Detectable Warning Products: Installation, Maintenance, and Durability Considerations

FINAL REPORT

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ABSTRACT

The objective of this study was to create a compilation of the available research and other information available with regard to the durability and maintenance of detectable warnings under different conditions. Researchers identified manufactured product types and materials, installation procedures, routine maintenance activities, damage caused by these activities, and durability and performance associated with each type of product.

Researchers synthesized published information from the literature regarding product types, installation, performance, and maintenance. Researchers also contacted knowledgeable individuals in the industry and within selected agencies known to have experience with detectable warnings.

This synthesis presents the following information:

- Types of detectable warning systems available;
- Case history performance evaluations as documented in the literature and within some agencies;
- Construction and installation considerations;
- Maintenance considerations;
- Durability considerations; and
- Research needs.
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Researchers synthesized published information from the literature regarding product types, installation, performance, and maintenance. Researchers also contacted knowledgeable individuals in the industry and within selected agencies known to have experience with detectable warnings.

This synthesis presents the following information:

- Types of detectable warning systems available;
- Case history performance evaluations as documented in the literature and within some agencies;
- Construction and installation considerations;
- Maintenance considerations;
- Durability considerations; and
- Research needs.
CHAPTER 2: BACKGROUND

NEED FOR DETECTABLE WARNINGS

Curbs have served to provide a reliable cue to pedestrians who were visually impaired that they had arrived at an intersecting street. Accessibility requirements in the 1960s, however, resulted in the disappearance of curbs at many intersections. Curb-ramps, blended curbs and depressed corners are now common sidewalk features. The absence of curbed intersections has made it much more difficult for visually impaired pedestrians to detect street crossings. They must rely on multiple clues which, when taken together, indicate the high probability they have come to a street. (Bentzen et al. 2000)

Persons who are visually impaired may be able to detect a change in slope at the curb ramp, a change in terrain, or a broken sidewalk. The end of a building line or grass line may suggest there is a street ahead. Changes in sun and wind are also clues. The sound of traffic on an intersecting street is often a reliable clue but at different times of the day or week there may be little or no traffic. (Bentzen et al. 2000) This lack of definitive clues has placed visually impaired pedestrians at risk and created a need for detectable warnings to alert them that they are approaching a street.

The US Access Board is the federal agency responsible for developing accessibility guidelines under the Americans with Disabilities Act (ADA). Detectable warnings were required in 1991 by the Americans with Disabilities Act Accessible Guideline (ADAAG) (regulatory standards) for hazardous vehicular ways, transit platform edges, and curb ramps. A suspension was placed on requiring detectable warnings at curb ramps and hazardous vehicular ways, but not for transit platform edges. The Department of Justice (DOJ) had the option of allowing the suspension to expire on July 26, 2001 and did so. Therefore, since July 26, 2001, detectable warnings are again required. FHWA is obligated to enforce the requirements, and State and local governments are required to apply the minimum design standards when constructing and altering pedestrian facilities, though FHWA encourages higher than minimum standards where possible.

WHAT IS AN ACCEPTABLE DETECTABLE WARNING

The ADAAG (as amended through September 2002) defines a detectable warning as:

\[
\text{A standardized surface feature built in or applied to walking surfaces or other elements to warn visually impaired people of hazards on a circulation path.}
\]

Truncated domes have a unique design that can be detected underfoot and with a cane as shown in Figure 1. The requirements for detectable warnings as specified by ADAAG (Section 4.29.2 as amended through September 2002) are as follows:
Detectable warnings shall consist of raised truncated domes with a diameter of nominal 0.9 in (23 mm), a height of nominal 0.2 in (5 mm) and a center-to-center spacing of nominal 2.35 in (60 mm) and shall contrast visually with adjoining surfaces, either light-on-dark or dark-on-light.

The material used to provide contrast shall be an integral part of the walking surface. Detectable warnings used on interior surfaces shall differ from adjoining walking surfaces in resiliency or sound-on-cane contact.

The Federal Highway Administration sent a memorandum on July 30, 2004 (http://www.fhwa.dot.gov/environment/bikeped/dwm04.htm) to field staff noting the requirements of detectable warnings. The memorandum states that there have been no changes to the existing requirements (since July 26, 2001) that detectable warnings must be applied to curb ramps in new construction and alterations. The memorandum also states that both FHWA and the Access Board encourage the use of the June 17, 2002 Draft Guidelines for Accessible Public Rights-of-Way (http://www.access-board.gov/rowdraft.htm) scoping and technical provisions for detectable warnings as an equivalent facilitation to the current requirements in the 1991 (current) ADAAG. These draft guidelines describe detectable warnings as a surface of truncated domes arranged in a square grid pattern.

