Report Title: Testing Different Materials for Tactile Walking Surface Indicators – Pilot Project Evaluation Report

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1.0 Introduction

The City of Toronto is developing a new standard for pedestrian intersection crossings at curb depressions to comply with the Design of Public Spaces Standards, which is Part IV.1 of Ontario Regulation 191/11, Accessibility for Ontarians with Disabilities Act, 2005. One of the new legislative requirements is the requirement for raised tactile walking surface indicators at the bottom of curb ramps and depressed curbs to assist visually-impaired pedestrians with detecting hazards such as the edge of the roadway. This report provides an overview of a pilot project conducted by the City of Toronto from November 2012 to December 2013 to test different tactile walking surface indicator materials, and summarizes the evaluation of the performance of the various materials in terms of installation, durability (physical condition), and cost.

1.1 Background

On December 12, 2012, The Province of Ontario passed Ontario Regulation 413/12 to amend Ontario Regulation 191/11, Accessibility for Ontarians with Disabilities Act, 2005 (AODA) to include Part IV.1, Design of Public Space Standards (Accessibility Standards for the Built Environment). The amendment to the regulation came into force January 1, 2013 and applies to public spaces that are newly constructed or redeveloped after January 1, 2016 by municipalities among other obligated organizations.

1.1.1 AODA Design of Public Spaces Standards – Sections 80.26 on Curb Ramps and 80.27 on Depressed Curbs includes raised tactile profiles

The Design of Public Spaces Standards (Accessibility Standards for the Built Environment) outlines standards for curb ramps and depressed curbs at pedestrian crossings in section 80.26(1) and 80.27(1) respectively. A curb ramp must align with the direction of travel and have a minimum clear width of 1,200mm, exclusive of flared sides. The maximum running slope of curb ramps is 1:8 (where elevation is less than 75mm) and 1:10 (where 75mm or greater). The cross slope cannot exceed 1:50. The flared sides of the curb ramp must have a maximum slope of 1:10. A depressed curb must have a maximum running slope of 1:20 and be aligned in the direction of travel. Both curb ramps and depressed curbs with pedestrian crossings must have tactile walking surface indicators that have raised tactile profiles, have high tonal contrast with the adjacent surface, are located at the bottom of the curb ramp (and extend the full width of the curb ramp) or the bottom portion of the depressed curb that is flush with the roadway, are set back between 150mm and 200mm from the curb edge and are a minimum of 610mm in depth.

1.1.2 Canadian Standards Association (CSA) Standard B651-12 – Tactile Walking Surface Indicators

The Canadian Standards Association Standard B651-12, titled "Accessible Design for the Built Environment" outlines standard dimensions of tactile walking surface indicators in sections 4.3.5.2 and 4.3.5.3. A tactile walking surface shall be installed in a manner that avoids interference from an irregular walking surface; and does not create a tripping hazard; have its base surface level with the surrounding surface, or not more than 3mm above or below it; be slip resistant; and be colour contrasted with the surrounding surface. A tactile walking surface indicator shall be composed of truncated domes with a height of 5mm ±1mm; with the top diameter between 12 and 15mm and the base diameter 10mm ±1mm greater than the top diameter; arranged in a square grid; and with a centre to centre distance of adjacent domes between 55 and 61mm for domes with a 12mm top diameter or between 57 and 63mm for domes with a 15mm top diameter. Systematic research has shown that a top diameter of 12mm is optimal for detection and discrimination underfoot. A tactile walking surface indicator shall be in a colour that contrasts at least 70% with the surrounding surface; or if yellow, contrasts at least 40% with the surrounding surface.

1.2 Pilot Project to Evaluate Materials for Tactile Walking Surface Indicators

The City of Toronto began a pilot project to evaluate four different tactile walking surface indicator products by installing the different selected products at the four corners of the intersection of Shuter Street and Victoria Street within the Downtown. The location was selected for this evaluation because of the intersection's location within a high pedestrian traffic area next to St Michael's Hospital which has enabled observations of diverse pedestrians with various needs and conditions. It maximized the ability to observe pedestrians individually and in groups, of different ages, and pedestrians using different assistive devices, such as wheelchairs, motorized scooters, canes, crutches, small carts with wheels, wheeled luggage, and strollers. Construction of the pedestrian crossings with the tactile walking surface indicators was completed on November 8, 2012.

