained and statistically significant reduction in the average speeds ranging from 5 to 14 km/h. This reduction was dependent mostly on the degree of excessive speeding prior to installation, and on the location within the school zone. Average speeds were reduced consistently to a level of approximately 36 km/h (in a 30 km/h posted zone).

Typical Implementation Considerations

This intervention should be used as a complement, rather than a substitution, for engineering measures. Speed reader boards are best used in areas that transition to low speeds, and around schools, bikeways, parks, or work zones. Speed reader boards can also be used to help address excessive speeding at problem locations. Periodic police speeding enforcement should be used to complement this measure. Municipalities should avoid placing boards where they obstruct pedestrian or cyclist travel ways or sight lines. To avoid provoking street racing, speed reader boards should not display speeds that are well in excess of the posted speed limit. Some studies have shown that speed reader signs can lose effectiveness overtime as regular road users may begin to ignore the boards.



Gateways

Description

Gateways, also sometimes known as pinchpoints, are placed on the side of, over, and/or on the road to provide a visual cue to drivers that they are entering a pedestrianized environment and that they must reduce their speed. Gateways can include one or more elements such as signs, pavement markings, coloured road surfacing, physical restrictions (e.g., street narrowing, medians, speed humps, and curb extensions), over-road structures (portal/arch, artificial or tree canopy), flagpole arrangement, and special lighting. Gateways can also include other streetscape treatments such as benches, different streetlights, and sidewalks, which are meant to indicate a changed or more urban environment.

How it Works

Gateways have a short-term effect on speeds, and their effect depends on a combination of the gateway itself and road conditions downstream. They are typically used to indicate a transition from a rural to an urban environment, a change from a higher-speed to lower-speed environment, or to signify an approach into a village, neighborhood, traffic-calmed area, downtown, and/or main street. A gateway design that motorists perceive as a lower speed environment can be self-enforcing, meaning that it may be effective even without intensifying police enforcement. However, enforcement still remains one of the most effective countermeasures for improving road safety.

Evidence of Effectiveness

Simple visual gateways such as signs and pavement markings have been found to reduce speeds by up to 3%, while more elaborate combination of treatment with physical features have been found to reduce speeds by up to 27%. A report by the United Kingdom Department of Transport found that the implementation of gateways reduced speeds by 6 to 7mph (9 to 11 km/h), and reduced 85th percentile speeds by as much as 10 mph (16 km/h).

According to the CMF Clearinghouse, gateways have a CRF of 32% for all crashes. Another report documented a CRF of 55% for fatal plus serious injury crashes, and a CRF of 19% for all injury crashes.

Research in Alberta found a reduction in serious injuries and fatalities of between 25 to 50% at treatment sites on suburban and rural high speed areas.

Several examples of cities that implemented gateway treatments can be found in the Pedestrian Safety Guide and Countermeasure Selection System. Some of these projects included implementation of several traffic calming measures along a corridor such as speed humps, corner extensions, medians, and chicanes, and found that both speeds and traffic volumes decreased, while the number of pedestrians using a corridor increased.

Typical Implementation Considerations

The effectiveness of gateways in reducing speeds can weaken 250m after passing a gateway, and therefore careful consideration must be given to conditions and countermeasures downstream from the treatment. In general, effective designs include a combination of horizontal and vertical treatments, and should consider the needs of motorists, large commercial vehicles, pedestrians, and cyclists. The United Kingdom Department of Transport design suggestions state that gateways should be visible over at least the stopping sight distance for the 85th percentile approach speed, visually linked to the start of the village, and be at least 5 to 10m long.

Examples of gateway design considerations, effectiveness on speed reduction, recommended practices and guidelines can also be found in the Traffic Calming Measures report prepared by the Northern Ireland Department of Transport.

Transverse Rumble Strips

Description

Transverse rumble strips consist of grooves pressed across the traveled portion of a roadway, which create sound and vibration as drivers pass over them. This alerts drivers of a potential roadway hazard or a change in environment. Transverse rumble strips have several applications where a required stop is important, such as in advance of toll booths, ferry terminals, or rail-road crossings. Transverse rumble strips can be used on the approach to an intersection where it is important that vehicles on a minor road stop before crossing a major highway, and in the transition zones to highly pedestrianized areas.

How it Works

A rumble strip is a road safety feature that is implemented to alert motorists of a potential danger. The most common use of this measure is shoulder and centreline rumble strips that alert a motorist that are drifting out of a travel lane. In contrast, a transverse rumble strip is a rumble strip that is installed across the lane to warn drivers of a STOP (or slowdown) condition ahead. The rumble strips provide a tactile vibration and audible rumbling that is effective to alert the driver of the need to respond to a potential safety hazard.

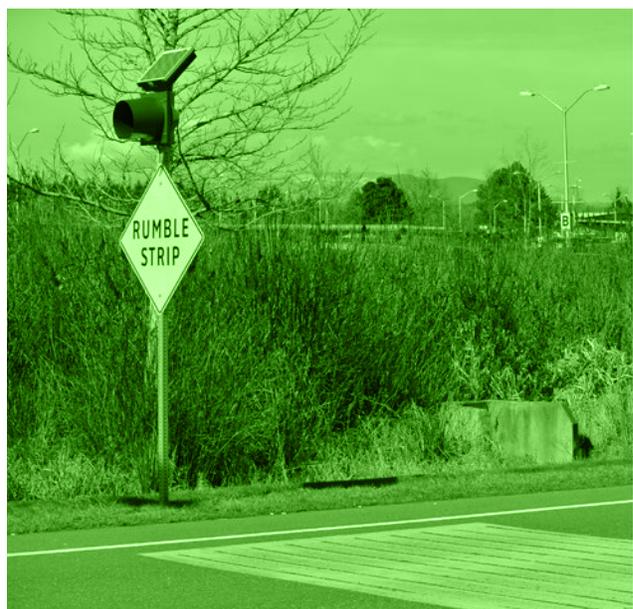
Evidence of Effectiveness

Transverse rumble strips have a CRF of 36% for serious and minor injury crashes. A study of the effectiveness of transverse rumble strips by the United States Federal Highway Administration found that transverse rumble strips were associated with an increase in crashes that result in damage to vehicles or objects, but decreases in injury crashes.