The domes shall have a base diameter of 0.9 inches (23 mm) minimum to 1.4 inches (36 mm) maximum, a top diameter of 50% of the base diameter minimum to 65% of the base diameter maximum, and a height of 0.2 inches (5 mm).

Truncated domes in a detectable warning surface shall have a center-to-center spacing of 1.6 inches (41 mm) minimum and 2.4 inches (61 mm) maximum, and a base-to-base spacing of 0.65 inches (16 mm) minimum, measured between the most adjacent domes on the square grid.

Detectable warning surfaces shall contrast visually with adjacent walking surfaces either light-on-dark, or dark-on-light.
Grooved concrete as shown in Figure 2, exposed aggregate concrete, and other textures have also been used as detectable warnings. But these textures are considered too similar to pavement textures, cracks, and joints and do not comply with ADA. Only truncated dome products are discussed further in this synthesis.

For more information on detectable warnings, the following websites may be useful:

- The design and application requirements in the ADA Standards are posted on the US Access Board’s website at http://www.access-board.gov/adaag/html/adaag.htm; see 4.7 and 4.29. Additional information on equivalent facilitation utilizing a consensus specification is posted at http://www.access-board.gov/adaag/dws/update.htm

• FHWA Memorandum noting Federal-aid requirements for detectable warnings: http://www.fhwa.dot.gov/environment/bikeped/dwm.htm

Figure 2. Grooved Concrete: Example of Noncompliant Detectable Warning.
CHAPTER 3: TYPES OF DETECTABLE WARNING PRODUCTS AVAILABLE

There are a number of different manufacturers of detectable warning products that meet the truncated dome geometric requirements of ADAAG. These products span a range of material and color choices. Some of these products are for installation during the construction of curb ramps and some can be applied to the surface of an existing curb ramp. Detectable warnings which can be applied to existing surfaces are sometimes called “retrofit” products. Researchers grouped these products into the categories described below:

Cast-in-Place, New Construction Installations

- Traditional size brick/concrete pavers;
- Large concrete/stone paver units/panels/tiles;
- Metal panels;
- Polymer composite/fiberglass rigid panels; and
- Stamped concrete.

Surface Applied and/or Retrofit Installations

- Flexible mats;
- Surface applied domes; and
- Thermoplastics.

The following is a discussion of some of the different types of products and materials available. This is not a comprehensive listing of products and it should also be noted that there are new products being developed and improvements being made to existing products that may not be included here. However, they represent the major types of products known to be commonly used in the U.S. The authors are not attempting to show preference to any product in the following discussion but are trying to provide the reader with an overview of the types of products available at this time.

PRODUCTS AVAILABLE FOR CAST-IN-PLACE, NEW CONSTRUCTION INSTALLATIONS

Traditional Brick/Concrete Pavers

Pavers are available in the traditional 4-in width by 8-inch length as shown in Figure 3. They can be obtained in thicknesses from ½ inch to 3 inches with material choices including conventional clay or shale bricks and concrete pavers. Concrete pavers are generally made from “no slump” concrete under high pressure with compressive strengths of 8000 psi or more.
Large Concrete/Stone Paver Units/Panels/Tiles

There are some manufacturers who produce pavers that are of a larger size than the more traditional brick pavers shown above. These types of units come in various colors and sizes including the following:

- 12 in x 12 in,
- 24 in x 24 in,
- 24 in x 36 in,
- 36 in x 36 in.

A variety of thicknesses are available ranging from 1-1/4 in to 4 in, though not all sizes may come in all thicknesses. These types of pavers vary in material composition depending on the manufacturer. They are available in a wide variety of colors and the color may be integrated throughout the paver or may be only in a coating on the surface. At least one product has a reflective surface and a gel coating for easy cleaning. Some of the materials available include the following:

- High density, hydraulically pressed concrete;
- Polymer concrete;
- Polymer concrete with fiberglass reinforcing mesh;
- Natural quarried stone such as limestone or granite.

An example of a large-size paver is shown in Figure 4. This product is only ¾ in thick but is made of 10,000 psi concrete and is reinforced with stainless steel, prestressed tendons. It is also treated on the surface with a penetrating sealer to decrease permeability to water and deicing chemicals.
Figure 4. Large Concrete Paver Units – ¾ in Thick.
(Photo Provided by Bill Naugle of CASTinTACT®)
Metal Panels

The product shown in Figure 5 is made from stainless steel and is coated with UV stable industrial grade polymers. The coatings are reported to be skid resistant and are used successfully in industrial, commercial, marine, military and truck bed industries. The product is about ¾-inch thick and is generally available in the following sizes:

- 24 in x 24 in,
- 24 in x 36 in,
- 24 in x 48 in,
- 24 in x 60 in.