2.0 Product Overview

Four different tactile walking surface materials were tested: plastic/composite polymers, clay brick pavers, concrete pavers, and cast iron plates.

2.1 Tactile Walking Surface Indicator Products

Various products were selected for use in the pilot project based on several factors. Access tiles were selected because they have previously been used in the City for different outdoor applications. The Unilock pavers were selected because the city currently uses Unilock pavers for various outdoor applications. The Unilock ADA paver is larger than the typical paving stone used and the Endicott product was selected because it is available in a smaller size that is consistent with what is already being used within the City. A cast iron product was also used in the pilot as it was assumed to have good durability and is already being used in different municipalities in Ontario and Quebec.

2.1.A Access Tile

Access Tile supplied by Engineered Plastics Inc. was installed at the northwest corner of Shuter Street and Victoria Street. The corner has two curb depressions, one in each direction of travel. Two straight sections of Access Tiles were installed. The tactile walking surface indicators for the north south crossing used Replaceable Cast in Place tiles in a Brick Red colour and the east west crossing used Surface Applied tiles in an Onyx Black colour. Access Tiles are made of engineered composite polymers and come in various rectangular sizes as well as in a 10' radius. Installation of the Replaceable Cast in Place tiles requires the tiles to be set into concrete. The anchors are set in the concrete and the panels can be removed and replaced if required. The Surface Applied tiles are applied onto an existing surface with adhesive and newly poured concrete is not required for installation.

2.1.B Endicott Handicap Detectable Warning Paver

Endicott Handicap Detectable Warning Paver supplied by Thames Valley Brick & Tile was installed at the southwest corner of Shuter Street and Victoria Street. The corner has a continuous curb depression for both directions of travel. A continuous curved section of Handicap Detectable Warning Pavers was installed along the curb depression using Manganese Ironspot coloured pavers. The pavers are made of clay and come in 4"×8" sized units. Installation of the Handicap Detectable Warning Pavers requires the fitting of the pavers into the required area.

2.1.C Unilock ADA Paver

Unilock ADA Pavers were installed at the southeast corner of Shuter Street and Victoria Street. The corner has a continuous curb depression for both directions of travel. A continuous curved section of ADA Pavers was installed along the curb depression using Charcoal coloured pavers. Unilock ADA Pavers are made of concrete and come in 12"×12" sized units. Installation of ADA Pavers requires fitting of the pavers into the required area. Note: at the time of the pilot project, no radial products were available, but since then, the supplier has a variety of radii options (e.g. 4.5m, 6m, 7.5m and 9m radii).

2.1.D Neenah Foundry Detectable Warning Plate

Neenah Foundry Detectable Warning Plates supplied by Crozier Enterprises was installed at the northeast corner of Shuter Street and Victoria Street. The corner has a continuous curb depression for both directions of travel. Two curved sections of Detectable Warning Plates were installed using unpainted plates, one section for each direction of travel. Neenah Foundry Detectable Warning Plates are made of cast iron and come in various rectangular (12"x12", 24"x24", 24"x30", and 24"x36") sizes as well as in 9'5", 15', 20', 25', and 35' radii. Installation of the Detectable Warning Plates requires the plates to be connected together and set into concrete.

2.2 Installation

Installation of tactile walking surface indicators generally requires the reconstruction of the sidewalk where the product is to be placed. This involves the removal of the existing sidewalk followed by forming, pouring, and finishing of the new sidewalk. The installation of tactile walking surface indicators should be accommodated during new

sidewalk construction or reconstruction. To install tactile walking surface indicators a void space must be provided in the concrete for pavers or the product must be placed into fresh poured concrete for cast in place applications.