Typical Implementation

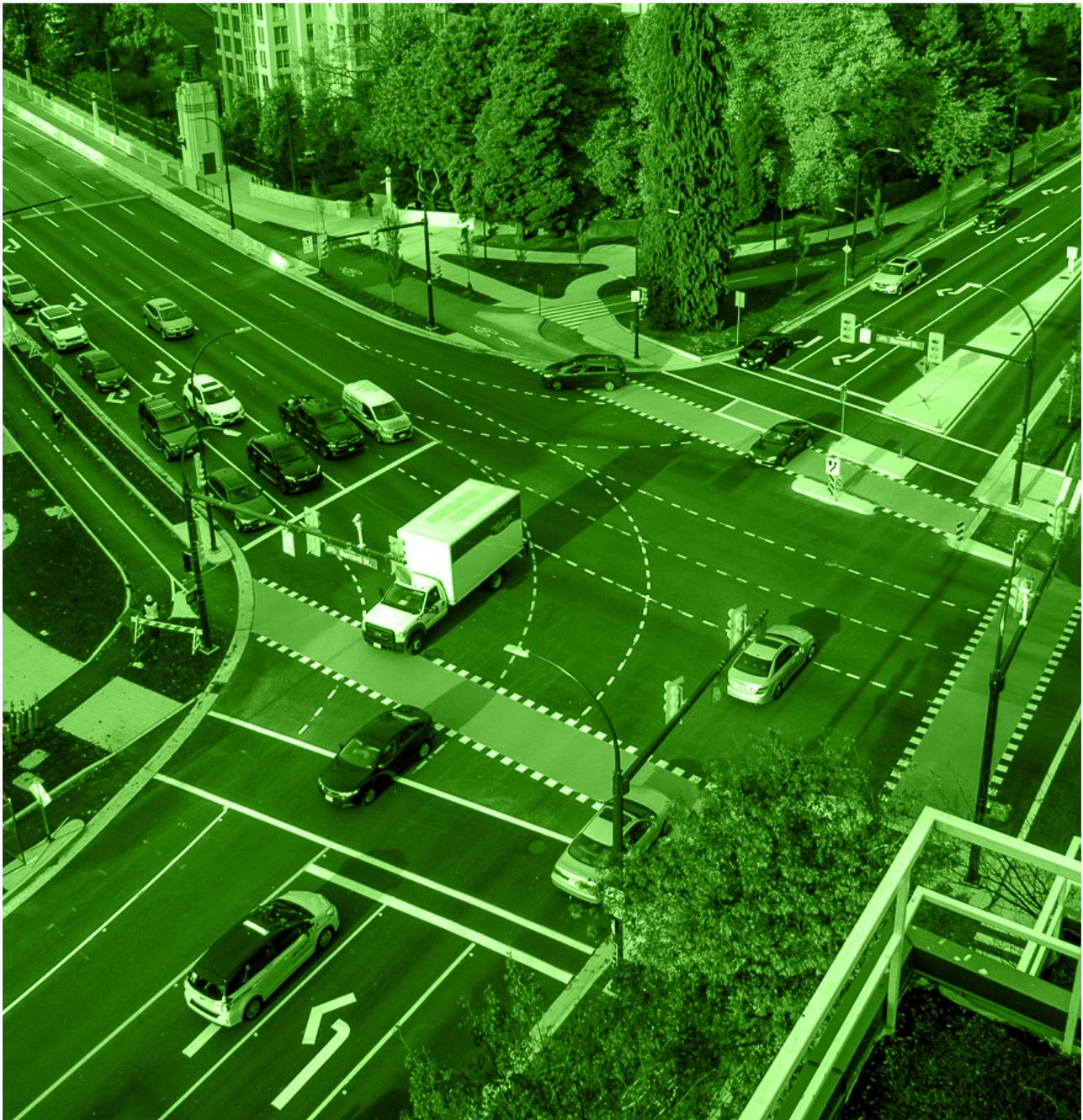
Considerations

Transverse rumble strips should only be used in locations where there is a potential for drivers to miss an important stop condition or when driver fatigue is known to be a problem. Over-use of transverse rumble may cause driver frustration and can cause other detrimental issues (e.g., there can be significant noise generated when a vehicle travels over a rumble strip which may be a problem in built-up residential areas).



Safe Intersection Design

Intersections are complex environments with a great deal of potential for conflicts between road users, which may lead to crashes. The intersection designs and strategies contained in this section focus specifically on improving intersections to make them safer for all road users.



Prohibiting Right-turn on Red

Description

In British Columbia, and most of Canada and the United States, laws that were largely put into effect in the 1970s allow drivers to make a right-turn-on-red (RTOR) unless signage specifically indicates that this is prohibited. This is not the case in most of Europe where most default laws prohibit the RTOR. Prohibiting the right-turn on red at signalized intersections lessens simultaneous road user movements, reducing all types of intersection conflicts and crashes.

How it Works

Where RTOR is permitted, drivers must look for pedestrians crossing from the left and right, for cyclists approaching from the rear, while simultaneously trying to find a gap in the vehicle and cyclist stream crossing the intersection from the left. This is a highly complex scenario requiring high driver workload and greater risk of driver error. With a site-specific prohibition on RTOR, drivers can only proceed to turn right on green. By separating road users from one another through time, this strongly reduces the likelihood of conflict between road users.

Evidence of Effectiveness

No CRFs were found for prohibiting RTOR. However, restricting RTOR has a CRF of 7% for all crashes, CRFs between -69% and -108% for vehicle/pedestrian crashes of all severities, and CRFs between -69% and -82% for vehicle/pedestrian crashes. A review and analysis of literature by Paul Zador found that the RTOR increases all right-turning crashes by about 23%, vehicle-pedestrian crashes by about 60%, and vehicle-cyclist crashes by about 100%.



Convert Two-way Stop Control to All-way Stop Control

Description

The appropriate form of traffic control is a critical factor for ensuring intersection safety. The conversion of a two-way stop control intersection to an all-way stop control (also known as a four-way stop control) will help to reduce and/or prevent crashes at intersections, especially at locations with a high proportion of side and frontal impact crashes, which can often be highly severe. Furthermore, the relatively low cost and ease of implementation makes this intervention highly attractive.

How it Works

All-way stop control can reduce right-angle crashes and turning crashes at unsignalized intersections by: creating more orderly movements; by reducing speeds for through and turning vehicles; and by minimizing problems associated with any sight-distance restrictions.

Evidence of Effectiveness

This measure has a CRF of 71% for all injury crashes, and a CRF of 39% for vehicle-pedestrian crashes. A study by Lovell and Hauer found that the conversion to an all-way stop control is likely to reduce the total number of crashes by 47%, and injury crashes by as much as 71%. Another recent study found that the effectiveness of all-way stop control was increased by the use of additional signing, including: oversized stop signs; dual stop signs; advanced warning signs; “stop ahead” pavement markings; stop bars; fluorescent markers on stop signs; and overhead or sign-mounted flashing beacons.

Typical Implementation

Considerations

Many believe that, in order to be effective, all-way stop controlled intersections should have nearly equal traffic volumes on all approaches. However, some studies have also shown that this measure can be very effective even with unbalanced traffic volumes. Considerations of whether to implement a two-way or all-way stop control should therefore be specific to each implementation site.

The all-way stop control should be implemented at a location that creates a reasonable expectation for drivers to have an all-way stop and thus avoid a situation where drivers feel they are being asked to stop for no apparent reason, which may lead to poor driver behaviours (e.g., non-compliance to the stop control). Each intersection should have a TAC warrant assessment completed to ensure that an all-way control is appropriate.



Advance Traffic Signal Warning Lights

Description

Advance Traffic Signal Warning Lights typically consist of davit-mounted warning signs with two alternating flashing signal heads. The flashers are used to warn drivers approaching a traffic signal that the lights will be changing from green to yellow. The signs are installed in advance of an intersection in order to allow drivers traveling at the posted speed limit sufficient time to come to a safe and controlled stop.

How it Works

Advance warning flashers are timed to activate a certain number of seconds prior to the traffic signal turning yellow. Drivers who have not yet passed the flashers when they are activated are made aware that they do not have enough time to reach and cross the intersection, and must therefore begin to slow down. This improves predictability for drivers, and reduces the risk of drivers braking abruptly. The distance of the signs from the traffic signal stop line is defined by the speed limit and the approach grade.

Evidence of Effectiveness

Results from a study of 106 signalized intersections in British Columbia indicated that crash frequency at intersections with advance-warning flashers have a lower frequency of crashes than similar locations without flashers. The results were not statistically significant at the 95% confidence level. Benefits were found primarily for moderate-to-high traffic volumes on the minor approach.