Panels are also available in cast iron. Cast iron panels are gray in color when new but over time will develop a natural rust patina that will contrast with adjacent concrete sidewalks.

![Stainless Steel Panel with Slip Resistant Coating](Photo Printed with Permission of MetaDome, LLC)

**Figure 5. Stainless Steel Panel with Slip Resistant Coating.**
(Photograph Printed with Permission of MetaDome, LLC)
Polymer Composite/Fiberglass Rigid Panels

This category of products includes the following types of materials:

- Vitrified polymer composite;
- Glass and carbon reinforced composite; and
- Molecular cross-linked reinforced composite.

These types of products (Figure 6) are generally high strength materials and are relatively thin. Some products have flanges for embedding into fresh, finished concrete or can be embedded into saw cuts on hardened concrete for retrofit applications. They are also available in a wide array of colors and sizes such as the following:

- 12 in x 12 in,
- 24 in x 24 in,
- 24 in x 36 in,
- 24 in x 48 in,
- 24 in x 60 in, and
- 36 in x 48 in.

Figure 6. High-Strength Polymer Composite, Thin Rigid Panel.
Stamped Concrete Systems

Partially set, fresh concrete may be stamped to provide a truncated dome textured surface. Forms used for this type of stamping may be either flexible or rigid (Figure 7).

Figure 7. Stamped Concrete Truncated Dome Surface.
(Photo Reprinted with Permission of MetaDome, LLC.)
PRODUCTS AVAILABLE FOR SURFACE APPLIED AND/OR RETROFIT INSTALLATION

Flexible Mats

Flexible mats with a truncated dome surface can be applied directly to an existing curb ramp (Figure 8). These products are usually applied with an adhesive plus additional anchors placed around the perimeter of the mat. A sealant is typically applied around the perimeter of the mat. The following types of materials are included in this category:

- Rubber composite reinforced with nylon and rayon fibers;
- Rubber mat with polyurethane coating, can be cut to size; and
- Polyurethane mat, can be cut to size.

Figure 8. Detectable Warning Flexible Mat.
(Photo provided by Robert Lohse, NYDOT)
Surface Applied Domes

Surface-applied domes are detectable warning systems where the individual domes are adhered to the existing surface and can usually conform to any surface irregularities (Figure 9). These domes are resilient and different manufacturers have different types of systems. The Safti-Trax product (from COTE-L Industries, Inc.) incorporates a system where prefabricated resilient rubber domes (attached to a removable backing sheet) are applied to a properly prepared surface and then overcoated with a proprietary product (Durabak) which is touted as durable, waterproof, repairable and anti-corrosive.

Domes are fabricated onsite with the Vanguard and Strongwall systems. Vanguard requires a licensed installer. A flexible mat serves as a mold with dome-shaped spaces in which the material is poured and forced into the domes. Once the product has cured, a topcoat product is applied to seal and provide color.

Figure 9. Surface-Applied Truncated Domes.
(Photo Provided by COTE-L Industries, Inc.)
Thermoplastic

The thermoplastic product shown in Figure 10 is the same type of product that is used for pavement markings and is applied in much the same manner.

![Figure 10. Thermoplastic Detectable Warning.](image)

PRODUCT MANUFACTURERS

While researchers have tried to include most of the product manufacturers of detectable warnings, it is likely that some are not included here. As stated at the beginning of this chapter, many new products are being developed and improvements being made to existing products which may not be included here. At this time, the website for *Accessible Design for the Blind* is maintaining a relatively updated list of current manufacturers at the following web address: [www.accessforblind.org](http://www.accessforblind.org).

Some of the product manufacturers for the different types of products discussed in this chapter are listed in the following
Products Available for Cast-In-Place, New Construction Installations

Traditional Brick/Concrete Pavers

Pavestone Company
5835 LBJ Freeway, Suite 200
Dallas, TX  75244
Phone: (800) 245-PAVE
Phone: (972) 404-0400
Fax: (972) 404-9200
www.pavestone.com

Whitacre-Greer
1400 S. Mahoning Ave.
Phone: (800) WGP AVER
Phone: (330) 823-1610
Fax: (330) 823-5502
www.wgpaver.com

Large Concrete/Stone Paver
Units/ Panels/ Tiles

CASTinTACT
N-Direct Distribution, Inc.
1833 E. Baseline Rd., Suite 237
Gilbert, AZ  85234
Phone: (800) 484-2261
Fax: (480) 813-2194
www.n-dir.com