2.3.A Access Tile
The installation of surface applied Access Tiles requires a finished sidewalk. The surface where the tile will be placed is scoured with a grinder and the dust is removed with a leaf blower. The provided adhesive is applied to the back of the tile as directed and pressed onto the concrete surface after the tile and concrete surface have been cleaned with acetone. Following this holes are drilled through the tile at specified locations into the concrete and upon cleaning of the hole, the supplied fastener is hammered to set it into the tile. The perimeter of the tile is cleaned to remove any escaped adhesive and a perimeter sealant is applied after masking tape has been placed around the perimeter.

The installation of cast in place Access Tiles requires a newly poured concrete surface. The tiles are placed onto the poured concrete and tamped. A concrete free recess is created around the perimeter of the tile and the concrete is finished.

2.2.B Endicott Handicap Detectable Warning Paver
The installation of Handicap Detectable Warning Pavers requires a space within the sidewalk to place the pavers. A form is created for the pavers to be placed before the concrete is poured for the sidewalk. The sidewalk is finished and after the forms are removed, the pavers are placed in the required configuration within the space provided. Pavers may require cutting to fit in the space provided.

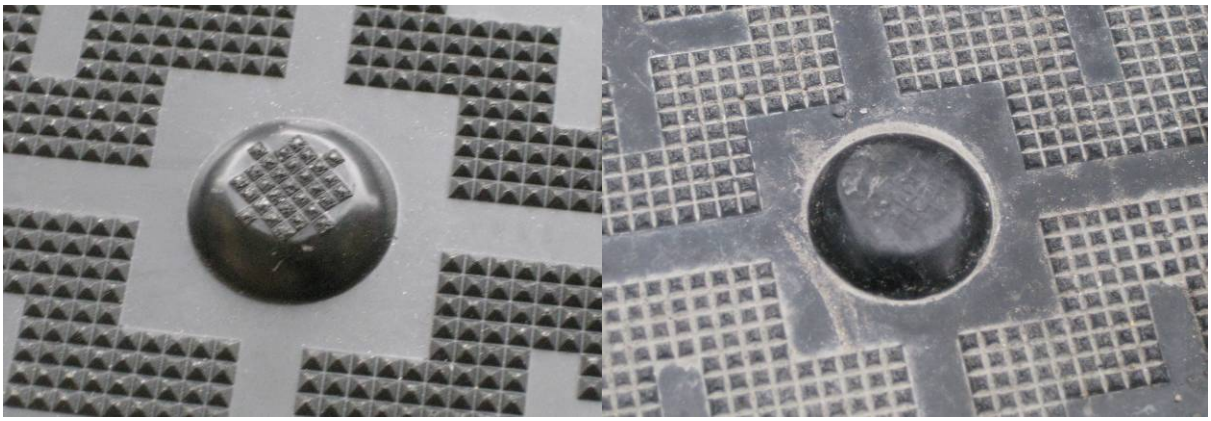
2.2.C Unilock ADA Paver
The installation of ADA Pavers requires a space within the sidewalk to place the pavers. A form is created for the pavers to be placed before the concrete is poured for the sidewalk. The sidewalk is finished and after the forms are removed, the pavers are placed in the required configuration within the space provided. Pavers may require cutting to fit in the space provided.

2.2.D Neenah Foundry Detectable Warning Plate
The installation of cast iron detectable warning plates requires a newly poured concrete surface. If required, multiple plates are connected together. The supplied lifting springs are used to lift and set the plates into position. After the lifting springs are removed the concrete is finished around the plate.

2.3 Physical Condition Evaluation
The physical condition was evaluated on December 4, 2013 approximately 13 months after installation. The evaluation was undertaken one year following installation to see how each product was affected by a cycle of four seasons. It was important to make sure at least one winter season had passed to evaluate how the products held up against sidewalk snow plowing operations. Durability of the product is an important component as these products will have to hold up to many years of snow plowing operations.

2.3.A Access Tile

The following are two close up photographs of the tactile walking surface indicators: one soon after installation, and and the other about one year later.



Cast in place Access Tiles showed minimal damage to the plates. The surface applied Access Tiles showed significantly more damage to the plates with sections around the edges torn off. The textured surface on the tops of the truncated domes for both applications was almost completely worn off leaving the tops of the truncated domes completely smooth.