Typical Implementation Considerations

The use and application of Advance Warning Flashers in British Columbia is outlined in Section 400 of the BC Ministry of Transportation and Infrastructure of BC Electrical and Traffic Engineering Manual.

The signs are warranted based on one or more of the following criteria:

- The legal speed limit on the highway is 70 km/hr or higher;
- View of the traffic signals at the intersection is obstructed due to a sharp horizontal curve prior to the intersection, to the extent that the safe stopping sight distance is insufficient;
- There is a grade approaching an intersection sufficient to require a greater than average braking effort; and
- Drivers are exposed to many kilometres of high speed driving before encountering the first signal of a community in a location where signals might be unexpected.



Roundabout Design for Cyclists and Pedestrians

Description

A roundabout is an alternative to a conventional intersection, and consists of a circulatory roadway where road users must yield to other traffic before entering. Roundabouts are highly effective in reducing fatality and injury crashes for motor vehicle occupants. However, unless properly designed, they can increase the risk of crashes for cyclists.

A bicycle path physically separated from the circulating carriageway is preferable. It can be a shared path of sufficient width and appropriately marked to accommodate both cyclists and pedestrians around the perimeter of the roundabout. The cycle path should approach the entry and exit legs at right angles where signed and marked crossings are provided.

How it Works

Roundabouts are generally superior to conventional intersections because they reduce vehicle speed, reduce the number of conflict points where crashes have the potential to happen, and simplify right-of-way assignment. Older designs of roundabouts have the potential to decrease safety for cyclists because they placed the cyclists on the outside edge of the roadway in an effective “blind spot” as drivers are focusing on looking for vehicles in the centre of the roadway.

To ensure safety, particularly of pedestrians and cyclists, the following design elements should be considered:

- **The design speed** should be 30 km/h or less to reduce the kinetic energy and the speed differential between all road users as this reduces the number and severity of crashes;
- **Pedestrian/cycle crossings** should be located at least one car length outside of the entrances/exits of the roundabout to provide a location for vehicles to wait without blocking the circulatory roadway and providing direct sight lines between vehicles and crossing users. The crossings on each approach should be offset from one another in a similar fashion to the Offset Crosswalk (see Module 1 – Protecting People Walking and Cycling), such that pedestrians are directed to face motor traffic before completing the second stage of their crossing. The addition of pedestrian activated Flashing Amber Warning Lights can also draw driver’s attention to the presence of pedestrians;
- **The approach arms** should be aligned toward the middle of the central island, rather than deflected to the left. This forces vehicles to enter the roundabout at a right angle, which causes drivers to slow down;
- **At single-lane roundabouts** like pedestrians, cyclists should be spatially separated from the traffic. On the approach to the roundabout ramps allow access/egress from a dedicated or shared-use pedestrian/cycle facility that surrounds the roundabout. With lower vehicle speeds in the roundabout confident and able cyclists may choose to travel through the roundabout with the other vehicles, however, they should be directed by the placement of road markings “sharrows” and signs to position themselves in the centre of the lane on the approach and throughout the roundabout;
- **At multi-lane roundabouts**, due to higher speeds, more conflict points, and greater overall complexity, it is recommended that the cyclists are directed to use the spatially separated facility; and
- **A Landscaping buffer** should be provided between the sidewalk/shared-use facility and circulatory roadway. This buffer will provide better delineation of the sidewalk for the visually impaired, will deter pedestrians from crossing to the central island, and will provide space for sign installations. The landscaping and vegetation should be designed such that sight lines to pedestrians are unobstructed.

Roundabout Design for Cyclists and Pedestrians continued

Evidence of Effectiveness

Pedestrian Safety

The United States Federal Highway Administration found that converting unsignalized intersections to roundabouts has a CRF of 27% for vehicle-pedestrian crashes. Analysis of pedestrian safety at roundabouts in Ontario revealed that pedestrian collision rates are lower at roundabouts than at signalized intersections with comparable traffic and pedestrian volumes. Giuffre and Grana include a review of previous studies on roundabouts and pedestrian safety, which provide consistent evidence that injury crash risks for pedestrians are less at roundabouts than at conventional intersections.

Table 1: Pedestrian Crash Rates by Intersection Category

	AADT \ AADP	Roundabouts		Traffic Control Signals	
		0 to 100	101 to 1,600	0 to 100	101 to 1,600
Pedestrian collision rate (pedestrian collisions/MPE)	1,500 to 10,000	0.00	0.00	0.00	0.57
	10,001 to 20,000	0.00	1.26	3.51	0.87
	20,001 to 38,000	1.94	1.24	2.50	1.41

Source: Henderson, R., and Button, N. (2013). Pedestrian Safety in Roundabouts. Paper presented at the 2013 Conference of the Transportation Association of Canada, Road Safety Strategies for Vulnerable Road Users Session.

Cyclist Safety

A number of studies have found that some roundabouts increase the risk of injury for cyclists. The Irish National Cycle Manual states that bicycle lanes should not be placed inside the roundabout.

Typical Implementation Considerations

Other than the above features, considerations need to be made to accommodate the various types of road users expected to use the roundabout, such as children, the elderly, and the hearing-impaired. This means that municipalities should consider ensuring things such as **safe crosswalks** and **reduced crossing distances**.



Eliminating and Redesigning Slip Lanes

Description

Slip lanes (also known as right-turn channels, with the corners islands sometimes referred to colloquially as pork chops) are separated lanes at intersections that allow right-turning vehicles to enter a cross street without passing through the intersection. This intersection design includes a raised concrete island, which pedestrians must reach as a first stage of crossing the intersection. Slip lanes reduce drivers' awareness of crossing pedestrians because they are led to focus on the traffic stream into which they are merging, and also impair visibility of the traffic stream because of the angle of approach. The design increases crash risks by encouraging faster speeds during a complex manoeuvre. Slip lanes also greatly increase crossing complexity for pedestrians and cyclists, by increasing total crossing distance, requiring judgement about crossing fast-moving traffic without the benefit of a traffic signal, and potentially requiring several signal phases to complete the crossing. Slip lanes may discourage these active modes of transportation. Pork chops islands can have significant impact on capacity, which may or may not have an adverse impact on safety.

This measure works best by eliminating the slip lane and regularizing the intersection to classic perpendicular crossing geometry. A compromise may be to redesign slip lanes so that vehicles enter the cross street at a sharper angle (typically 70°). The latter measure is known as the "Urban Smart Channel." This measure is best accompanied by a **raised crossing** across the slip lane to clarify right-of-way and slow right-turning vehicles.

How it Works

Eliminating slip lanes obliges drivers to pass through the intersection to execute the right-turn, resulting in reduced travel speeds, improved driver awareness of crossing pedestrians or cyclists, and improved driver sight lines of the traffic stream approaching from the left.

Reconstructing slip lanes along the "Urban Smart Channel" concept forces vehicles to enter the cross street at a sharper angle. This reduces the turning radius, which causes drivers to slow down to complete the turn. The sharper entry angle also means that more of the intersection and cross street is within the driver's immediate cone of vision. As a result, the driver does not need to do a sharp left shoulder check, which simplifies the turn. Finally, this layout also positions crossing pedestrians more directly in the line of sight of oncoming vehicles, which increases their visibility to drivers.

Evidence of Effectiveness

No CRFs were found for this measure. Research on slip lanes has documented substantial risks to pedestrians at intersections, particularly with high-speed turns. Evidence to date about smart channel design with a 70° angle of entry into the intersection points to a CRF of 56.3% reduction in overall collisions, based on a Full-Bayes analysis.

