SIDEWALK DESIGN, CONSTRUCTION, AND MAINTENANCE

A BEST PRACTICE BY THE NATIONAL GUIDE TO SUSTAINABLE MUNICIPAL INFRASTRUCTURE

National Guide to Sustainable Municipal Infrastructure

Guide national pour des infrastructures municipales durables

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Why Canada Needs InfraGuide

Canadian municipalities spend $12 billion to $15 billion annually on infrastructure but it never seems to be enough. Existing infrastructure is ageing while demand grows for more and better roads, and improved water and sewer systems to respond to higher standards of safety, health, and environmental protection as well as population growth. The solution is to change the way we plan, design, and manage infrastructure. Only by doing so can municipalities meet new demands within a fiscally responsible and environmentally sustainable framework, while preserving the quality of life.

This is what the *National Guide to Sustainable Municipal Infrastructure: Innovations and Best Practices (InfraGuide)* seeks to accomplish.

In 2001, the federal government, through its Infrastructure Canada Program (IC) and the National Research Council (NRC), joined forces with the Federation of Canadian Municipalities (FCM) to create the National Guide to Sustainable Municipal Infrastructure. InfraGuide is both a new, national network of people and a growing collection of published best practice documents for use by decision makers and technical personnel in the public and private sectors. Based on Canadian experience and research, the reports set out the best practices to support sustainable municipal infrastructure decisions and actions in six key areas: municipal roads and sidewalks, potable water, storm and wastewater, decision making and investment planning, environmental protocols, and transit. The best practices are available on-line and in hard copy.

A Knowledge Network of Excellence

InfraGuide's creation is made possible through $12.5 million from Infrastructure Canada, in-kind contributions from various facets of the industry, technical resources, the collaborative effort of municipal practitioners, researchers, and other experts, and a host of volunteers throughout the country. By gathering and synthesizing the best Canadian experience and knowledge, InfraGuide helps municipalities get the maximum return on every dollar they spend on infrastructure, while being mindful of the social and environmental implications of their decisions.

Volunteer technical committees and working groups, with the assistance of consultants and other stakeholders, are responsible for the research and publication of the best practices. This is a system of shared knowledge, shared responsibility, and shared benefits. We urge you to become a part of the InfraGuide Network of Excellence. Whether you are a municipal plant operator, a planner, or a municipal councillor, your input is critical to the quality of our work.

Please join us.

Contact InfraGuide toll-free at **1-866-330-3350** or visit our Web site at <www.infraguide.ca> for more information. We look forward to working with you.

ACKNOWLEDGEMENTS

The dedication of individuals who volunteered their time and expertise in the interest of the National Guide to Sustainable Municipal Infrastructure (InfraGuide) is acknowledged and very much appreciated.

This best practice was developed by stakeholders from Canadian municipalities and specialists from across Canada. The following members of InfraGuide's Municipal Roads and Sidewalks Technical Committee provided guidance and direction in the development of this best practice. They were assisted by the Guide Directorate staff and by R.V. Anderson Associates Limited.

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EXECUTIVE SUMMARY

The purpose of this best practice is to help decision makers understand the importance of safe and accessible sidewalks and provide managers and staff with tools to improve sidewalk infrastructure. It is important that sidewalks provide universal accessibility for the full range of users, including visually and mobility impaired users. Safe sidewalks will also reduce the risk to users and increase user satisfaction.

This document describes the best practices for the design, construction and maintenance of sidewalks within the public right of way. Several aspects of sidewalk planning are outlined including inventory and assessment of current conditions, universal design and sidewalk location guidelines, and basis for material selection.

Sidewalk design recommendations related to various technical aspects are presented including intersection and driveway locations. Guidelines to improve accessibility for sidewalk users with mobility and visual impairments are included. Techniques to minimize tree root damage to sidewalks are outlined as well as winter design considerations.

Construction practices have a significant impact on the service life of sidewalks. Recommended construction procedures and materials specifications are outlined for poured in place concrete, asphalt and interlocking pavers.

After construction, sidewalks may heave, tilt, crack in various patterns for a variety of reasons. Various failure mechanisms together with remedial measures are described.

Winter maintenance of sidewalks varies significantly across Canada. Some municipalities plow, salt and sand the sidewalks, while others view it as the property owners’ responsibility. A recommended approach to winter maintenance is presented.

Undertaking preventive maintenance is a cost-effective measure to minimize the life-cycle costs for sidewalks. Measures include providing good drainage across the sidewalk and boulevard area, pruning tree roots, and repairing localized defects before they become a larger problem.

1. GENERAL

1.1 INTRODUCTION

Sidewalks are an integral component of the municipal landscape that should be safe and universally accessible. They should be capable of accommodating all users, including mobility and visually impaired users. The use of sidewalks should be encouraged as an alternative to using the automobile to promote a healthier lifestyle.

The proper planning, design, construction, and maintenance of sidewalks will help achieve these objectives. The support of elected municipal officials as well as the senior management team of the municipality is needed to ensure development and sustainability of a safe and accessible sidewalk system.

1.2 PURPOSE AND SCOPE

The purpose of this best practice is to help decision makers understand the importance of safe and accessible sidewalks and provide managers and staff with tools to improve sidewalk infrastructure. It is important that sidewalks provide universal accessibility for the full range of users, including visually and mobility impaired users. Safe sidewalks will also reduce risks to users and increase user satisfaction.

When sidewalks are designed and constructed using best practices, the service life of the sidewalk can be extended thereby reducing life-cycle costs. Limited municipal financial resources can be optimized.

1.3 HOW TO USE THIS DOCUMENT

Section 2 presents some background information as well as the potential benefits and risks associated with the implementation of the best practice.

Section 3 presents information on the planning, design, construction, and maintenance of sidewalks.

Section 4 presents some considerations for the implementation of the sidewalk best practice.

Section 5 describes the benefits of implementing this best practice.

Section 6 outlines suggested areas for research related to sidewalks.

Throughout this guide, various references are provided where the reader can supplement information or obtain detailed information on technical specifications and standards contained in this best practice.

1.4 GLOSSARY

Accessibility — Barrier free access to assist persons with disabilities.

Air entrainment — Intentional introduction of air in the form of minute, disconnected bubbles, (generally smaller than 1 mm) during mixing of Portland cement concrete, mortar, grout or plaster to improve desirable characteristics, such as cohesion, workability, and durability.

Asset — A physical component of a facility, which has value, enables services to be provided, and has an economic life of greater than 12 months. Dynamic assets have some moving parts, while passive assets have none.

Customer — In this best practice, the residents and sidewalk users are referred to as customers.

Level of service — The defined service quality for a particular activity or service area against which service performance may be measured. Service levels usually relate to quality, quantity, reliability, responsiveness, environmental acceptability, and cost.

Life cycle costing — A method of expressing cost, in which both capital costs, and operations and maintenance costs are considered, in comparing different alternatives.

Maintenance — All actions necessary to retain an asset as near as practicable to its original condition.

Quality control — Actions taken by a producer or contractor to provide control over what is being done and what is being provided so applicable standards of good practices for the work are followed.

Rehabilitation — Works to rebuild or replace parts or components of an asset, to restore it to a required functional condition and extend its life, which may incorporate some modification. Generally involves repairing the asset to deliver its original level of service without resorting to significant upgrading or renewal, using available techniques and standards.

Replacement — The complete replacement of an asset that has reached the end of its service life to provide an alternative that satisfies the targeted level of service.

Service life — The time period that an asset provides an acceptable level of service. The economic service life is defined as the time period when the present worth of the future maintenance costs are equal to the present worth of its replacement.

Sidewalk user — Any person using the sidewalk including pedestrians, and persons in a wheeled vehicle or persons with disabilities including visual, hearing or mobility.

Tree drip line — The drip line is the edge defined by the extent of the leaves/growth of the tree.

2.0 RATIONALE

2.1 BACKGROUND

According to the National Research Council Institute for Research in Construction, there are about 100,000 km of sidewalks in Canada. It is estimated that 15 to 20 percent are in need of replacement at an estimated cost of $1.5 billion to $2.4 billion.