2.3.B Endicott Handicap Detectable Warning Paver

The following are two close up photographs of the tactile walking surface indicators: one soon after installation, and and the other about one year later.

Endicott pavers had several of the truncated domes damaged. Damage consisted of truncated domes being completely torn off and with significant portions of the truncated domes chipped away. Many of the truncated domes did appear to be in good condition. The pavers also showed signs of differential settling in some areas.

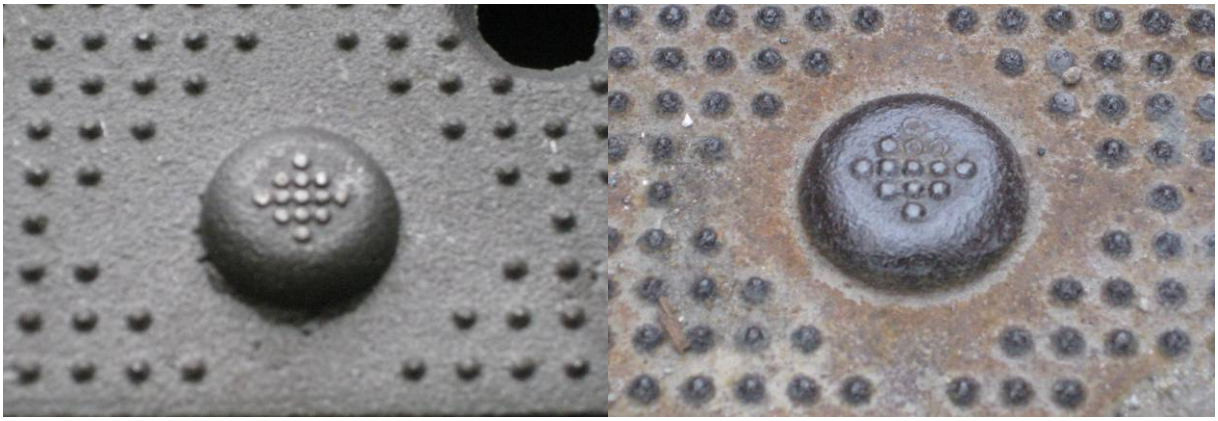
2.3.C Unilock ADA Paver

The following are two close up photographs of the tactile walking surface indicators: one soon after installation, and and the other about one year later.

Unilock pavers had almost all of the truncated domes damaged. Damage consisted of truncated domes being completely torn off and with significant portions of the truncated domes being chipped away. There were no visible truncated domes that remained in good condition. The gaps between the pavers provided voids for litter such as cigarette butts to collect.

2.3.D Neenah Foundry Detectable Warning Plate

The following are two close up photographs of the tactile walking surface indicators: one soon after installation, and and the other about one year later.



Neenah Foundry plates showed minimal damage. All the plates and truncated domes were completely intact. There were a couple truncated domes with some of the bumps of the textured surface removed. The concrete curb also showed signs of rust staining that was expected in the first year and is expected to fade over time as the cast iron turns into a naturally dark patina.

2.4 Conformity to Standards

Tactile walking surface indicator products must conform to CSA Standard B651-12 and installations with the products must be able to conform to the Accessibility for Ontarians with Disabilities Act, 2005 as noted in this report under section 1.1.1.

Table 2.4.1 below outlines the truncated dome dimensions.

	Top (mm)	Base (mm)	Spacing (mm)	Height (mm)
CSA Standard	12-15	22-25	55-63	5±1

Access Tile	11.4	22.9	59.7	5.1
Endicott Detectable Warning Paver	19.1	22.9	50.8	5.1
Unilock ADA Paver	17.9	27.9	61.0	5.1
Neenah Foundry Detectable Warning Plate	12.7	22.9	50.8	5.1

2.4.A Access Tile

The truncated dome dimension for the top of the dome is 11.4mm which is 0.6mm less than the required 12-15mm. All other dimensions of the domes meet the required CSA standards. The surface applied Access Tiles are not able to meet the CSA standards for difference in elevation between the base surface of the tile and the surrounding surface. The surface applied Access Tiles are adhered onto the surface of the existing concrete and cannot be set into the concrete to adjust the elevation of the tile. The difference in elevation from the base surface of the tile and the bottom of the tile is 4.6mm which is 1.6mm greater that the required 3mm maximum on the curb side and 4.6mm greater than the required 0-3mm.