Interlock San Diego
4351 Stanford Street
Carlsbad, CA  92008
Phone: (760) 434-5586
Fax: (760) 434-38480
Detectablewarning.tierranet.com

Cold Spring Granite Company
202 South 3rd Ave.
Cold Spring, MN  56320
Phone (800) 328-7038
Fax: (320) 685- 5490
www.coldspringgranite.com

Steps Plus, Inc.
6375 Thompson Rd.
Syracuse, NY  13206
Phone: (315) 432-0885
Fax: (315) 432-0612
www.steps-plus.com

Hanover Architectural Products, Inc.
240 Bender Road
Hanover, PA  17331
Phone: (717) 637-0500
Fax: (637-7145
www.hanoverpavers.com

Step-Safe
Transpo Industries, Inc.
20 Jones Street
New Rochelle, NY 10801
Phone: (914) 636-1000
Fax: (914) 636-1282
www.transpo.com
Metal Panels

MetaDome, LLC
(stainless steel)
Duane F. Sippola
2136 E. Dayton St.
Madison, WI  53704
Phone (608) 249-8644
Fax: (608) 249-8644
www.metadomellc.com

East Jordan Iron Works, Inc
(cast-iron)
301 Spring Street
P.O. Box 439
East Jordan, MI  49727
Phone: (800) 874-4100
Fax: (231) 536-4458
www.ejiw.com

Polymer Composite/Fiberglass Rigid Panels

ADA Armor-Tile
Engineered Plastics, Inc.
300 International Drive, Suite 100
Buffalo, NY 14202
Phone: (800)682-2525
Fax: (800) 769-4463
www.armor-tile.com

Transit-Tile
2635 Pine Street, Suite 102
Boulder, CO  80302
Phone (303) 223-1511
Fax: (330) 223-1414
www.transit-tile.com

ADA Tactile Systems
P.O. Box 179
N. Billerica, MA  01862
Phone: (978) 262-9900
Fax: (978) 262-1455
www.adatile.com

TG Lining
20 Doelen 17, 1935 BN
Egmond Binnen
The Netherlands
Phone: +31 (0) 72 5070153
Fax. +31 (0) 72 5070531
www.tglining.nl/engels.html

Stamped Concrete Systems

Cobblecrete
485 West 2000 South
Orem, UT  84058
Phone: (800) 798-5791
Phone: (801) 224-6662
Fax: (801) 225-1690
www.cobblecrete.com

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Snohomish, WA  98296  
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www.vanguardonlin.com

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Thomasville, NC  27360  
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www.flinttrading.com
Several agencies are in the process of evaluating the characteristics and performance of different detectable warning products. The following is a discussion of some of the information available from these agencies.

**WISCONSIN DOT (Kemp, 2003)**

The Wisconsin DOT (WDOT) initiated a study in partnership with the Federal Highway Administration (FHWA) and the City of Madison Engineering Division. Eight different detectable warning systems were installed in the fall of 2002 and evaluated over the winter and following spring. The products were selected to represent the various types of systems that were commercially available and were categorized into two main types: retrofit and cast-in-place. Products were installed on 44 curb ramps. The different products evaluated were as follows.

**Retrofit**

- COTE-L Safti-Trax – flexible mat;
- Detectable Warning Systems, Inc – flexible mat;
- COTE-L Safti-Trax – surface applied domes;
- Strongwall – surface applied domes; and
- Engineered Plastics Armor Tile – polymer composite rigid panel.

**Cast-in-Place or New Construction**

- Increte – stamped concrete;
- Hanover Architectural Tiles – precast concrete panels; and
- Engineered Plastics Armor Tile – polymer composite rigid panel.

Other undocumented concrete stamping systems included Stampcrete System (Increte) and Metadome Stamping Systems.

The products were subjected to snowplowing, snow blowers, residential shoveling and salting. Installations were inspected for damage to or loss of domes and field material.

WDOT reports that the system types that have shown the best durability are the Increte Stamping System, Detectable Warning Systems, Inc. flexible mat, Hanover Architectural Tiles precast concrete tiles, and Engineered Plastics Armor Tile.

While the Increte Stamping System showed relatively good durability, it yielded inconsistent results (average of 25% of the domes were deformed or missing). The forms were prone to
clogging of the vent holes and required frequent cleaning. Kemp (2003) reports that the stamping success is very sensitive to concrete consistency and substantial effort is needed to train contractors on the use of this system and other similar stamps available. Though undocumented, Kemp (2003) reports that better success was obtained with the Metadome Stamping System. The DOT is currently evaluating this product.