Municipal financial resources are limited and, generally, there are insufficient funds to keep pace with the deteriorating infrastructure. If proper planning, design, construction, and maintenance of sidewalks is undertaken, the service life of a concrete sidewalk can be extended to approximately 80 years. However, according to a survey undertaken for the preparation of this best practice, a majority of municipalities interviewed indicated their concrete sidewalks had a service life of from 20 to 40 years. This best practice is intended to provide information to extend the service life and, therefore, save considerable funds, which can be reallocated more effectively and efficiently.

Safe, accessible, esthetically pleasing sidewalks are an important component of the municipality's urban infrastructure. It is important to provide sidewalk users with safe accessible areas for walking outside of the traffic area. Deteriorating sidewalks can create hazards that affect public safety and liability.

The population of Canada is ageing; therefore, more senior citizens are using sidewalks. According to research undertaken by the City of Lethbridge, Alberta, senior citizens normally walk within a two-block radius of their homes. An injury due to a fall on the sidewalk can have a significant impact on a senior's lifestyle and can cost significant dollars to the health care system, not only in the immediate care related to the injury, but follow-up care related to impairment of mobility.

The location of sidewalk construction should be based on pedestrian needs, safety and affordability. With limited resources available for construction and maintenance, the municipality needs to optimize available funding to meet the greatest needs in the community. Once a sidewalk has been constructed within the public right-of-way, the municipality assumes the maintenance, rehabilitation, and replacement costs.

Some sidewalk design and construction practices have not changed to counter premature sidewalk failures. Poor winter maintenance practices can also cause damage to sidewalks, thereby shortening service life.

2.2 BENEFITS

Safe, accessible sidewalks, if appropriately designed, constructed and maintained, offer a number of benefits to the community and the broader society in general as follows:

- Attractive and functional sidewalks promote the healthy exercise of walking and reduce reliance on vehicular transportation.
- Appropriate design and construction facilitates the use of sidewalks by mobility and visually impaired users.
- The use of strollers, and other wheeled family recreational equipment can be comfortably accommodated.
- Customer comments are reduced.
- Life cycle costs are reduced.
- The service life of sidewalks is extended.
- The risk of injury to users is reduced.

2.3 RISKS

The following risks are assumed if best practices are not followed.

- Safety for sidewalk users is reduced, resulting in increased injuries to users and the associated higher health care costs.
- The level of service is reduced leading to more inquiries from users concerning sidewalk infrastructure.
- Service life is reduced requiring sidewalk replacement at an earlier date. This means higher life cycle costs for sidewalks.
- Accessibility to visually and mobility impaired users is reduced thereby restricting their use of sidewalks.
- Overall maintenance costs are increased.

Initially, the capital, operating, and maintenance costs may increase with the implementation of this best practice as the municipality catches up to its backlog. However, in the longer term, the municipality will gain the benefits of best practices with an opportunity for net savings and a sustainable sidewalk infrastructure, thereby showing due diligence.

3.0 WORK DESCRIPTION

3.1 PLANNING AND DESIGN

The average service life of a sidewalk depends on a variety of factors including environmental conditions, materials, design standards, construction quality, and maintenance standards. If best practices are undertaken throughout the life cycle of the sidewalk, the expected service life is:

- concrete – 80 years
- interlocking paving stones – 80 years
- asphalt – 40 years

Poorly designed and constructed sidewalks with inappropriate maintenance standards have a substantially shorter service life. Some sidewalks have been replaced within five years due to inappropriate practices.

This section outlines design, construction, and maintenance practices to assist municipalities in extending the service life of sidewalks. When the service life is extended, and if all other costs and factors are unchanged, the average life cycle cost for the sidewalk is lower, and the funding available to the municipality can be used more efficiently.

3.2 SIDEWALK INVENTORY AND ASSESSMENT OF CONDITION

Each municipality should have a current inventory and condition assessment of its sidewalks including information on the location of various deficiencies. This inventory can be used to set priorities for repair and replacement, and the appropriate budget allocations for sustainable funding.

The inventory should be updated regularly to reflect new sidewalks added to the system as well as recent repairs and replacements. The sidewalk inventory can be combined with the inventory of other municipal assets. The inventory system should also be capable of tracking customer inquiries and their status. With this information, the municipality can track the status from year to year on the overall condition of the sidewalks and inform senior management and Council.

3.3 UNIVERSAL DESIGN

Sidewalks should be designed for all users to incorporate the requirements for all users. Sidewalk characteristics with a significant impact on accessibility include grade and surface type, and the design and construction of curb ramps. Curb ramps provide access between the sidewalk and the street and, therefore, directly affect accessibility. The recommended guidelines are presented below starting at Section 3.4.

Pedestrians with visual impairments have different requirements for the design and construction of sidewalks than customers in wheelchairs. Pedestrians with visual impairments receive important navigational information from the sidewalk surface and edges. This is especially important at curb ramps. More information is provided below on recommended design for curb ramps to facilitate visually impaired pedestrians. Additional information on wheelchair accessibility and the visually impaired can be found in a report prepared by the US Department of Transportation, Federal Highway Administration (1999), *Designing Sidewalks and Trails for Access Part I of II: Review of Existing Guidelines and Practices*.

The US Access Board has developed draft design guidelines for various elements of public right-of-way. Information can be found on their website – **http://www.access-board.gov/**.

When sidewalks are being reconstructed at intersections and driveways, consideration should be given to revising the sidewalk and curb design to incorporate curb ramps that meet accessibility guideline criteria.

In areas where natural grades exceed the maximum grade of 8 percent for persons with a disability, it may not be technically feasible or operationally practical to provide a design solution at the problem location. Consideration should be given to identifying the problem with signage and, possibly providing an alternative route.

3.4 Sidewalk Location Guidelines

Sidewalks should provide a safe, comfortable area for pedestrians separated from the flow of traffic. Once sidewalks are constructed within the public right-of-way, the municipality assumes responsibility for all future repair, reconstruction, maintenance, and operation during the life of the asset. Therefore, it is important that long-term financial liability be recognized when the municipality decides when and where sidewalks are required.

3.4.1 New Rights-of-Way

Municipalities generally have development policies that outline which types of new streets require sidewalks, and whether sidewalks are required on one or both sides of the street. The developer will undertake, by agreement with the municipality, to ensure the sidewalk is constructed to the current municipal design standards and specifications and transfer the completed sidewalk to the municipality.

3.4.2 EXISTING RIGHTS-OF-WAY

Municipalities should use the listed criteria to develop their own methodology and selection procedure for locating new sidewalks. For older sections of the municipality, especially for residential areas, sidewalks may not have been included with the original roadway construction. The following factors should be considered when determining where in the community additional sidewalks should be constructed.

- addition of transit or school bus routes;
- providing access for the elderly and persons with disabilities;
- continuity of sidewalks (avoid missing sections of sidewalk where possible);
- increased pedestrian volumes;
- addition of new facilities including schools, institutions, parks, and sports complexes;
- the presence of other pedestrian generators (library, community centre, church, hospital, shopping precinct or mall);
- community input;
- vehicle speed, traffic, and truck volumes;
- collision data related to pedestrians;
- existing sidewalk on the other side of the street;
- weather implications (prevailing winds or sun/shade);
- type of roadway shoulder and width; and
- population density.

The municipality will receive petitions and inquiries from customers to construct new sidewalks along various streets. It is recommended that the criteria listed above be used to develop the municipality’s own methodology and selection procedure when the addition of sidewalks is being considered.

When sidewalks are not available, pedestrians normally walk on the roadway, increasing the likelihood of pedestrian injuries. Therefore, from a safety point of view, sidewalks should be considered on a minimum of one side of the street for arterial and collector roads. For local streets, the factors outlined above should be evaluated to determine where sidewalks should be constructed. There is a risk to installing, but there may also be a risk in not installing a sidewalk. A risk assessment should be undertaken by the municipality to determine potential liability in areas without sidewalks.

3.4.3 PEDESTRIAN ZONE

The width of the pedestrian zone for the sidewalk should be related to pedestrian demand, which is determined by the type of adjacent land uses. Each municipality should set its own guidelines for the minimum width of the pedestrian zone, depending on factors, such as pedestrian volumes, road classification, adjacent land use, and right-of-way width.