Typical Implementation Considerations

There may be concerns about accommodating large vehicles if a slip lane is removed and smaller turning radii implemented. However, intersection designs have often overlooked the "effective" turning radius, which can be greater than the corner radius if the right-turning lane is not immediately adjacent to the face of the curb (for example, where there are parking spaces). Newer engineering practices determine the effective radius by measuring the actual path that vehicles may follow into receiving lanes.

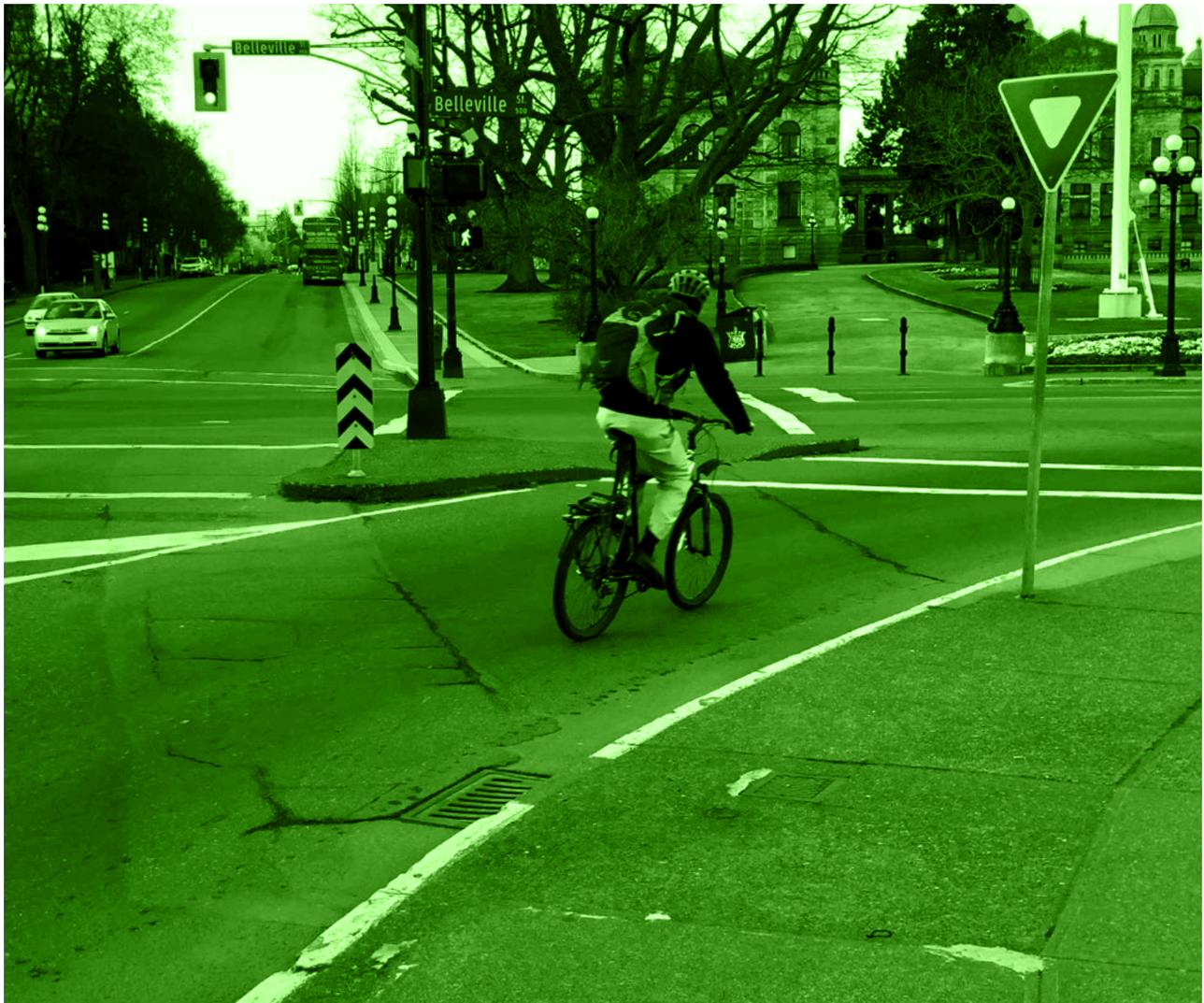
B.C. Community ROAD SAFETY TOOLKIT

Module 2: Safe Roadway Designs to Protect All Road Users

Eliminating and Redesigning Slip Lanes continued

Where the Urban Smart Channel is used, the following design features should be included to improve safety:

- Controlled slip lanes (i.e., vehicles must yield to cross traffic, no dedicated exit lanes), combined with raised, painted crosswalks over the slip lane with warnings and pedestrian activated signals to encourage yielding to pedestrians. Flashing overhead crosswalk signs can be particularly effective;
- Small compound radius turn with an angle of at least 70°. Avoid a constant radius slip lane with shallow exit angles;
- Larger, raised “pork chop” island with cut-throughs/ramps (for bicycles, wheelchairs, mobility scooters) and good road lighting; and
- Crosswalks located 6 metres/one car length in front of where vehicles merge.



Left-turn Lanes and Signalization

Description

Left-turn bays, or lanes, are “auxiliary” lanes used for the deceleration and queuing of left-turning vehicles. Signalized left-turns at intersections are installed where warrants (i.e., criteria) are met to provide a dedicated signal phase for left-turning vehicles. These signals may or may not make use of auxiliary lanes. During the “protected” left-turn phase, all opposing traffic and conflicting pedestrian traffic is stopped.

How it Works

Left-turn bays and signalized left-turns reduce potential for conflict by separating road users through space and time. The auxiliary lane reduces crash risk by separating left-turning vehicles from following through-traffic meaning that the following vehicles will not manoeuvre to change lanes in the attempt to pass the turning vehicle ahead.

Signalized left-turns give left-turning vehicles an opportunity to complete the turn without the risk of confronting opposing through-traffic, or striking pedestrians that are traversing the cross-street

Evidence of Effectiveness

Implementing a protected left-turn phase has a CRF of 16 to 17% for fatal, serious injury, and minor injury crashes. A combined protected/permitted left-turn phase with a left-turn bay at high-speed intersections has a CRF of 34% for all crashes.



Typical Implementation Considerations

Operationally, the addition of a left-turn lane can increase the capacity of the intersection by separating left-turn traffic from the through-traffic stream. This can enable municipalities to implement shorter signal cycle lengths, and thus improve safety for pedestrians (see [the measure adequate signal crossing times and signal cycle lengths](#)).

The use of warrants and guidelines are essential for left-turn lanes and left-turn signalization to ensure that all factors are considered for the overall safety and operational performance of the intersection. Guidelines for installation and design of left-turn lanes in Canada is provided by the Transportation Association of Canada (TAC), Geometric Design Guide for Canadian Roads. Guidelines related to left-turn signalization can be obtained from the TAC/ITE Canadian Capacity Guide for Signalized Intersections. Dedicated left-turn lanes can be further improved by including a “positive offset.” This measure separates left-turn lanes from the adjacent same-direction through-lane, thus lining up the opposing left-turn lanes. This addresses a situation involving two opposing left-turning vehicles that obstruct one another’s view of adjacent through-traffic. See the document “Provide Offset to Left-turn Lanes” in the Technical Resources for a diagram of a positive offset.