Using troweled-in color on the stamped concrete was found to be very labor intensive and not cost-effective. Kemp (2003) reports that painting or staining of the concrete may be the most effective way to provide the necessary color contrast. Special care would need to be taken to ensure a slip resistant surface by adding glass beads or similar material to the paint. The Wisconsin DOT is pursuing the development of a specification allowing the use of stamps.

The Hanover concrete panels also performed well and no damage was seen over the evaluation period. However, the DOT found that this installation was too labor intensive to be cost-effective. The product required that a recess be formed and finished around the concrete. The contractor had to return later the first day to remove the form. The recess was left to cure for 28 days prior to installing the concrete panels. The panels then received a thin-set bonding mortar followed by a thickset mortar bed. After installation, the edge joints were filled. In the future, the DOT will pursue and develop a specification allowing a full-depth panel that is mechanically anchored to the sidewalk.

The Detectable Warning Systems flexible mat showed good durability with no apparent field damage. There were some problems with the product holding dirt in the pores of the material giving it a stained appearance.

Both of the COTE-L products gave a good aesthetic appearance and consistent dome pattern. However, Kemp (2003) reports that the COTE-L products did not stand up to winter snow removal. The installations exhibited loss of domes and field material. The mat product had areas which had debonded prior to any snowfall. The installation of the surface applied domes (2-step process) was labor intensive taking two days.

The Strongwall product also produced a consistent dome pattern but did not hold up to winter maintenance. It was labor-intensive taking two days for installation.

Wisconsin DOT Conclusions

Based on the study described herein, the Wisconsin DOT concludes the following (Kemp, 2003):

“Engineered Plastics Armor Tile performed the best of all products in the combined evaluation of ease of construction, slip resistance (subjective), aesthetics, and durability.

The concrete stamp shows promise of becoming a useable technology with further development. Questions still remain about the uniformity of the stamped domes. How many domes can be deformed before the ramp is out of conformance? Who will inspect these ramps for conformance? How do you incorporate a color in the
concrete that is not labor intensive or requires regular maintenance? These questions need to be answered before a stamped dome pattern could be accepted.

Precast masonry panels also have shown that they are an option if a full depth panel that is mechanically anchored to the sidewalk is developed. The tested panels in this study were too labor intensive to be considered even though their performance was adequate. The performance of the latex modified mortar remains to be seen and will take several years to evaluate.”

MONTANA DOT (Abernathy, 2003)

In July and August of 2003, the Montana DOT installed detectable warnings at fifteen locations in Great Falls. Seven different products were installed as described below.

Retrofit

- ADA Fabricators, ADA Tactile Systems – copolymer composite tile;
- COTE-L Safti-Trax – flexible mat;
- Disability Devices Distributor – flexible mat;
- COTE-L Safti-Trax – surface applied domes;
- Strongwall – surface applied domes; and
- Vanguard – surface applied domes.

Cast-in-Place or New Construction

- Disability Devices Distributor – anchor box is embedded into fresh concrete and detectable warnings mat is attached to the anchor box.

Product Performance

The above devices were installed in July and August of 2003 and a post-construction initial evaluation was performed soon after construction in October. Initial product evaluations as described by Abernathy (2003) are listed below.

**ADA Fabricators, Copolymer Composite Tile:** All three site installations were in good condition at the time of inspection. No noticeable loss of adhesion or mat deterioration was observed.

**COTE-L Safti-Trax, Flexible Mat:** There was only one installation of this product and some of the domes are torn or damaged. Causes of the damage are unknown.

**Disability Devices, Flexible Mat:** The two site installations were in good condition with no noticeable loss of adhesion or mat deterioration. Some of the plastic setting pins have pushed up several millimeters above the dome attachment.

**COTE-L Safti-Trax, Surface Applied Domes:** There were two installations of this product and they are in good condition, with all domes intact.
Strongwall, Surface Applied Domes: There were three installations of this product and they are performing well, with only a couple of missing domes.

Vanguard, Surface Applied Domes: All three installations are in good condition. All domes are intact.

Disability Devices Distributor, Wet Anchor Box System: This single installation is in good condition. The wrong adhesive application was used during installation causing an undulating surface texture, but this may not affect performance. Some of the plastic setting pins have pushed up and are exposed above the dome. Most likely, they will eventually be broken off through use.

NEW HAMPSHIRE DOT (Boisvert, 2003)

The New Hampshire DOT Bridge Maintenance Bureau installed eight different detectable warning systems in Concord in January of 2003. Two samples of each product were installed for a total of sixteen installations. Detectable warning systems were evaluated for ease of installation and durability when subjected to normal winter maintenance and weather conditions. Color and contrast was not evaluated. The following products were installed and evaluated.