A clear pedestrian zone is required to accommodate pedestrians. No street furniture, trees, utilities, poles, signs, mailboxes, or other streetscape elements should be allowed in the pedestrian zone. Figures 3–1 and 3–2 show typical pedestrian zones for residential and commercial areas. The sidewalk grades and finishes in the pedestrian zone should be compatible with design guidelines outlined in Section 3.6.

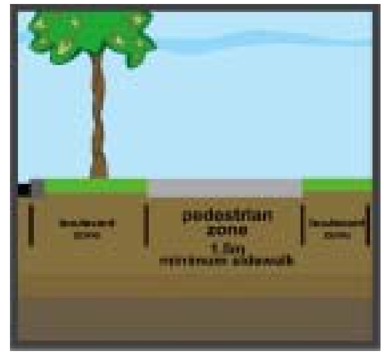

Figure 3–1: Pedestrian Zone in Typical Residential Street

This best practice recommends a minimum sidewalk width of 1.5 metres. When the sidewalk is located adjacent to the curb on major roadways, the width should be increased to 1.8 metres. The preferred width to provide for the safe passage between an adult and a person pushing a baby carriage or in a wheelchair, or a child on a tricycle is 1.8 metres.

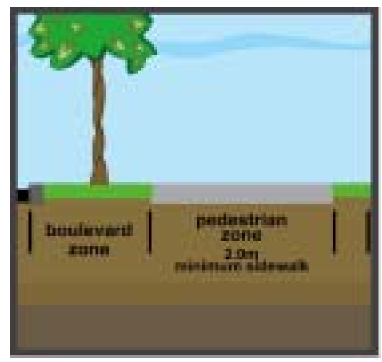

Figure 3–2: Pedestrian Zone in Typical Commercial Area

A minimum vertical clearance of 2.0 metres is recommended in the pedestrian zone from the sidewalk to potential obstacles such as tree branches, hanging baskets, signs and banners.

Near hospitals, schools, offices, industrial and commercial areas, where large pedestrian volumes may occur, the sidewalk width should be increased accordingly. In shopping and entertainment areas, sidewalk widths of at least 2 metres should be considered.

Sidewalks in residential areas should be located away from the roadway adjacent to the property line. An offset should be considered to ensure the sidewalk is constructed within the public right-of-way. The offset also allows for a utility corridor for a variety of uses, such as water boxes and gas valves. A minimum offset of 0.5 metres is recommended. The offset also provides a clearance to private retaining walls, fences and driveway curbs thereby facilitating municipal sidewalk winter maintenance activities.

3.5 SIDEWALK MATERIALS

3.5.1 BASIS OF MATERIALS SELECTION

According to the survey undertaken for this best practice, most sidewalks within the public right-of-way are constructed of concrete. Asphalt is the next choice followed by interlocking pavers. The life cycle cost of alternative sidewalk structures should be considered when selecting the type of sidewalk surface.

In choosing the material for the sidewalk, consideration should also be given to materials that are non-slip and provide adequate drainage, as well as the requirements of users with strollers, inline skates and also the visually and mobility impaired. It is recommended that, materials made with rough surfaces, not be placed in the pedestrian zone. Minimizing the joint width in the surface of the pedestrian zone will facilitate wheelchair, stroller and inline skates use of the sidewalk. Therefore, it is important that sidewalks be constructed and maintained with a textured, non-slip surface.

Location

Another consideration in material selection is the location of the sidewalk and durability requirements. If the sidewalk is located immediately behind the curb, it will need to be more durable than a sidewalk set further back. A sidewalk set further back from the curb has less potential for damage from vehicles who mount the curb and park on the boulevard.

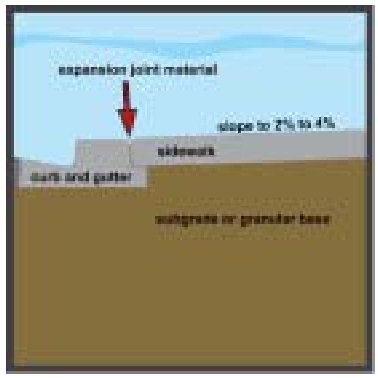

Figure 3–3: Typical Section – Concrete Sidewalk Adjacent to Curb and Gutter

In areas where the sidewalk is immediately adjacent to the back of the curb, two options are available for the design and construction of a concrete sidewalk. One option is to have the sidewalk integral with the curb, while the second is to have the back of the curb widened below the bottom of the sidewalk to minimize the potential for sidewalk settlement. The front of the sidewalk is then constructed on top of this lip (Figure 3–3). This design feature has been used successfully by many municipalities to minimize differential settlement between the front edge of the sidewalk and the back of curb.

Durability

In some commercial and industrial areas, service vehicles will tend to travel or park on the sidewalk area. When these conditions are present, the sidewalk must be designed to accommodate this loading. The sidewalk design cross-section should be modified which may include increasing the concrete thickness and granular depth for flexible pavements depending upon soil types, environmental conditions and other factors.

Similarly at intersections, the design of the sidewalk cross section should take into consideration that vehicles, especially trucks, might track onto the corner of the sidewalk when turning the corner.

Inspection and quality control during construction is critical during the installation of interlocking pavers.

Interlocking concrete pavements and concrete pavements are generally the lowest maintenance alternatives due to the durability requirements provided for both by the Canadian Standards Association (CSA). Nevertheless, settlement of interlocking concrete pavers can occur if the supporting soil structure is not properly constructed, whereas concrete may bridge minor localized problems. Therefore, it is strongly recommended that the municipality follow the design and construction practices outlined at the Interlocking Concrete Pavement Institute website (www.icpi.org).

3.5.2 MATERIAL TYPES

Concrete

Concrete sidewalks are the most common in North America, because of long-term serviceability and low maintenance costs. Initial construction costs for concrete sidewalks are higher than asphalt. Concrete reflects more light than asphalt and hence reduces the cost for sidewalk illumination. If adjacent roadways are constructed with asphalt, a visual contrast in colour is present which provides a definition between the roadway and sidewalk.

Asphalt

Asphalt sidewalks have lower initial construction costs and a shorter service life than concrete. Asphalt sidewalks are more susceptible to damage during snow removal and normally require more maintenance than concrete. Asphalt sidewalks are normally used where a shorter service life is required.

Interlocking Pavers

Interlocking paving stones may be more visually pleasing than concrete or asphalt sidewalks. The construction cost is normally higher than concrete. It is recommended that concrete pavers for a municipal project meet or exceed the requirements set forth in the Canadian Standards Association CSA-A231.2 (Latest Edition) *Precast Concrete Pavers*.

Interlocking pavers do not require any in-place curing time and, therefore, are not subject to vandalism during curing. Pavers can tolerate minor settlement in the subgrade surface without cracking. The joints in interlocking pavements are known to fill with sediment and detritus overtime. This will increase the runoff potential, however ponding will be exacerbated due to localized settlement if attention is not paid to proper subgrade and base compaction.

Alternative Materials

Some municipalities in the United States are using recycled rubber as a substitute for concrete. Since the first recycled rubber sidewalk was only installed in 1999, the evaluation of the long-term benefits and limitations has just begun.[1]

3.6 DESIGN CONSIDERATIONS

3.6.1 GRADES AND CROSSFALL

Generally, sidewalk grades follow the roadway. The grade of the sidewalk is permitted to be as steep as the adjacent roadway. When the sidewalk grade is steeper than the roadway grade and exceeds 8%, then the sidewalk should be treated as a ramp with appropriate rest areas and handrails. Sidewalks constructed at intersections and approaches should follow the guidelines for ramp design as noted below.

The recommended crossfall is 2 percent. The crossfall can range from 1 to a maximum of 4 percent to provide adequate drainage and minimize concerns of a sliding hazard on the sidewalk.

If there is a boulevard area between the sidewalk and the roadway, the grade and crossfall should be properly designed to facilitate drainage from the sidewalk area.