Right-turn Lanes at Intersections

Description

Right-turn lanes are curbside lanes that separate the movements of through-traffic from vehicles wishing to turn onto a cross street.

How it Works

Right-turn lanes at intersections improve safety by separating and significantly reducing the conflicts between right-turning vehicles and the following through-traffic. They may help to make the environment more predictable for all road users

Evidence of Effectiveness

There are numerous CRFs for right-turn lanes at intersections. Municipalities may refer to the CMF Clearinghouse by searching the term “install right-turn lane” and determine which CMF/CRF best fits the profile of the proposed implementation sites.

The following CMFs apply:

- 96% all collisions (3-leg i/s one approach);
- 96% all collisions (4-leg i/s two approach); and
- 92% all collisions (4-leg i/s all approach).

Typical Implementation Considerations

Right-turning vehicles potentially increase the risk to cyclists in any situation because of cyclists’ small size and vulnerability. To reinforce the right-of-way for cyclists, cycling lanes should be positioned to the left of the right-turn lane. **Coloured bicycle lanes** on the intersection approach can help draw drivers’ attention to the presence of cyclists. Specific attention should be paid to the geometry of cycling lanes and right-turn lanes (see NACTO’s discussion on “Through Bike Lanes” in the Technical Resources).



Reduced Access Point Density in the Vicinity of Intersections

Description

The functional area of an intersection extends upstream and downstream from the physical area of an intersection. Access points within this functional area include private and business driveways, as well as minor or side-street intersections. These access points have the potential to increase the complexity and unpredictability of the road environment.

How it Works

Access points located within 80 metres upstream or downstream of an intersection are undesirable because this area already requires a high level of driver care and attention. Closing or relocating access points to a location outside this functional area helps reduce the number of decisions motorists must make while travelling through an intersection, and improves safety in the vicinity of an intersection.

Evidence of Effectiveness

CRFs for all crashes can be calculated using the formula on page 92 of the BC Ministry of Transportation and Infrastructure's Collision Modification Factors for British Columbia.

These CRFs are for rural stop-controlled intersection. A CRF for urban intersections was not found; however, a reduction in rear-end and angle crashes is expected.

Typical Implementation Considerations

The functional area of an intersection includes all intersection auxiliary lanes and encompasses the intersection's perception-reaction-decision distance, manoeuvre distance, and queue-storage distance.

A minimum distance of 80 metres can be assumed for the application of this safety countermeasure in the absence of a more detailed analysis.

Ideally, an **access management** program exists to carefully manage the access approval process and achieve balance between land development plans and preservation of the functional integrity of the functional area of intersections.

Opportunities to reduce access can vary significantly from site to site, and may include:

- Converting an access strip to an access point;
- Closing redundant accesses;
- Consolidating multiple accesses into a single new access, which can be achieved by improving circulation between adjoining properties;
- Relocating the access to a corner property from the main arterial to a collector cross street; and
- Constructing frontage roads.



Smaller Corner Radii

Description

A corner radius reduction is the reconstruction of an intersection corner that places it further into the turning lane. The main purpose of a smaller radius is to slow down right-turning vehicles.

How It Works

Smaller corner radii make the path of a right-turning vehicle tighter, which requires a slower speed. Slower speeds increase the amount of time that road users have to react to a conflict, reduce the stopping distance in case the driver has to brake, and reduce the kinetic forces in the case of a crash.

Intersection corner reconstructions also work to position pedestrians further forward before they begin crossing a street, which increases their visibility to drivers, and shortens their crossing distance. This is important because corners are where drivers and pedestrians are most likely to encounter one another.

Evidence of Effectiveness

No CRFs were found for curb radii reductions. However, smaller curb radii are known to improve safety, especially for pedestrians and cyclists, at right-turn locations.

Typical Implementation

Considerations

Smaller corner radii can be applied on local and collector streets. They may not be effective in very large intersections because right-turning vehicles might not manoeuvre into the nearest receiving lane.

They may also not be suitable on routes with large volumes of buses or trucks, as large vehicles may need to move into the opposing lane in order to negotiate the turn. One possible way to mitigate the risks is by recessing the stop line in the nearest lane of the receiving street, allowing more room for a large vehicle to complete the turn.

In some cases, corner radii reductions through curb extensions may inhibit the installation of bicycle lanes. Consideration should be given in the planning stages to the possibility of bicycle lane construction in the future.



Safe Corridor Design

The roadway designs described in this section improve safety for all road users by making physical changes to road corridors that help reduce the likelihood of driver error and help lessen the consequences to road users when mistakes happen.



Continuous Raised Median Barriers

Description

A continuous raised median barrier is any non-traversable physical barrier installed down the middle of a roadway. It may be used to prevent left-turns, or to prevent deadly cross-over head-on crashes caused by one vehicle moving into the path of opposing traffic.

Raised medians can be composed of modular concrete barriers, raised curbs with landscaping in the middle, or a wide space with grass, gravel, sand, or other material.

How it Works

Installation of a continuous raised median in an urban setting will prevent left-turns in and out of driveways and minor side-streets, significantly reducing the number of conflict points along an arterial roadway and leading to fewer crashes.

In a rural setting, a continuous median barrier is very effective at reducing off-road left and head-on crashes, which at higher speeds lead to high injury crashes for motor vehicle occupants. A median barrier can also have this function on higher speed urban roads.

Evidence of Effectiveness

Installing a continuous raised median has a CRF of 22% for fatal and injury crashes on urban multi-lane roads, and a CRF of 39% for all crashes on urban two-lane roads.

Typical Implementation Considerations

Installing a continuous raised median barrier is generally easier in a rural setting compared to an urban setting. Often, a more realistic configuration in an urban setting is to provide openings in the median at a few designated locations (e.g., major access points/intersections). Openings can also be used at the ends of deceleration and storage lanes in order to accommodate left-turns off of the arterial street and to remove them from the through lanes. Access into some areas will be right-turns only, and generally access out of developments will be right-turns only. The design of medians requires adequate provision for left-turns to avoid over concentrating these movements at individual intersections.



Continuous Centre Two-way Left-turn Lanes

Description

A continuous two-way left-turn lane (TWLTL) is a special shared lane in the centre of a roadway reserved for mid-block left-turns into or out of driveways or side streets.

How it Works

A TWLTL improves safety by separating turning vehicles from through lanes and by providing a refuge for vehicles entering through lanes from access points along a road.

Evidence of Effectiveness

CRFs for all crashes can be calculated using the formula on page 42 of the BC Ministry of Transportation and Infrastructure's Collision Modification Factors for British Columbia. This CRF only applies on road segments where the access point density is greater than 3.

Typical Implementation Considerations

Due to the complexity and number of design factors to be considered, each site needs to be examined by experienced design and traffic operations personnel to determine the improvements required to successfully implement a TWLTL. The Transportation

Association of Canada (TAC) Geometric Design Guide provides a good description of the major factors to be considered. Some of these are listed here.

TWLTLs are normally used with 3 and 5 lane cross sections, with 5 lanes being the most common. They are best suited for urban roads with operating speeds of 50 to 60 km/h. A traffic volume of 24,000 vehicles per day is generally recommended; however, this measure has been successfully implemented for volumes up to 35,000 per day. In some cases a TWLTL is achieved by eliminating a parking lane or by converting an existing 6 lane road to 5 lanes with a centre TWLTL and curbside cycling lanes. Arterial roadways with straight flat alignments and low to moderate volume number of driveways represent typical applications.