Retrofit

- COTE-L Safti-Trax – flexible mat; and
- COTE-L Safti-Trax – surface applied domes.

Cast-in-Place or New Construction

- Stampcrete – stamped concrete;
- ADA Retrofit Kit – stamped concrete;
- ADA Fabricators, ADA Tactile Systems – copolymer composite tile;
- Castek Division, Transpo Industries, “Step-Safe Tile”, – precast concrete panel tiles;
- Hanover Architectural Tiles – precast concrete panel tiles; and
- Endicott Clay Products – brick paver.

Boisvert (2003) describes installation of most of the products as “easy” though some products involved a two-step process spanning two days. The Stampcrete stamped concrete produced domes with varying heights and deformities. The installation crew had difficulties with the ADA Retrofit Kit for stamping concrete and less than satisfactory results.

Product Performance

The installations were subjected to de-icing treatments and snow plowing. A total of 20 plowing cycles were performed on the installations. Performance of the detectable warnings after 20 plow passes as described by Boisvert (2003) are listed as follows.
COTE-L Safti-Trax surface applied domes: Early damage resulted due to the lack of recess in the concrete surface. The plow edge caught the mat edge and peeled the system off the concrete.

COTE-L Safti-Trax flexible mat: Seventy-nine percent of the domes were damaged or removed. Product reported to be not durable against plowing.

Stampcrete, stamped concrete: Eighteen percent of the domes were damaged or removed. Color seal deteriorated soon after construction.

ADA Retrofit Kit, stamped concrete: Seventy-five percent of the domes were damaged or removed. Crew questions whether there may have been a defect in their mix. Color seal began peeling.

ADA Fabricators, ADA Tactile Systems copolymer composite tile: Eight percent of the domes were damaged or removed. After 11 plow passes, water would squeeze out from beneath the tile, perhaps indicating breakdown of adhesive.

Castek Division, Transpo Industries, “Step-Safe Tile”, precast concrete panel tiles: Ten percent of the domes were damaged or removed. Material showed high durability.

Hanover Architectural Tiles, precast concrete panel tiles: No domes were damaged or removed; however the first row of domes encountered by the plow showed progressive wear.

Endicott Clay Products, brick paver: Seven percent of the domes were damaged or removed.

The Department concluded that the Castek “Step Safe Tile” and the brick paver systems performed well but that they do not appear to meet ADAAG requirements. In his report of 2003, Boisvert recommended the ADA Fabricators thin tile and the Hanover Architectural panels.

VERMONT AGENCY OF TRANSPORTATION (Kaplan, 2004)

Working with the City of Burlington, Vermont, the Vermont Agency of Transportation (VTRANS) identified 4 locations of existing ramps that were to be retrofit with truncated domes and 4 additional locations where ramps were either being constructed or reconstructed and would include the truncated dome surface. Eight different detectable warning products were installed between the end of July 2003 and the beginning of November 2003. The following products were installed and evaluated.

Retrofit
- Vanguard – surface applied domes;
- Strongwall – surface applied domes;
- COTE-L Safti-Trax – surface applied domes;
- COTE-L Safti-Trax – flexible mat; and
- ADA Fabricators, ADA Tactile Systems – copolymer composite tile.
Cast-in-Place or New Construction

- Castek Division, Transpo Industries, “Step-Safe Tile”, – precast concrete panel tiles;
- Engineered Plastics Armor Tile; and

These products were evaluated over one winter under regular winter maintenance conditions. The principal potential cause of damage to the products was snow plowing. A summary of Kaplan’s (2004) description of product performance is listed below.

**Vanguard, Surface Applied Domes.** Approximately 20 percent of the domes are missing. Some of the domes that are present are worn down or tops are scraped off. Some small sections of the dome field have peeled up completely from the underlying concrete.

**Strongwall, Surface Applied Domes.** The domes bonded well to the underlying concrete but did not have adequate strength within the domes to withstand the shear forces of the plow. More than 90% of the domes have lost at least half of their original height.

**COTE-L, Safti-Trax, Surface Applied Domes.** Almost 100% of the domes were removed due to snow plowing.

**COTE-L, Safti-Trax Flexible Mat.** Entire sections of the mat have been torn from the surface. Significant damage to the domes also occurred.

**ADA Fabricators, ADA Tactile Systems, copolymer composite tile.** Majority of domes remained intact. One corner of one of the panels had been removed by the plow.