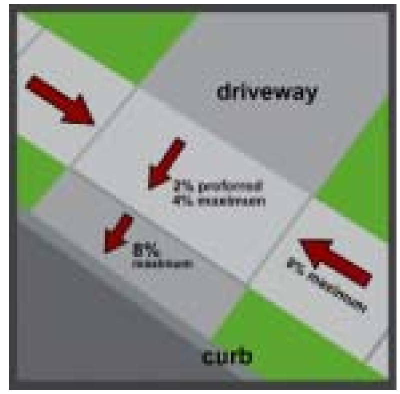

Figure 3–4: Driveway Apron – Where Sidewalk is Not Adjacent to the Curb

3.6.2 DRIVEWAY APRONS

It is desirable that driveway aprons not intrude into the pedestrian zone as shown in Figure 3–4. It is recommended to design the driveway apron slope to a maximum of 8 percent between the curb and the front of the sidewalk. To achieve this guideline, it may be necessary to drop the sidewalk partially through the driveway, when the sidewalk is located close to the curb. This approach is recommended instead of increasing the crossfall in the pedestrian zone, which should be kept at a recommended 2 to 4 percent crossfall.

When the boulevard is narrow or the sidewalk is integral to the curb, a depressed sidewalk may be used to meet wheelchair design guidelines. The depressed sidewalk should have maximum grades of 8 percent on the approaches to the depressed driveway area as shown in Figure 3–5. The crossfall should be kept to a recommended 2 percent across the driveway.

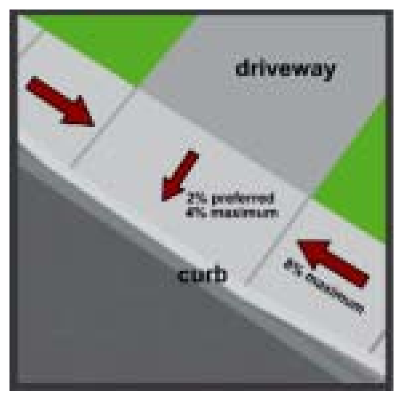

Figure 3–5: Driveway Apron – Where Sidewalk is Adjacent to the Curb

At driveway locations, the sidewalk cross-section should be increased to support the additional vehicular loading. The following minimum concrete sidewalk thicknesses are recommended:

- residential driveways – 150 mm; and
- commercial and industrial driveways – 175 mm or more.

[1] *Reducing Infrastructure Damage by Tree Roots – A Compendium of Strategies*, p.37

In driveway and laneway areas where wheelchair accessibility is required to the roadway, consideration should be given to providing an even transition between the curb and the roadway.

3.6.3 CURB RAMPS

Curb ramps allow universal access between the sidewalk and the street. The ramps are normally found at intersections, but can also be located between intersections.

A variety of curb ramp designs contain some or all of the following components shown in Figure 3–6. (U.S. Department of Transportation, Federal Highway Administration, Designing Sidewalks and Trails for Access Part I of II: Review of Existing Guidelines and Practices, July 1999).

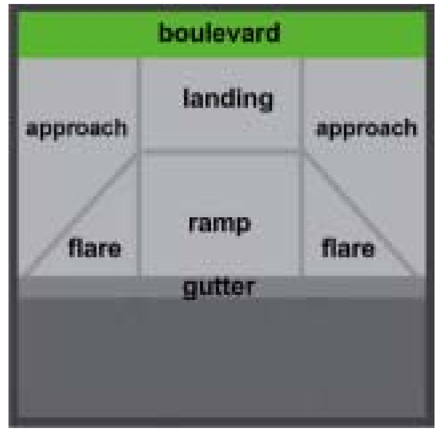

Figure 3–6: Curb Ramp Components

- **Landing –** The area at the back of the sidewalk, in the middle of the curb ramp. Landings allow the wheelchair user to move around the intersection corner without using the curb ramp. The recommended minimum landing width is 1.2 metres and maximum grade is 2 percent.

- **Approach –** The area on each side of the landing, extending from the back to the front of the sidewalk. The recommended maximum grade should not exceed 8 percent according to the accessibility guidelines.

- **Flare –** The transition area between the curb ramp and the approach areas. It is desirable that the slope on the flare not exceed 8 percent. However, if the grade is steeper, then it is recommended that the landing width be increased accordingly. The transition area can be grass in residential areas.

- **Ramp –** The sloped transition between the landing and the curb. To meet accessibility guidelines, the curb ramp grade should not exceed 8 percent. The preferred width of the curb ramp should be at least 1.2 metres, not including the width of the flairs.

- **Gutter –** The gutter is located at the bottom front face of the curb and provides drainage along the street. The preferred maximum slope on the gutter surface immediately adjacent to the curb should not exceed 5 percent. The curb should be trowelled level to the gutter on the roadside edge at the curb ramp. It is recommended that catchbasins not be located in the gutter in front of the ramp area to aid accessibility for wheel chairs.

At an intersection corner, a municipality may decide to have one diagonal curb ramp located in the middle of the curb radius or two separate perpendicular curb ramps, one at each pedestrian crossing location, as shown in figures 3–7 and 3–8.

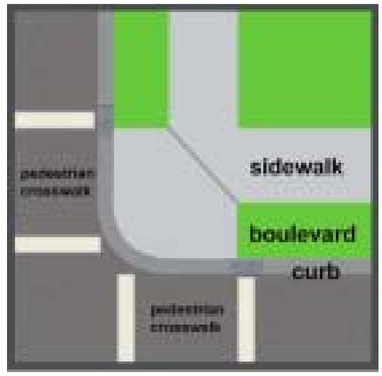

Figure 3–7: Curb Ramps – One Curb Ramp at Intersection

Two perpendicular curb ramps with level landings are recommended, because they are considered to be generally safer and more usable for pedestrians than a single diagonal curb ramp. For the diagonal curb ramp, the width of the ramp must be sufficient to allow wheelchairs to continue across the intersection without directing them into the centre of the intersection. The installation of ramps should take place on all four corners of the intersection.

Figure 3–8: Curb Ramps – Two Separate Ramps at Intersection

Additional information on the design of curb ramps can be found in the report prepared by the U.S. Department of Transportation, Federal Highway Administration (1999) for *Designing Sidewalks and Trails for Access, Part 1 of II: Review of Existing Guidelines and Practices*[2]. Only the ramp and landing areas need to be constructed of even, solid materials. The flairs and area between ramps can be landscaped or decoratively paved.

Visual Impairments

Pedestrians with visual impairments utilize curb ramps differently than pedestrians with or without mobility impairments. Several methods are available to assist people with visual impairments at an intersection, including raised tactile surfaces, materials with contrasting sound properties, grooves in the sidewalk, and installation of audible warnings at intersections with signals. The FHWA report is a good source of information related to curb ramps and pedestrians with visual impairments.

The US Access Board has developed draft design guidelines for various elements of public rights-of-way including sidewalks. Information is available at their website www.access-board.gov**.**

[2] This report is available on the web at **http://www.fhwa.dot.gov/environment/bikeped/access-1.htm**

It is recommended that research be undertaken in Canada to develop the guidelines to improve accessibility for pedestrians with visual impairments.

Figures 3–9 and 3–10 show examples of grooves in the sidewalk in Vancouver, which were designed in conjunction with a local advocacy group. The score lines are parallel to the line of travel for wheeled vehicles and do not create a bumpy ride. The score lines also assist the visually impaired using canes.

Figure 3–9: Examples of Grooves in Sidewalk

3.6.4 Surface Finish and Jointing

To aid accessibility, it is important that the decorative jointing/scoring is minimized in the pedestrian zone. For concrete surfaces, saw cutting the control / construction joints and a broom finish is recommended. Any joints in the sidewalk should be as even, level and as narrow as possible to facilitate movement of wheeled vehicles, seniors and the visually impaired.

For interlocking pavers, the maximum variation in height between adjacent units should be 2 mm.

Figure 3–10: Examples of Grooves in Sidewalk

3.6.5 Trees and Landscaping

Trees are an important component of the urban landscape and provide aesthetic, environmental, and social benefits. Trees add value to the area and must be taken into account and balanced as part of the street infrastructure requirements.