TWLTLs are generally not extended through major intersections and are not suitable for high volume driveways. A combination of exclusive left-turn lanes at high volume driveways and a TWLTL elsewhere may be feasible if the high volume accesses are well spaced in relation to the other accesses.



Drainage

Description

Drainage refers to measures that collect and divert water away from the road surface, and redirect it to desired locations. A drainage system for a road network typically includes retention devices to manage flow rates, ditches and catch basins to gather the water, culverts and piping systems to pass the water under roads, and manholes for maintenance purposes.

How it Works

Well-designed drainage systems efficiently remove water from the road's surface, which in turn improves road safety performance by reducing the likelihood of hydroplaning for vehicles and improves road friction, and improves visibility by reducing the amount of spray. Adequate drainage also improves the road environment for pedestrian and cyclist

Evidence of Effectiveness

No CMFs were found for this measure. High friction pavement treatments that are deployed to improve drainage have a CRF of 8%, which can be applied to all road types and targets all crash types.

Typical Implementation Considerations

Drainage systems should be designed to control downstream flooding, maintain base flows in streams to support aquatic life, minimize pollution, cause minimal siltation in water courses, and be cost effective.

In addition to being cycle friendly when curbside, avoid locating the catch basin in the ramp area for a crosswalk/shared-use facility. If unavoidable, ensure the grate is of a design that will not trap the wheels of wheelchairs, walking aids and buggies or have gaps large enough to let a walking cane pass through.



High Friction Pavement

Description

There are many types of treatments that can be used to improve the surface quality for a road or highway. Some examples include the application of chemical de-icing, using high-friction additives to pavement surfaces, the use of porous asphalt composed of larger stones to allow better drainage, and cutting grooves into the pavements to increase friction and assist in drainage.

How it Works

High friction pavement treatments include any intervention that can help to increase the friction between a vehicle's tires and the road surface. An improved level of friction helps drivers to better steer the vehicle, improves stopping control, and helps prevent loss of control. This is especially the case in rainy or wet conditions. High friction pavements are typically used on the approach to intersections, locations with challenging horizontal and vertical alignment (e.g., sharp curves or steep grades), or at locations where the road surface quality is poor or weather conditions are frequently problematic.

Porous asphalt also reduces water spray from vehicles, which improves visibility for drivers in rainy weather.

Evidence of Effectiveness

The road safety engineering literature is somewhat limited in the details related to specific treatments, but a general CRF for improvements to road surface treatments is provided for guidance. Some judgement may be required to select a CRF that accurately reflects the effectiveness of the high friction pavement treatment in relation to typical, non-treated road surface and recognizing that there is considerable variability in the effectiveness of high-friction road surface treatments.

Elvik and Vaa list some CRFs for improved road surface conditions. For example, anti-icing chemicals have a CRF of 13%, which can be applied to all road types and target all crash types. High friction pavement treatments that are deployed to improve drainage have a CRF of 8%, which again can be applied to all road types and targets all crash types

Typical Implementation Considerations

Some high-friction pavement treatments can be costly, and due to the added wear and tear caused by increased friction, may need to be repaired more often. As such, the location for the use of these types of interventions should be limited to higher-priority locations first to ensure cost-effective results.

Some studies have found that improvements in road friction were accompanied by greater evenness of the road surface, which in turn resulted in slightly higher speeds. As part of efforts to improve surface friction, municipalities may consider implementing other measures for reducing speeds.

Highly Readable and Well-positioned Road Signs

Description

Highly readable road signs are visible and legible from the distance that drivers need to safely execute manoeuvres in response to the sign message. Signs that are properly positioned, both laterally and vertically, are typically more visible and legible. In turn, they help improve the overall predictability of the road environment.

How it Works

Highly readable road signs provide sufficient legibility and retro-reflectivity for drivers to perceive, process, and react to the contents of the sign.

The following characteristics maximize the readability of road signs:

- **Retro-reflective sheeting:** retro-reflective signs consist of a layer of glass beads, microprisms, or other highly reflective material embedded and sealed into the letters and background of a sign. This design can significantly improve the legibility of a sign, particularly during night-time or low visibility conditions. The Transportation Association of Canada (TAC) has documented minimum reflectivity characteristics, based on American Standards for Testing Materials (ASTM). It is recommended that for all larger regulatory and warning signs, that diamond-grade sheeting be used;
- **Proper lateral placement:** signs should be located within the driver's cone of vision to provide the best opportunity to observe and comprehend the sign. The maximum angle of the cone of vision at the time the information on the sign is typically taken in is 10 degrees; therefore signs should be placed such that drivers finish reading the sign before exiting the cone of vision;

- **Proper longitudinal placement:** signs that are more complex need to be legible from a greater distance, so that it can be fully read and understood before the driver exits the cone of vision. Detailed guidance is provided in the Manual of Uniform Traffic Control Devices for Canada and other TAC documents;
- **Choice of sign lettering:** certain types of lettering are known to be associated with increased legibility. For example the Clearview font on guide signs is considered superior to the traditional Arial font and is now the standard in most jurisdictions; and
- **Use of symbols:** there may be language barriers for visitors to British Columbia. Comprehension is more universal when symbols are incorporated into signs. Several signs in the Manual of Uniform Traffic Control Devices for Canada have already been converted from text to symbolic. However, when transitioning to symbolic signs, a text tab below the new symbolic signs may need to be provided for an educational period.



Evidence of Effectiveness

There are various CRFs for various different elements of improved road signs:

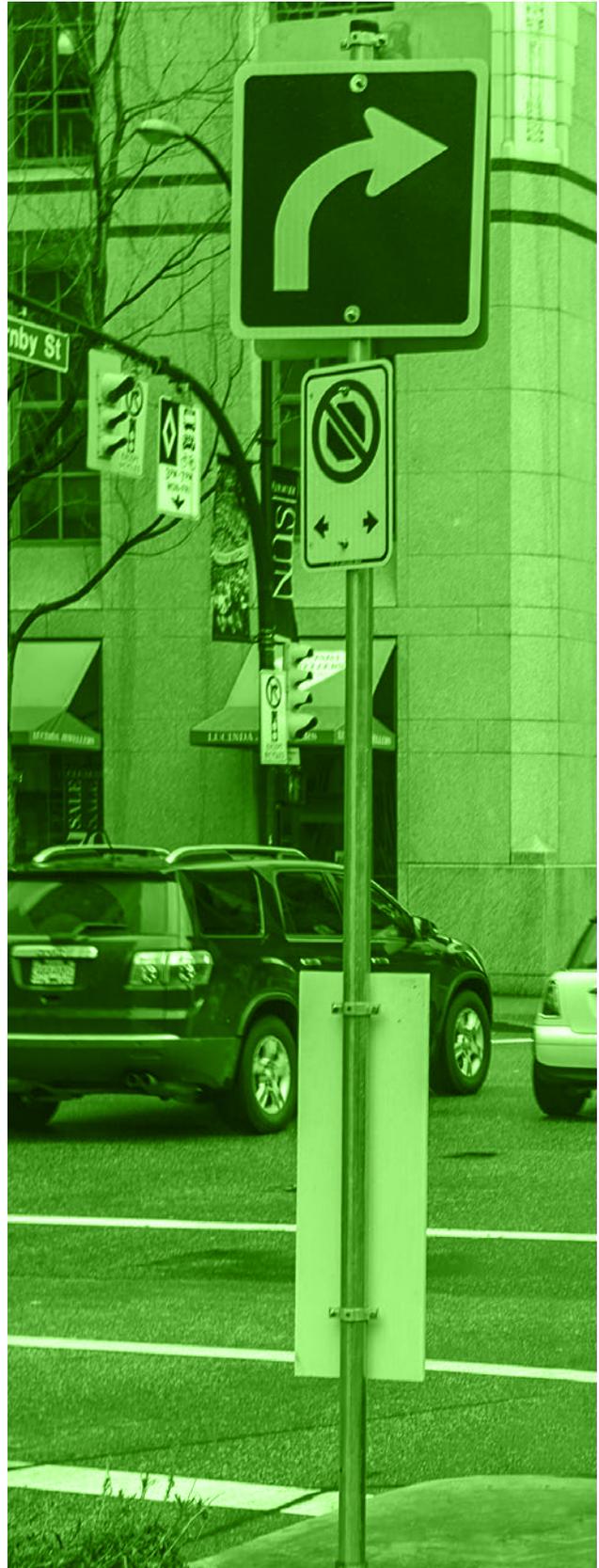
- Based on research done by Elvik and Vaa, signs that conform to the Manual of Uniform Traffic Control Devices have a CRF of 15% for injury crashes;
- Enlarging the signs can have a CRF of 5% for all crashes;
- Improving the reflectivity levels of signs can have a CRF of 10% for all crashes; and
- Installing signs with Clearview font has a CRF of 26% for all crash severities, and a CRF of 34% for all crash severities at night in urban areas.