Installations of Access Tiles are only able to conform to standards when cast in place tiles are installed at curb depressions along straight sections of curbs. Access Tiles are available in rectangular sections and in 10' radius sections making it difficult to maintain the required 150-200mm offset from the edge of curb.

2.4.B Endicott Handicap Detectable Warning Paver

The truncated dome dimension for the top of the dome is 19.1mm which is 4.1mm greater than he required 12-15mm. The dimension for the spacing of domes is 50.8mm which is 4.2mm less than the required 55-63mm. All other dimensions of the dome meet the required CSA standards. The spacing of domes will also be affected when the pavers are installed along curved sections because the pavers are rectangular and pavers cannot be installed parallel to each other if they are to be placed in a curved section.

2.4.C Unilock ADA Paver

The truncated dome dimension for the top of the dome is 17.9mm which is 2.9mm greater than the required 12-15mm. The dimension for the base is 27.9mm which is 2.9mm greater than the required 22-25mm. All other dimensions of the dome meet the required CSA standards. The spacing of domes will also be affected when the pavers are installed along curved sections because the pavers are rectangular and pavers cannot be installed parallel to each other if they are to be placed in a curved section. The Unilock ADA Paver is larger in size than typical pavers resulting in greater variations in spacing when installed along a curve.

2.4.D Neenah Foundry Detectable Warning Plate

The truncated dome dimension for the spacing of the domes is 50.8mm which is 4.2mm less than the required 55-63. All other dimensions of the dome meet the required CSA standards. Neenah Foundry Detectable Warning Plates should be able to fit a wide

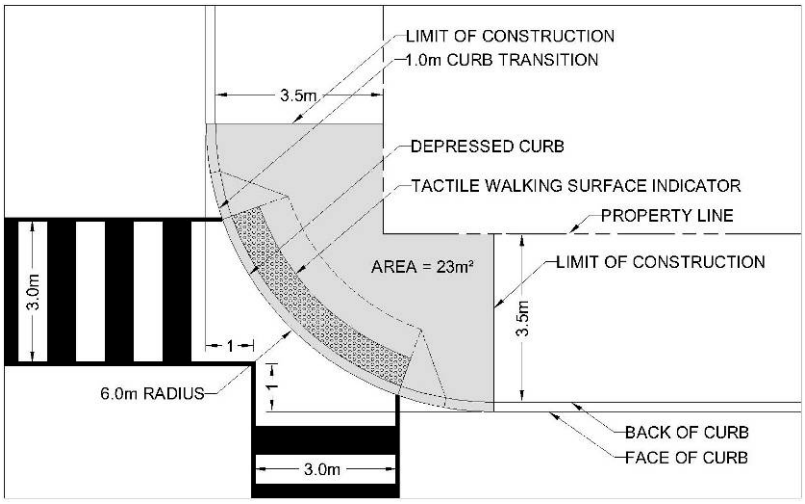
range of radii because they are available in 9'5", 15', 20', 25', and 35' sections which can be combined to fit different radius curves while maintaining the required 150-200mm offset from the edge of curb. The spacing of domes will also be affected when using radial plates because the dome spacing cannot be consistent throughout the entire plate due to the curve.

2.5 Cost Evaluation

The cost of installation was evaluated for new construction and retrofit scenarios. The cost for new construction includes just the additional cost of installing tactile walking surface indicators at the time of sidewalk construction. This figure does not include the cost of constructing a curb and sidewalk since the tactile walking surface indicators are being installed at the time of sidewalk construction. A retrofit scenario would be the upgrading of a pedestrian crossing for the purpose of installing tactile walking surface indicators. The cost for retrofit scenarios is an estimate of the cost to install tactile walking surface indicators on existing pedestrian crossings and includes the cost of reconstructing the curb and sidewalk if necessary.