Tree root damage to sidewalks varies drastically from city to city, block to block, and tree to tree. In some cases, a sidewalk may never be damaged by a tree growing directly adjacent to it. On the other hand, a small tree can completely upheave a sidewalk causing a major pedestrian hazard. The degree of damage to a sidewalk is not always known, however, variables such as soil type, tree species, growing space and construction practices appear to play a pivotal role. Recognizing this damage requires on-going management and is critical to the existence of both the tree and the sidewalk. For example, trees can lead to considerable maintenance costs to repair damage to sidewalks and other infrastructure including curbs, sewers, and driveways. The report, *Reducing Infrastructure Damage by Tree Roots: A Compendium of Strategies* (Costello and Jones, 2003) offers a good source of information regarding strategies to reduce potential infrastructure damage. Information on where to obtain a copy of the report is found in the References.

Selecting the appropriate tree species for the proposed planting space is one of the key preventive strategies to avoid conflicts later with sidewalks and other infrastructure. Tree species which generate roots that grow near the soil surface have a high potential to damage sidewalks unless the planting area is sufficiently large, ideally to the size of the tree drip line area. Increasing space around established trees by curving the sidewalk is another option. An alternative is to reduce the width of the roadway or remove parking spaces to create space for trees and landscaping. Directing roots away from the sidewalk area can reduce potential damage. Root barriers installed at the edge of the sidewalk as shown in Figure 3–11 may also deflect roots. The root barrier can be thermoplastic panels, or sheets. Various methods to channel the growth of roots in specific areas can also be used, such as trenches or pipes filled with soil favourable for root development (Costello and Jones, 2003).

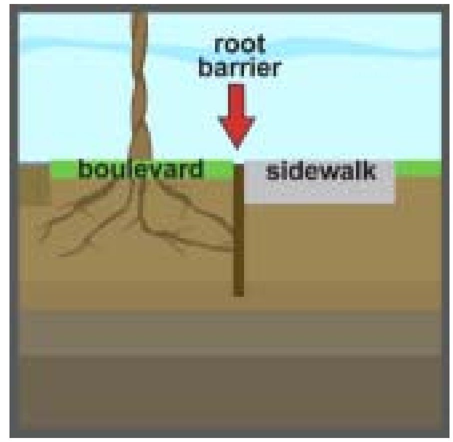

Figure 3–11: Root Barrier Parallel to Sidewalk

Structural soil can also be used to distribute tree roots through the soil to reduce the potential for damage to adjacent sidewalks. Structural soil is a mixture of soil and stone, or soil and a derived aggregate, such as expanded slate or shale. The mixture may also use a stabilizing material to encourage consistency. When planting space is limited, use of structural soil as a replacement for native soils should be considered. Information on structural soil and root barriers can be found in Costello and Jones (2003).

As a guideline, up to 30 percent of the tree roots within the drip line can be removed without any adverse effect on the tree. Furthermore, changes in grade by placing fill or removing soil within the drip line area should be minimized whenever possible. Finally, where projects involve removing and replacing sidewalks near large trees, an arborist should be consulted in the planning stages.

3.6.6 WINTER DESIGN CONSIDERATIONS

Sidewalks should be designed to increase user friendliness and minimize effects of winter snow and wind.

The prevailing wind in the northern hemisphere is from the northwest. When sidewalks are constructed on only one side of a roadway, consideration should be given to placing the sidewalk on either the north or west side of the roadway.

Prevailing wind direction should be considered when selecting sidewalk locations on or under bridges.

Bridge retaining walls, abutments, piers, and pedestrian protections such as New Jersey Barriers act as snow fences, resulting in accumulation of drifts from blowing snow. Wind direction should be considered when selecting the location of sidewalks on and under bridges.

A boulevard area between the roadway and the sidewalk provides a location for snow storage from roadway plowing operations. When the sidewalk is located immediately adjacent to the roadway, the snow plowed from the roadway will be placed on the sidewalk. For municipalities who plow sidewalks, it is important to schedule the sidewalk clearing after the roadway plowing.

New Jersey Barrier and similar barriers placed in front of sidewalks should have large openings at the bottom to allow snow to blow away from the sidewalk. These openings also allow snow melt to run off away from sidewalks and boulevard area to the roadway.

3.7 CONSTRUCTION

Construction practices have a significant impact on the service life of sidewalks. On-site inspectors who ensure that the appropriate levels of compaction are achieved will play a key role to ensure that the installation is successful and premature failures are minimized. Compaction of the subgrade and base are critical thus it is important that all contractors understand the importance of achieving the required compaction levels.

The Institute for Research in Construction of the National Research Council has conducted a number of investigations into performance of concrete sidewalks. Construction Technology updates 53 and 54 (Rajani, 2002 a,b) are especially helpful; information on the purchase of these updates can be found at <http://irc.nrc-cnrc.gc.ca>.

3.7.1 SUBGRADE

Subgrade is defined as a native soil that is graded and compacted to provide an even surface to support the sidewalk Reference (Construction Technology Update No. 54, Institute for Research in Construction). All frost-susceptible materials should be removed from the subgrade and replaced with granular or non-frost susceptible materials, whenever practical. If not practical, the use of cement, cement kiln dust, or lime-modified subgrades may improve the engineering properties of the soil. It is important that the subgrade be a uniform material with no abrupt changes in soil conditions. The subgrade should be a well-drained material with a uniform bearing capacity.

It is essential that the subgrade be uniformly compacted to a minimum 98 percent standard Proctor density. It is also essential that all previous utility trenches that cross the sidewalk area are excavated and recompacted properly to minimize differential settlement of the subgrade. At a minimum, uniform compaction reduces the differential settlement and, consequently, the various types of cracking.

3.7.2 BASE

The base is a layer of granular material placed on top of the uniformly compacted subgrade. The best practice is to provide a minimum 100 mm to 150 mm of free-draining granular material under the concrete, asphalt and interlocking paver sidewalks. In some locations, soil and environmental conditions may be such that only a leveling course of granular material is required under concrete sidewalks.

A report on concrete sidewalks prepared by the Institute for Research in Construction of the National Research Council highly recommends a layer of 100 mm to 150 mm of compacted granular material, because it reduces tensile cracking stresses and consequent cracking. The base material also provides a uniform support by bridging over minor subgrade defects. This is important when the underlying soil is susceptible to shrinkage from moisture depletion and frost heave during cold seasons. The investment in the granular material will be repaid several times over in the extended service life of the sidewalk.

When the sidewalk is located immediately behind the curb, consideration should be given to installing a subdrain system placed parallel to the curb and connected to a catch basin or some other positive drainage outlet. The subdrain will facilitate the removal of water away from the base and assist in reducing frost heave of the sidewalk. In colder climates, increasing the depth of granular material and sloping the sidewalk subgrade toward the curb can also help reduce heaving due to freeze–thaw cycles.

The Interlocking Concrete Pavement Institute has prepared several technical specifications on design and construction for concrete pavers. These technical specifications can be found at the website <http://www.icpi.org>. A minimum of 100 mm of compacted granular material is recommended for sidewalks. This is increased to a minimum thickness of 150 mm at driveway locations. A minimum of 200 mm is recommended over slow draining soils and frost zones. In colder climates and in areas of continually wet or weak soils, the recommended minimum thickness is increased by at least 50 to 100 mm, resulting in a minimum of 150 – 200 mm.

Compaction of the soil subgrade and granular material should be a minimum of 95% standard Proctor density for poured in place concrete and asphalt sidewalks and 98% standard Proctor density for interlocking concrete pavements. Monitoring and inspection of the density of compacted soil and base materials will provide greater assurance of a stable surface over the service life of the pavement. Special attention should be paid to measuring and inspecting density in areas next to curbs, buildings, utility structures and other pavements that may be in the sidewalk area.

All interlocking concrete pavements require edge restraints to hold the pavers in place. These are typically concrete curbs. If plastic edge restraints are used, the compacted granular material should extend at least 150 mm beyond the back of the edge restraints to provide support.

It is important to ensure sound sidewalk construction techniques are used to maximize service life and minimize maintenance.

Geotextile fabric may be considered in areas where there are freeze–thaw cycles or over clay and moist silty subgrade soils, where part of the subgrade may become saturated during the year.

Proper sampling and testing of the materials, including compaction testing, is important to ensure appropriate construction techniques are used so the service life of the sidewalk is not shortened due to poor construction practices and incorrect material selection and installation.