Typical Implementation Considerations

Lateral sign placement also takes into account clear zone requirements (for large signs with supports), as well as offset requirements to accommodate maintenance activities, such as the mowing of grass.

The readability of signs over time depends on their effective maintenance. A progressive sign washing and sign replacement program will increase the effectiveness of the signage.

The longitudinal placement of signs needs to be implemented to avoid excessive driver workload. This is accomplished with only providing necessary and standard signage, spaced at intervals that meet the perception and reaction time requirements for each individual sign.



Winter Maintenance of Roads

Description

Snow, ice, and reduced visibility on roads during winter drastically increase the risk of drivers losing control of their vehicle and crashing. The maintenance that is applied in the winter months can help reduce this risk during the winter season. Effective snow and ice removal on sidewalks and cycling facilities also facilitates safe operation on these facilities.

How it Works

Clearing snow maintains sight lines, reduces drainage concerns during periods of snow melt, and maintains access to properties.

Municipalities can develop a “Snow and Ice Control Plan” or “Winter Maintenance Plan” in order to help determine the likely frequency, amount, and type of snowfall, as well as periods of low average temperatures that can cause freezing. With this knowledge, municipalities can establish schedules and priorities in the community for high traffic or highly-affected roads.

The standard truck plow is the basic tool for clearing snow, along with a loader and dump truck to move the snow. Some municipalities use graders to windrow the snow to the roadside or to the centre of road, and then collect it after the main clearing is complete. Another tool is outfitting the plow equipment with ice-cutting blades. This is practical in freeze/thaw cycles where rain or wet snow create ice on the roadways.

It is common in BC to apply a fracture or sand material onto the roadways to reduce the risk of slipping. The selection of the fracture is important in terms of it being readily available at a reasonable cost. Salt is mixed with the fracture and applied in combination on the roadways following plowing. This practice extends the salt supply which can be costly or difficult to obtain.

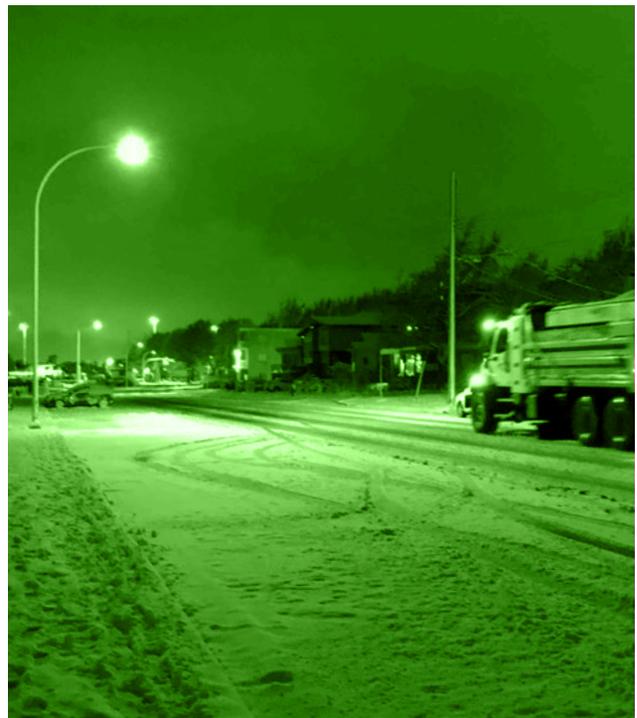
It is recommended that if salt is to be included in winter maintenance plans, that the municipality acquire the sufficient product prior to winter.

Fixed Automated Spray Technology (FAST)

is being increasingly used in cities during winter. This system consists of sensors that automatically detect current weather conditions, and trigger the spraying of a de-icing agent through nozzles embedded in the roadside. This system does not prevent the need to monitor manual monitoring and patrol.

Evidence of Effectiveness

Elvik and Vaa indicate a CRF of 11% with an increase in one level of maintenance standard.



Improved Lane Markings

Description

Improved lane markings can include the placement of paint lines in the centre or edge of the road or between multiple travel lanes to help guide drivers; enhancement of existing markings by widening them (wider edge-lines), and/or using retro-reflective paint; and the addition of retro-reflective road markers (i.e., cat's eyes).

How it Works

Bright and highly visible centre- and edge lines help drivers judge their position on the road, and other painted symbols may be used to provide information about conditions ahead.

Highly reflective road markings are produced by mixing small glass beads into the paint and its surface to help reflect vehicles' headlamp light back to drivers. Retro-reflection can be enhanced in rainy weather by providing a raised texture that keeps the surface of the paint clear of the water. Raised rib markings also produce an acoustic or vibrating effect, signaling to a driver that they are drifting away from the lane.

Improved visibility in all weather conditions may also be achieved by painting a wider line. Retro Reflective Pavement Markers (RRPMs) (i.e., road studs, or cats' eyes) are used to increase the visibility of road lines.

Depending on the type installed, some can provide tactile and audible warnings to drivers, similar to rumble strips.

Evidence of Effectiveness

No CRFs were found for lane markings in urban or suburban areas. However, there are several CRFs for wider edge-lines in rural locations.

Painting an edge line on narrow two-lane roads has a CRF of 15% for all crashes.

Typical Implementation Considerations

Line markings can easily be ignored and physical barriers may be required to prevent drivers crossing the centre line, especially on higher speed roads. RRPMs need a good quality road surface to ensure good durability.



Improved Street Lighting

Description

Driving during darkened conditions is more dangerous than driving during daylight. Only 25% of all travel occurs between 7pm and 8am, however, 40% of fatal and serious injuries from motor vehicles crashes occur during this time period. The reduced visibility and increased risk strongly affects pedestrians and cyclists. Increasing the level of illumination for a roadway is known to improve the safety for all road users. However, there has been a recent trend to reduce lighting in the interest of energy savings.