**Castek Division, Transpo Industries, Step-Safe Tile, precast concrete panel.** This product exhibited the least damage of any of the products with less than 5% of the domes exhibiting damage. Most of the damage occurred on the domes at the leading edge of the panel.

**Engineered Plastics Armor Tile.** A small percentage of the domes on this product were damaged or removed (primarily along the leading edge of the panel.) Some of the slip-resistant dots on top of the individual domes were removed. Overall it is very durable and providing an adequate detectable warning.

**Mexcon, Inc., Detecto-Tile, precast concrete panels.** Many domes were sheared off completely or pulverized by plowing operations. In addition to dome loss, the product exhibited delamination of the top surface from the rest of the tile.

**ALASKA DOT**

During the construction season of 2002, the Alaska DOT (AKDOT) evaluated the in-service performance of the several types of products. Kim Phillips and Clint Adler with the AKDOT report damage in a 2003 Planning, Design, and Field Notes to products after the first winter and associated causes as described below.
**Armor-Tile Cast-in-Place.** Domes were abraded due to cold temperatures and mechanical brooming.

**Armor-Tile Surface Applied Mats.** Complete removal of installations, damage to edges, domes chipping off from snow plows.

**Strongwarn Surface Applied Domes.** Domes chipped off. Grout may not be resistant to extreme cold temperatures.

**Carsonite Pathfinder Tile.** Domes chipped off, adhesive deteriorating due to snow plows and weathering.

**OREGON DOT**

The Oregon DOT has been conducting a study since fall of 2002 to monitor the performance of four truncated dome products designed for retrofitting existing sidewalk ramps. Mr. Alan Kirk, Research Analyst, with the Oregon DOT will be posting a report on these research results very soon to the Oregon DOT website. Some preliminary results reported by Mr. Kirk as of the summer of 2004 are discussed in the following.

The field test site is in a community in northwestern Oregon where the climate is relatively mild year-round, so the products have not been subject to harsh environmental conditions. The predominant factors in this area are the effects of rain and some solar radiation. The products which are being monitored are all retrofit applications as follows:

**Retrofit**

- Detectable Warning Mat (Detectable Warning Systems, Inc.)
- Strongwarn Tactile Warning (Strongwall Industries, Inc.)
- Safti-Trax Domes (Cote-L Industries, Inc.)
- Safti-Trax Mat (Cote-L Industries, Inc.)

The Detectable Warning Mat has shown little change since installation and no damage or problems with adhesion to the concrete.

The Strongwarn product has been fading in color, presumably due to UV radiation. This has resulted in a reduction in the contrast between the surrounding (light colored) concrete and the truncated dome field. A few domes are broken.

Both the Safti-Trax Domes and the Safti-Trax Mat have experienced considerable discoloration, due to water which leaves dirty deposits. The depositions adhere to the surface of the product. While this might be removed by washing, ODOT probably has neither the authority nor the personnel to enforce this action. There is no evidence of damage or adhesion to the concrete.

Thus, the most significant issue ODOT is experiencing appears to involve the contrast between the detectable warning and the concrete, either due to fading or discoloration.
NEW YORK DOT

The New York DOT is maintaining a Provisional Approved list of detectable warning products. The products on their list are installed in the field and are in the process of being evaluated for performance. The products installed in this environment are subjected to many freeze-thaw cycles. The types of mechanical forces which may be used on the installations may not be known because the NYDOT does not maintain the sidewalks. Snow removal may vary by community. In many cases, snow removal is done by heavy machinery (snow plows or tractors/skid-steers with snow blowers). In some cases, snow removal is done by property owners.

Mr. Bob Lohse of the Landscape Architecture Bureau of NYDOT provided a synopsis of the site visits in which the different types of product installations were evaluated. Mr. Lohse’s observations are described herein. In general, all of the installations looked very good, with the exception of Mexcon’s Detect-Tile which has since been disapproved due to very poor performance. However, Mexcon also had an earlier prototype which has performed well over two winters and is now on the approved list. Below is a list of the products reviewed. All of the installations had one winter except the Whitacre-Greer Brick and the early Mexcon prototype, both of which have been installed for two years.

Retrofit

*DWS tile by TroyDiecutting Inc (3M).* Overall the ramp is still intact, with no major damage to the warning field. The edges of the warning tiles are still adhered to the underlying concrete and show no signs of lift/curl at all. A small 2"x 6" piece was torn off near the edge of curb. Some of the domes showed signs of damage. No plowing is thought to have been performed on this sidewalk.