3.7.3 MATERIALS AND CONSTRUCTION

Concrete
Concrete will be exposed to freeze–thaw cycles and de-icing salts; therefore, the recommended concrete standard for sidewalk construction is CSA-A23.1 latest edition. A summary of the standard is as follows:

- minimum 28-day compressive strength of 32 MPa;
- air content based on maximum size aggregate of up to 20 mm (recommend 5.0 to 8 percent) or 4.0 to 7.0 percent if aggregate size is up to 40 mm;
- nominal maximum size of aggregate up to 40 mm;
- maximum water cementing ratio 0.45; and
- exposure classification C–2;

Supplementary cementing materials (SCM) can be used, based on CSA Standards and local conditions. Some examples of SCM's are slag cement, fly ash, and silica fume.

The thickness of the sidewalk slab will depend on the subgrade material and expected axle loading. The Canadian Portland Cement Association (now known as the Cement Association of Canada or CAC) publication *Concrete Parking Areas Design and Construction* (nd-a) outlines the recommended concrete thickness for a variety of axle loadings and subgrade conditions. The minimum recommended depth for light axle loadings is 110 mm on a sand/gravel subgrade and 130 mm on a silt/clay subgrade. For heavy axle loading, which would be appropriate for most driveway locations, the minimum recommended concrete depth is 140 mm for a sand/gravel subgrade and 160 mm for a silt/clay subgrade considering up to 40 axle load repetitions per week. Light axle loadings are predominately passenger cars with some commercial vehicles up to 4 tonnes single axle. Heavy axle loadings are tractor semi-trailer units up to 8 tonnes for single axles and 13 tonnes for tandem axles.

Information on the construction of concrete sidewalks can be found at various sources including the CPCA (now CAC) publication (nd-a, nd-b) as well as the National Research Council Construction Technology updates 53 and 54 (Rajani 2002 a,b). A general summary of the main construction procedures follows.

Concrete Forming and Placement

Sidewalks may be constructed using timber or metal forms or may be slip formed by machine. Concrete should not be placed on a frozen subgrade or base. The granular material immediately ahead of the concrete-placing operation should be wetted down thoroughly, concrete should be placed continuously and consolidated. Concrete should be levelled and the appropriate surface finish applied before the concrete sets.

Good curing procedures will have a positive impact on the strength, durability and longevity of concrete sidewalks.

While the concrete is hydrating, it is essential that all exposed surfaces be properly cured to prevent loss of moisture. It is important to avoid wet–dry cycles since the curing procedures will have an important impact on the strength, durability, and longevity of the concrete sidewalk.

It is highly recommended that all concrete be allowed to air dry for one month before de-icing salts are applied. If a one-month period is not available, then a lower water/cement ratio should be used and de-icing salts not applied until curing is complete.

In cold weather, at or below 5ºC, fresh concrete needs to be protected from freezing during the required curing period. Protection methods include insulation blankets or polyethylene sheets, and straw or similar materials. Considerations should be given to using a lower water cement ratio to minimize the amount of water in the sidewalk.

In hot weather, at or above 30°C, the initial temperature of the concrete should be reduced to prevent shrinkage.

Joints

Full depth isolation joints should be placed adjacent to existing rigid structures such as poles, walls, hydrants and buildings. Isolation joints should also be located at the beginning and end of curved sections of sidewalk and at all intersections. Refer to CPCA (now CAC) publications for more information. Isolation joint material usually consists of approximately 12 mm of compressible material, which will allow adjacent sidewalk sections to move independently of each other.

Control joints, also known as contraction joints, provide a location where drying shrinkage cracks can occur without affecting the appearance of the sidewalk. Control joints are to be located at a maximum distance of 24 to 30 times the thickness of the concrete. The transverse contraction joint should extend to a depth of one quarter to one third of the depth of the concrete sidewalk and be a maximum width of 5 mm. If the sidewalk width is 2.5 metres or greater, a control joint should also be formed along the centre line of the walk. It is recommended that the control joints be saw cut instead of trowelled.

It is important that proper quality assurance be undertaken during construction, through sampling and testing of materials and compaction, to ensure standards and specifications are being met, thus extending the durability and life cycle of the sidewalk as long as possible.

Asphaltic Concrete

The recommended asphaltic concrete specification for sidewalk construction is as follows:

- asphalt cement content 5 to 7 percent;
- voids in mineral aggregate (VMA) 16 percent minimum;
- air voids 2.5 to 5 percent;
- stability minimum of 4 kN;
- flow of 6 to 16; and
- maximum aggregate size 12 mm.

The use of Performance Graded Asphalt should be considered for sidewalks. The municipality can select the appropriate performance grade depending on their climate conditions.

Minimum depth of asphalt is suggested at 50 mm. Consideration should be given to increasing the depth at commercial and industrial driveways. Asphalt may be placed by hand or with a small mechanical spreader, depending on the width of the sidewalk area. A uniform depth of asphalt should be placed and compacted. A nuclear gauge should be utilized to determine the compaction obtained and compared to the municipal requirements. Segregation of the surface of the asphalt should be avoided as it will allow water to penetrate the asphalt and shorten the service life.

Asphalt should not be placed on a frozen subgrade. Appropriate quality assurance should be undertaken during construction to ensure materials and workmanship conform to the specifications.

Geotextiles will prevent the loss of sand along edges and minimize settlement in interlocking power installations.

Interlocking Paving Stones

Inspection and quality control during construction is critical, especially compaction, to obtain a finished product which minimizes differential settlements of individual pavers. The Interlocking Concrete Pavement Institute has prepared several technical specifications on the design and construction procedures for pavers. A summary of the information is provided below. Additional information can be found at <www.icpi.org>.

Edge restraints provide lateral resistance to vertical loads and keep the interlocking pavers confined adjacent to each other. It is a best practice to use edge restraints for all interlocking paver projects. To eliminate loss of bedding sand at the edge of the pavement, geotextile should be placed on the top of the base material for a minimum width of 300 mm behind the edge of the restraint and vertically to the top of the paver unit. A 300 mm wide strip of geotextile should be placed on the top of the base and wrapped up the inside edge of the restraint extending to the top of the paver.

Bedding sand is placed on the base granular material and its gradation should conform to CSA A23.2 with no greater than 1% passing the 0.080 mm sieve. The bedding sand should be spread and compacted to a uniform depth between 25 to 40 mm. The depth of the bedding sand should not exceed 40 mm to minimize localized settlement of individual pavers.

The paving stones should meet or exceed the requirements set forth in the Canadian Standards Association specification, CSA–A231.2 (Latest Edition) Precast Concrete Pavers. Paving stones are placed on the bedding sand which has been uniformly leveled. Joints between the paving stones should be between 2 to 5 mm to allow the sand to enter between each paving stone unit. Paving stones should be compacted with a vibrating plate compactor which will be capable of exerting 5,000 lbs. (22 kN) of compaction force. The compaction will seat the paving stones into the bedding sand and force the sand into the joints. Most settlement of paving stones occurs near edges and around utility boxes due to insufficient compactors or a poor subgrade. Extra care should be taken to ensure that these areas are well compacted using a mechanical tamper. Jointing sand should be placed and swept into the joints until they are full. The pavers should be compacted again and jointing sand added until all the joints are full. Excess sand should be swept from the surface of the interlocking paving stones to provide the finished surface.

The ICPI recommends that all interlocking concrete pavements should be designed as flexible pavement over dense graded base. Nevertheless, pavers can be overlain on a lean concrete or cement treated base with the same thickness of sand bedding layer on top. If this is done, attention to drainage of the bedding sand layer and the prevention of bedding sand loss through the base is critical. The cities of Edmonton and Winnipeg currently follow this procedure for interlocking paving stone installations to eliminate settlements, extend the life of the pavements and reduce maintenance costs.

It is always recommended that extra pavers are purchased from the same production run as the initial installation and stored for use in future maintenance and repair.

Other Materials

Other materials, such as rubber and composites (e.g., brick over concrete), are also used for sidewalk construction. These materials are in limited use in Canada at present and, therefore, are not described in this report.

3.7.4 TREE PROTECTION DURING SIDEWALK CONSTRUCTION

Trees that are not impacted by sidewalk construction should be protected from construction equipment through the use boarding or other similar methods. Whenever possible, the entire drip line of the tree should be protected from construction activities.