The intersection corner layout used for the cost evaluation was created to replicate an intersection in the Downtown so it could be used to estimate quantities for road reconstruction scenarios and retrofit scenarios. Retrofit scenarios are most likely to occur in areas with high pedestrian volumes such as within Toronto's Downtown. In the Downtown, sidewalks are generally adjacent to the curb without a boulevard and are constructed monolithic with the curb and sidewalk being formed together during construction. Sidewalk widths are often 3-4m wide and curb radii are often around 6m. For the estimation of costs used for the cost evaluation, a right angled intersection with 3.5m sidewalks and 6m curb radii was used. Depressed curb locations were determined using a 3m wide painted crossing path that is offset 1m from the travelled lane. Depressed curbs were placed for the width of all pedestrian crossing pavement markings with curb transitions being 1m long. For reconstruction of the sidewalk it was assumed that the entire radius section of the sidewalk would be replaced. For the intersection corner layout used, a linear 15' (4.57m) of 2' (610mm) deep tactile walking surface indicators placed in a continuous section would be required along with 23m² of 150mm thick, monolithic curb and concrete sidewalk at a cost of approximately $2576 will be required for retrofit scenarios where the sidewalk must be reconstructed.

Figure 2.5.1 below shows a diagram of a street corner used for cost estimate



The unit prices used were the average unit prices for 2013 contracts. Labour for the installation of tactile walking surface indicators was about 2 person-hours for all products included in the pilot project. The associated cost of labour estimated at $48 per hour for 2 person-hours results in a total labour cost of $96. Variations in labour required for installation were negligible and an equal amount of labour for each installation is assumed. Therefore the variations in cost are a function of material costs and the requirement for sidewalk reconstruction in retrofit scenarios.
The table below lists (by product) the number of units, total costs, cost per unit and cost per square metre.

	Units	Total cost	Cost per unit	Cost per m²
Access Tile	5	$647.50	$129.50	$231.25
Endicott Detectable Warning Paver	135	$796.50	$5.90	$284.46
Unilock ADA Paver	30	$407.40	$13.58	$145.50
Neenah Foundry Detectable Warning Plate	5	$741.65	$148.33	$264.88

2.5.A Access Tile
The installation cost for the intersection corner layout used consists of $647.50 in materials and approximately $96 in labour for a total additional cost of construction per intersection corner of approximately $743.50. Retrofit scenarios using surface applied Access Tiles are the most cost effective because they do not require the reconstruction of the sidewalk to install. Therefore the installation cost of Access Tiles is the same as in road reconstruction scenarios. Retrofit scenarios using cast in place Access Tiles requires reconstruction of the sidewalk and the total cost is approximately $3319.50 per intersection corner.

2.5.B Endicott Handicap Detectable Warning Paver

The installation cost for the intersection corner layout used consists of $796.50 in materials and approximately $96 in labour for the total additional cost of construction per intersection corner of approximately $892.50. Retrofit scenarios require the reconstruction of the sidewalk and the total cost is approximately $3468.50 per intersection corner.

2.5.C Unilock ADA Paver

The installation cost for the intersection corner layout used consists of $407.40 in materials and approximately $96 in labour for the total additional cost of construction per intersection corner of approximately $503.40. Retrofit scenarios require the reconstruction of the sidewalk and the total cost is approximately $3079.40 per intersection corner.

2.5.D Neenah Foundry Detectable Warning Plate

The installation cost for the intersection corner layout used consists of $741.65 in materials and approximately $96 in labour for the total additional cost of construction per intersection corner of approximately $837.65. Retrofit scenarios require the reconstruction of the sidewalk and the total cost is approximately $3413.65 per intersection corner.