How it Works

A streetlight/light standard is a raised source of light that is provided to help illuminate a roadway or walkway in order to help guide road users and to provide an increased level of security. Street lighting commonly use high-intensity discharge lamps, with high-pressure sodium lamps or more recently LED lighting, which can have significant energy saving benefits. There are defined standards for the level of lighting required for different roadway facilities, but the greatest benefit for lighting occurs at locations with the greatest risk of conflict (i.e., intersections, cross-walks, etc.).

Evidence of Effectiveness

Elvik and Vaa indicate a CRF of 42% for night-time collisions involving pedestrians at intersections. However, this CRF would be lower if it was applied to all collisions. Research has indicated that there are significant safety benefits in providing roadway lighting at locations where illumination has not been previously installed. A literature review in a report from SWOV indicated that injury crashes could be reduced by 30% on urban roads when lighting is provided. A Japanese study found a 43% reduction in night-time crashes following the provision of lighting and that higher intensity lighting provided greater safety benefits.

Typical Implementation Considerations

There are a number of circumstances where it is important to consider potential negative impacts from roadway lighting. This includes the loss of night vision when a driver rapidly travels from a highly illuminated area to a dark area. Similarly, if there is an abrupt shift from a darkened area to an intensely lit one, drivers' vision can become overwhelmed. This is similar to the situation a driver encounters when entering and leaving a dark tunnel on a sunny day.

Street lighting poles can be roadside hazards and as such, it is important to try to protect road users from these hazards (e.g., provide break-away bases for poles).



Reduced Access Point Density

Description

Access point density is the number of places where vehicles may turn onto a road, per kilometre along the roadway. Accesses include private and business driveways. Reducing access point density means reducing the number of access points per kilometre of roadway.

How it Works

There is a direct and significant relationship between access point density and crash frequency. Each access point creates potential conflicts between through-traffic and turning-traffic. A reduction in access density will result in a “cleaner” roadway with fewer conflict points where drivers must make complex decisions. This leads to fewer crashes.

Evidence of Effectiveness

There are numerous CRFs for reducing access point density. For injury crashes on suburban arterials and multi-lane highways, the following CRFs apply:

- 29% (reduce number of accesses per two-way kilometre from >30 to 16-30);
- 31% (reduce number of accesses per two-way kilometre from 16-30 to 6-15); and
- 25% (reduce number of accesses per two-way kilometre from 6-15 to <6).

CRFs for all crashes on urban arterials can be calculated using the formula on page 73 of the BC Ministry of Transportation and Infrastructure’s Collision Modification Factors for British Columbia.

Typical Implementation

Considerations

Ideally, an access management program exists to carefully manage the access approval process and achieve balance between land development plans and preservation of the functional integrity of the roadway.

Opportunities to reduce access density can vary significantly from site to site, and may include:

- Converting an access strip to an access point;
- Closing redundant accesses;
- Consolidating multiple accesses into a single new access, which can be achieved by improving circulation between adjoining properties;
- Relocating the access to a corner property from the main arterial to a collector cross street; and
- Constructing frontage roads.

Safe Parking Lots and Parking Lot Driveways for Pedestrians and Cyclists

Description

Parking lots are areas with complex interactions and strong potentials for conflicts between road users. Safe parking lots are achieved through design features to accommodate the unbroken safe movement for pedestrians and cyclists. The parking lot driveways should also ensure safe access/egress for all road users.

How it Works

Many of the measures discussed in this toolkit can be used to design safe parking lots. Strong considerations should be given to separating different types of road users from one another, reducing vehicle speeds, and improving sight lines. Doing so can alleviate the unpredictability of all road user movements. Specific attention may be given both to parking lot entrances/exits, and parking lot interiors.

Parking lot entrances/exits:

- Well-designed driveway entrances can ensure safe access and egress to parking lots. For example, **smaller corner radii** and **raised pedestrian crossings** increase drivers' awareness and reduces their speeds;
- Since many pedestrians are hit on sidewalks adjacent to parking lot entrances/exits, curb and sidewalk extensions can be designed, or later added, to wrap around and extend away from these parking lot entrances/exits to provide much improved visibility that enhances safety considerably;
- Raised crossings, speed humps or other raised surfaces should be placed at regular intervals to slow speed;
- **Painted bicycle lanes** can be placed across the face of a driveway entrance to signal to drivers that there may be cyclists present. Bicycle lanes may also extend from the roadway into the parking lot; and

- The spacing of driveways along a roadway may be reduced in order to minimize the number of potential conflict points between through-traffic and vehicles exiting the parking lot. This is typically referred to as **access management**, and can be specified at the early stages of a development in the zoning bylaws

Parking lot interiors:

- Providing at least one uninterrupted pedestrian route between the main building entrance and the sidewalk/roadway will help ensure that more pedestrians and vehicles are kept separate from one another;
- Pedestrian and cyclist-scale lighting can be used to illuminate the paths for pedestrians, and also to help mark the appropriate path from a distance;
- **Speed bumps** or other raised surfaces should be placed at regular intervals to slow vehicle speeds;
- Avoiding the use of overly large driveways and wide drive aisles (i.e., the spaces between rows of parking stalls), will help signal to drivers that the parking lot is a slow speed zone; and
- Planting trees and vegetation along pedestrian paths and on the perimeter of the parking lot creates the sense of a traffic-calmed area by distinguishing the parking lot from the higher speed roads surrounding it.

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Typical Implementation Considerations

Ensuring proper drainage and storm water management will help reduce erosion and improve the longevity of the parking lot.

Vegetation is an important aspect of attractive and pedestrian-friendly parking lots. Such vegetation should be maintained and cut back periodically to prevent the obstruction of sight lines.

Providing adequate lighting is important for safety and security. To avoid excessive light pollution effects on nearby residents, and to lessen energy consumption, pedestrian paths may have downward-facing lights.

Bicycle parking should be provided in sufficient quantity, and should not obstruct pedestrian pathways.



Resources



Defined Terms

Collector roads: low-to-moderate capacity roads that allow traffic flow within larger neighbourhoods and distribute motor vehicle traffic between arterial roads and local roads.

Collision Modification Factors (CMFs): is simply a multiplicative factor to reflect the expected change in safety performance associated with the corresponding change in highway design an/or the traffic control feature.

Crash Reduction Factors (CRFs): is the percentage crash reduction that might be expected after implementing a given countermeasure at a specific site.

Local road authority: the local public body that has authority to install and maintain traffic control devices (i.e., road signs and signals), and install road safety infrastructure.

Local roads: roads that primarily serve local neighbourhood traffic, provide connections within communities, provide access to residential properties, and usually have on-street parking.

Major roads: arterial roads and collector roads.

Pedestrian: a person travelling by foot, skateboard/longboard, roller skates, push scooters, or any other small-wheeled form of transport, or using mobility assistance devices like wheelchairs or electric scooters. This toolkit uses the terms “pedestrians” and “people who walk” interchangeably.

Sight lines: the distance in any direction where different road users can easily see one another.

Signalized intersection: an intersection where road user movements are controlled by traffic lights.

Vulnerable road user: anyone outside of a motor vehicle including pedestrians, cyclists, people using mobility assistance devices (i.e., people who use wheelchairs, mobility scooters, etc.), and motorcyclists. These road users do not benefit from vehicle protections like crumple zones, airbags, and a protected passenger compartment. For the purposes of this toolkit, vulnerable road users also refers to skateboarders and longboarders, people using push scooters, and people using in-line skates.

Reducing Driver Speeds

Lowering of Speed Limits

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Module 2: Safe Roadway Designs to Protect All Road Users

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