When roots have damaged the sidewalk and repairs are undertaken, the tree roots causing the damage are normally removed. This can impact the structural strength and health of the tree. If roots are required to be cut, then a sharp clean cut is needed to minimize damage to the tree roots. When roots are removed it may be necessary to prune the tree. It is recommended that an arborist be retained to review the trees affected before sidewalk construction begins.

In most species of trees, the majority of the feeder tree roots grow within the top 500 mm of soil. For trees where the roots are to be affected by construction, it is suggested that fertilizer be applied for root growth before the sidewalk construction begins and annually for up to three years.

3.8 MAINTENANCE

The main causes a sidewalk problems and failures are: freeze/thaw of subgrade (insufficient drainage), tree roots (poor planning), settlement of base materials, inferior installations, and poor surface finishing (poor quality control).

After construction, sidewalks may heave, tilt, and crack in various patterns for a variety of reasons. Based on the survey of 15 municipalities conducted as part of this Best Practice, the main causes of problems related to sidewalks are:

- Freeze/thaw cycle – affecting soil conditions in concrete properties;
- Tree roots; and
- Structural failure.

3.8.1 Failure Mechanisms

The Institute for Research in Construction of the National Research Council has undertaken an extensive study of concrete sidewalk behavior and has defined the following four major deformation modes in Rajani (2002a).

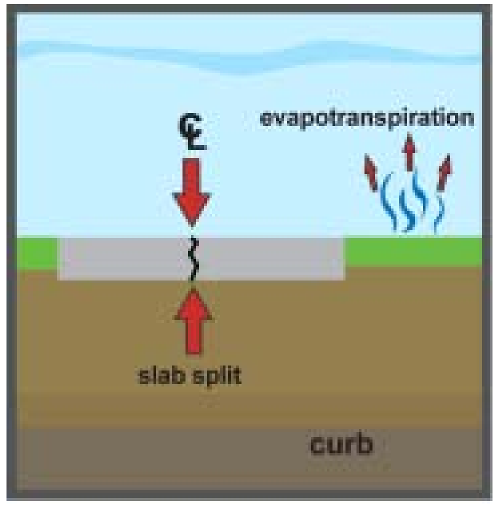

Figure 3–12: Tensile Shrinkage of Concrete Sidewalk

Rigid Body Uplift or Settlement

The tendency for the sidewalk slab to rise, subside, or tilt as a result of expansive native soil, frost action, or thermal expansion of the concrete slab.

Tensile Shrinkage

Deformation resulting from tensile stresses caused by the shrinkage of underlying soil from decreasing moisture content (Figure 3–12).

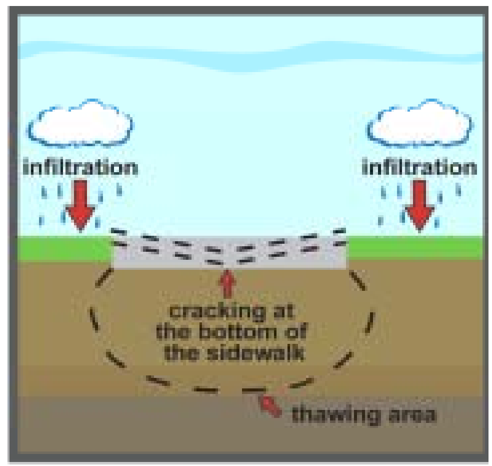

Figure 3–13: Sagging of Concrete Sidewalk

Sagging

The unequal movement of the slab as a result of the centre of the sidewalk having a larger thaw settlement than at the edges, or native soil conditions where clays swell significantly at the edges. This leads to longitudinal cracking (Figure 3–13).

Hogging

Unequal movement of the slab caused by frost heave or upward vertical movement due to swelling of clay native soils being greater at the centre than at the edges. Hogging also leads to longitudinal cracking (Figure 3–14).

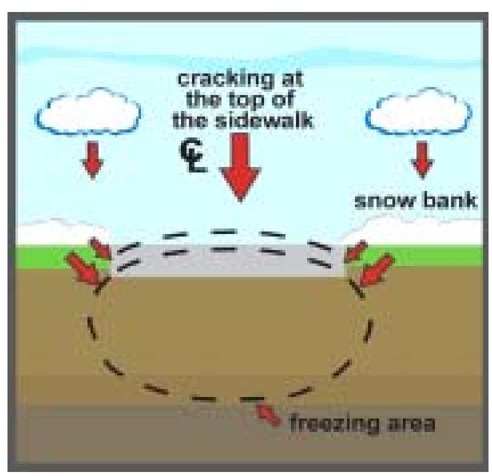

Figure 3–14: Hogging of Concrete Sidewalk

Deformation of the concrete sidewalk may result in longitudinal cracks, transverse cracks, and corner breaks.

Longitudinal cracks occur along the length of the sidewalk, usually in the middle third of the sidewalk and can extend through several expansion or control joints (Figure 3–15).

Transverse cracks occur across the width of the sidewalk due to non-uniform subgrade compaction where sidewalks are subjected to high vehicle loads (Figure 3–16).

Corner cracking is non-diagonal cracking occurring at the corners of a slab resulting primarily from non-uniform subgrade compaction (Figure 3–17). This is usually a sign of loss of support under the concrete.

Surface defects in concrete such as scaling, spalling, and popouts are caused by either poor curing practices, poor concrete placement and finishing techniques, or poor concrete quality. These surface defects affect the appearance and may also become a safety concern.

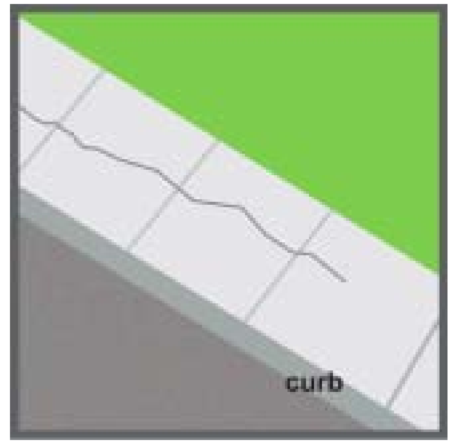

Figure 3–15: Longitudinal Cracks

3.8.2 TREE ROOTS

Trees can also cause damage to sidewalks. Forces exerted by the tree roots can crack and cause vertical separation along the cracked joint.

Tree roots can also accelerate the depletion of moisture in the subgrade, leading to cracking of the concrete sidewalk. Damage is created when the sidewalk is constructed directly on clay that is prone to significant volume changes from moisture depletion. Using segmental flexible pavements, such as interlocking concrete pavers, are an effective way to minimize tree root damage to sidewalks.

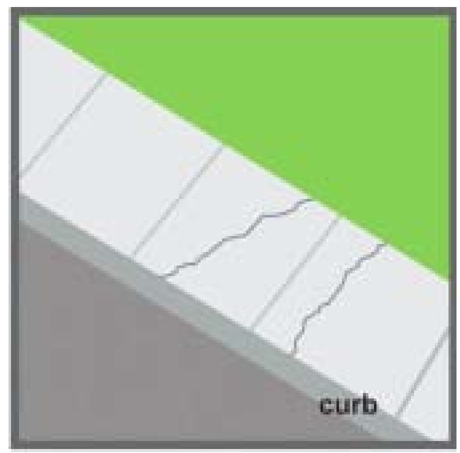

Figure 3–16: Transverse Cracks

3.8.3 REMEDIAL MEASURES

When maintenance is required, it is important to first identify the primary cause of the problem. Once identified, the appropriate action can be taken to resolve the problem so it does not reoccur.

When deformities in the concrete sidewalk occur, various remedial measures are available as outlined below.