3.0 Summary of Assessment

In conclusion, cast iron is the material that has performed best overall based on durability after winter maintenance, and effectiveness in terms of the detectability of the domes (i.e., the surface of the domes remaining intact for detection). Installation and costs were all within a relatively similar range. The durability of the cast iron, however, sets it apart in terms of reducing the costs of maintenance and replacement due to the need to replace the tactile indicators less frequently. The cast iron can be sourced from recycled scrap metal, and has the potential to be reused (i.e., plates could be cleaned and reused, or recycled).

All of the materials had truncated domes which are used internationally and nationally. The cast iron product also most closely met the CSA standard than did the clay brick and concrete pavers. Overall, the feedback has been positive from various users including members of the City of Toronto's Disability Issues Committee that visited the site on December 7, 2012 to test the four corners and different materials. There were conflicting preferences in comments from the public for the different materials. Some felt the cast iron was more detectable under foot, and others liked the Access Tile and the pavers. There were some comments about the plastic/composite polymers being more slippery underfoot in rainy and snowy conditions and looking worse from dirt and stains (e.g., gum). There were many comments about the poor condition of the domes on the clay brick pavers and the concrete pavers which had chipped domes and missing domes, and had some differential settling of the pavers (unevenness over time). Opinions differed again regarding aesthetics – some liked the tonal contrast of the Access Tile (red), however others (urban designers and landscape architects) like the patina of the cast iron (once the rust fades), as they felt the appearance does not clash

with but enhances streetscapes. The domes are notably more intact over the course of the year for the cast iron material.

3.1 Recommendations

Based on durability, cost, maintenance, and detectability (intactness of domes) over time, the cast iron material has performed the best among the four materials tested in this pilot project from November 2012 to December 2013. It is recommended that the City of Toronto use cast iron for its tactile walking surface installations. As the city and other jurisdictions have greater experience with the use and installation of tactile walking surface indicators, there may be new developments and new products that will be available for consideration.

3.2 Additional Resources

Some additional resources are provided below that considers various materials for tactile walking surface indicators.

Accessibility for Ontarians with Disabilities Act, 2005 Weblink: http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_05a11_e.htm

Built Environment
Weblink:http://www.mcss.gov.on.ca/en/mcss/programs/accessibility/built_environment/index.aspx

Design of Public Spaces Standards – Part IV.I of Ontario Regulation 191/11 Weblink: http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_110191_e.htm#BK92

Canadian Standards Association, 2012 (May). Final *B651-12 Accessible Design for the Built Environment*. Weblink: http://shop.csa.ca/en/canada/accessibility/b651-12/invt/27021232012

Canadian National Institute for the Blind, 2009. *Clear Our Path Guide*.
Weblink: www.cnib.ca/

Federal Highway Administration, 1999. Designing Sidewalks and Trails for Access.
Weblink:http://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/sidewalks/contents.cfm

Federal Highway Administration and Westat (Jenness, J and Singer, J) 2006. *Visual Detection of Detectable Warning Materials by Pedestrians with Visual Impairments*.

International Association of Traffic and Safety Sciences (2008). *Guidebook for the Proper Installation of Tactile Ground Surface Indicators (Braille Blocks): Common Installation Errors*. Weblink: http://iatss.or.jp/pdf/tenjie.pdf

International Standards Organization - ISO 23599 "Assistive Products for Blind and Vision-Impaired Persons - Tactile Walking Surface Indicators" - March 2012 Weblink:http://www.iso.org/iso/catalogue_detail?csnumber=55867

Montana Department of Transportation 2007. *Detectable Warning Devices (Truncated Domes) for use by the Visually Impaired.*

National Cooperative Highway Research Program, Transportation Research Board of the National Academies, and Texas Transportation Institute. Estakhri, C and Smith, R. 2005. *Detectable Warning Products: Installation, Maintenance, and Durability Considerations.*

National Cooperative Highway Research Program, Transportation Research Board of the National Academies, 2010. *Report 670: Recommended Procedures for Testing and Evaluating Detectable Warning Systems*.

Vermont Agency of Transportation, Bicycle and Pedestrian Program, Local Transportation Facilities, 2006. *Report on Spring 2006 Evaluation of Detectable Warning products installed 2003- 2005*.