If a crack does not widen or there is no vertical elevation difference across the crack, then from a safety point of view, no action is required. However, the municipality may decide to replace the sidewalk for esthetic reasons, especially if there is good probability a vertical separation may occur

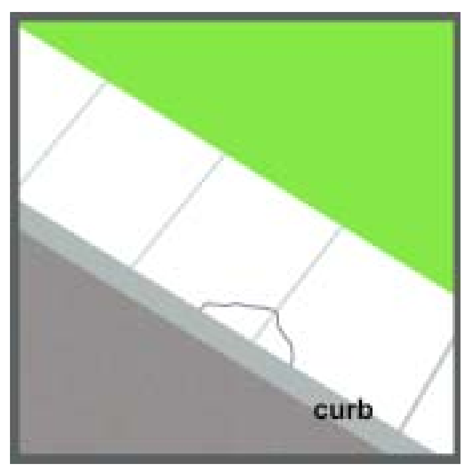

Figure 3–17: Corner Cracks

along the crack in the future. If a crack widens to greater than 10 mm, it is recommended that the sidewalk section be corrected by either replacement or repair.
When a difference in elevation occurs across the crack of a concrete sidewalk, various options are available for repair.

- Grind the elevated sidewalk edge (joint or crack) to establish an even, continuous surface across the crack area when the differential elevation is 20 mm or less. If the sidewalk continues to lift, then it must be replaced or the sidewalk edge ground again.

- Construct an asphalt or concrete ramp to remove the transition from one edge of the slab to the other. The ramp is usually a temporary measure. Asphalt patches can be a nighttime visibility issue and, therefore, the permanent repair should be programmed into the maintenance schedule.

- Saw cut the elevated concrete sidewalk surface to establish an even, continuous surface across the crack. The maximum depth of sidewalk surface to be removed is 20 mm in driveway areas and 40 mm at other locations.

- When the sidewalk has tilted or undergone some uniform movement, mud jacking can be utilized to relevel the sidewalk. Mud jacking means that a cement grout or slurry is injected below the lower section of the sidewalk and any voids under the sidewalk are filled and then the pressure of the grout raises the slab to the required elevation. The sidewalk area to be mud-jacked should be free of cracks and have no significant spalling.

According to National Research Council investigations, mud-jacking is about 10 to 50 percent of the cost of new construction and requires careful application. Mud-jacking costs can vary significantly across municipalities, depending on the number of contractors available and their expertise. Mud-jacking doesn’t always achieve a level surface with the adjacent concrete slabs, and grinding is sometimes required.

Some municipalities have successfully undertaken crack sealing with a clear compound. A mastic product is not recommend as it will impact wheeled vehicles and in line skates.

At locations where the sidewalk is integral with the curb, tie bars can be placed into the back of the curb and the front of the sidewalk to prevent differential heaving of the sidewalk during freeze–thaw cycles. The sidewalk slab should also be thicker adjacent to the back of the curb. Another alternative is to construct a step in the back of the curb to support the front edge of the sidewalk as shown in Figure 3–3.

The sidewalk slab should be thicker adjacent to the back of the curb.

Asphalt sidewalks may heave for the various reasons outlined above. If the surface of the asphalt becomes unsafe due to heaving, it is recommended that the asphalt and the granular base be removed, the problem causing the heaving rectified, and the granular base and surface replaced and compacted to the standard specifications.
Crack sealing of asphalt sidewalks is undertaken by several municipalities. Rubber crack sealing is not recommended as it sticks to inline skate wheels creating a tripping hazard.

When concrete pavers heave, it is recommended that the same approach be taken as with asphalt sidewalks. However, concrete pavers can be reinstated contributing to a sustainable infrastructure.

3.8.4 WINTER MAINTENANCE

Winter maintenance of sidewalks varies significantly among municipalities across Canada. Some municipalities plow, salt, and sand the sidewalks, while others view it as the property owners' responsibility. If this method is chosen for the abutting owner to clear the municipal sidewalk of snow and ice and keep it clear, the municipality must realize that they cannot transfer their liability for damages from a slip and fall to an abutting property owner.

An important aspect of winter maintenance is striking a balance between the amount of salt needed to provide a safe walking area while minimizing the effects of salt on the environment. It is recommended that each municipality develop a salt management plan and convey this information to the public through newspapers and other media options. The Transportation Association of Canada (1999) has prepared a salt management guide that addresses key issues related to road salting.

If the municipality clears sidewalks, it is important that the municipality outline, by way of council resolution, the accepted level of service for clearing, salting, and sanding sidewalks. This accepted level should be communicated to the public.

It is important that the sidewalk pedestrian zone be kept safe and clear during the winter. Street furniture, such as benches, should be removed during the winter months where possible.

It is also important to identify any driveway retaining walls or other objects that the property owner may have recently constructed within 300 mm to 500 mm of a back edge of the sidewalk. If these objects conflict with municipal snowplowing operations, it is recommended that the municipality discuss the issue with the property owner and ask the property owner to remove any obstructions within the public right-of-way.

It is difficult for sidewalk plow operators to follow a winding sidewalk. If the municipality is clearing snow, the alignment of the sidewalk should be considered.

For mobility concerns, sidewalk plowing near transit stops should be a priority.

3.8.5 PREVENTIVE MAINTENANCE

Undertaking preventive maintenance is a cost-effective measure to minimize the life-cycle costs for sidewalks. Many preventive maintenance features can be included in good design and construction practices. These measures include:

- pruning roots or installing root barriers before the sidewalk is impacted;
- repairing localized defects before they become a larger problem; and
- providing good drainage across the sidewalk and boulevard area.

Lethbridge Alberta has developed a program to cut the tree roots on each side of the sidewalk before damage occurs. Tree roots are cut about 150 mm deep with a saw mounted on a specially adapted skid steer loader. In observations to date, root cutting has had minimal negative impact on the trees. An arborist should be consulted before undertaking this activity.

In municipalities where road sand is utilized during winter maintenance, the sand can accumulate on the boulevard area over time as a result of plowing snow and snow storage. Regrading boulevards to remove the sand accumulation is recommended to maintain good drainage across the sidewalk and boulevard areas.

4. APPLICATIONS AND LIMITATIONS

4.1 APPLICATION

This best practice applies to all sidewalks within public right-of-ways, but must be tailored to reflect local climatic conditions, regulations, agency requirements, and level of service as established by the municipality.

4.2 LIMITATIONS

It is recommended that this best practice be reviewed every five years to be updated to reflect any new research findings or technology development.

5. BENEFITS OF USING THE GUIDE

The best practices outlined in this guide provide the following benefits to the municipality.

- Risks to pedestrians from falling or tripping on sidewalks are minimized due to the reduction in the number of potential hazards.
- Customer satisfaction increases as a result of the greater safety and comfort of the sidewalk system.
- The number of customer requests for repairs declines.
- Maintenance is reduced, service life increases, and life cycle costs decline.
- The aesthetic value of the sidewalk infrastructure is increased.

If the various repair strategies outlined in this best practice are undertaken at the appropriate time, then more extensive sidewalk replacement can be avoided.

6. AREAS FOR FUTURE RESEARCH

Research should be undertaken in several areas to extend the service life for sidewalks and reduce capital and maintenance costs.

- Mud-jacking of concrete sidewalks is a repair method which has been used by several municipalities to reduce rehabilitation costs. It is recommended that the materials and techniques required to undertake mud-jacking be investigated and improved.

- Saw cutting of elevated concrete sidewalk surfaces to establish an even, continuous surface across the crack is an alternative to mudjacking. The performance standards need to be developed.

- Structural soil is a relatively new product that can meet engineering load requirements and assist in controlling root growth in confined spaces. A specification on the use of structural soil should be developed for the various soil types across Canada.

- Research can be undertaken on the benefits of potentially using rubber sidewalks in Canada. Since 1999, rubber sidewalks have been constructed in California. The research would evaluate the California experience and determine if rubber sidewalks would be appropriate and cost effective in the Canadian climate. The use of recycled materials could also be examined. If so, the appropriate design standards and specifications need to be developed.

- Sidewalk users with visual impairments would benefit from a detectable warning surface at interface areas with vehicles. Various types of measures are being utilized in the USA, England, Sweden and Japan (US Access Board), such as raised sidewalk lines, grooves in sidewalks, and truncated domes. Information on investigations undertaken in the USA is available on the US Access Board website, <www.access-board.gov>. Research should be undertaken to determine the most appropriate type or types which are compatible with Canadian requirements and climate conditions.

Continuous improvement through research and rethinking how we do things is essential to improving sidewalks infrastructure across Canada.

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