*Trelleborg TGS (TG Lining).* Damage to about 20% of the domes are the result of snow removal (heavy duty tractor-driven snowblower)

Cast-in-Place or New Construction

*ADA Fabricators, Tactile warning Tile.* Weathered very well. Signs of mechanical damage (Plow or snowblower damage) to about 10% of the domes. Product was embedded in the concrete ramp - not the surface applied version.

*Armor-Tile embedded unit by Engineered Plastics Inc.* Excellent condition, about 2% of what appears to be mechanical damage. Installation seemed very good with the tiles firmly embedded in the underlying curb ramp.

*Detecto-Tile By Mexcon.* The Mexcon precast paver in its latest form using EMACO T-415 Bridge patching material, has after one winter performed very poorly. The paver itself has been disintegrating, there is extensive separation of the domes from the tiles. This has occurred to about 50% of the installations.
Detecto-Tile (early prototype). This product was used on several projects before switching to the above material. These pavers have gone through two winters with less than 5% damage.

Transpo Industries, STEP-Safe Precast Polymer Concrete. After one winter almost all of the domes still intact. Only one or two domes damaged (appeared to be the result of mechanical snow removal). Installation seemed very good with the tiles firmly embedded in the underlying curb ramp. Snow removal is thought to be performed by small snow blower or shovel.

Whitacre-Greer Brick. Installed two years ago, only one ramp looked bad (40% dome loss) and it was found that it was being cleared with a pickup truck snowplow. Signs of mechanical damage on other ramps affects about 5% or less of the domes (Plow or snow blower damage.)

Oaks Detectable Warning Paver by Oaks Concrete Products. Excellent condition on all installations, less than 2% damage

OTHER DOTs

Several other DOTs were interviewed in this study but most are only beginning to place and evaluate detectable warning products and were not able to comment on performance.


Interviews conducted by Bentzen et al. (2000) identified the following information on installation and durability:

City of Austin, Texas

The city of Austin has installed truncated dome detectable warnings at curb ramps since 1992 and now have over 1000 ramps with detectable warnings.

Materials and Installation

- In 1992, the first installations were stamped concrete but were discontinued due to the difficulty associated with stamping concrete and the poor durability of the painted surface.
- Dark red brick pavers have been installed since 1995. Problems were reported with settling when the pavers were installed in sand, but setting in mortar solved that problem.

Maintenance and Durability

- Pavers are never washed and there has been no experience with snow and ice.
- Revising the installation method solved the problem of settling.
- A few individual pavers have been replaced due to settling and damage from trucks.
Metropolitan Atlanta Rapid Transit Authority (MARTA)

The MARTA in Atlanta, Georgia installed truncated dome detectable warnings at all platform edges in all stations. The installation program began in 1992 in 12 stations and now all 36 stations have detectable warnings.

Materials and Installation

- Products used were Armor-Tile or High-Quality Tile.
- Tiles are secured with mechanical fasteners and structural adhesive.
- In the retrofit installations, the tiles replaced a two-foot portion of a three-foot granite strip along the edge of the platform, which was originally installed as a tactile warning. A portion of the granite strip was ground down to allow installation of the tiles. The installation was accomplished in stages, with most of the construction done at night when trains were not in service.

Maintenance and Durability

- Detectable warnings are pressure washed and scrubbed approximately bimonthly. MART has had little experience with snow and ice removal.
- Staff report minor problems with chipping, cracking, and occasional lost screw covers. The chipping of the detectable warning surface at the platform edge has been determined to be caused by either MARTA’s money carts, or escalator equipment carts. Replacing the steel wheels with rubber wheels has largely solved the problem. The previous granite edge strip had suffered similar damage and required repair so the chipping of the Armor-Tile is not considered significant.

City of Roseville, California

The City of Roseville has several hundred curb ramps with detectable warnings.

Materials and Installation

- Since 1997, the City of Roseville requires the Armor-Tile panel which is installed in wet concrete.

Maintenance and Durability

- Tiles are not cleaned on a regular basis – rain washes them off. There has been no experience with snow or ice.
- No problems with cracking or lifting of the panels have been observed since it is embedded in the concrete.
- The color has faded somewhat.
Metro North Railroad

Metro North is the second largest commuter railroad in the nation and has installed detectable warnings along platform edges in 29 stations, including indoor and outdoor, elevated and non-elevated stations. Detectable warnings are two feet deep along the length of the platform and are set back 4 inches from the platform edge. Setback is to prevent damage from trains to the detectable warning along the platform edge. Installations took place from 1995 to 1997.

Materials and Installation

- Detectable warnings are Lanxide (SMC) and Armor-Tile (Engineered Plastics).
- Various installations methods have been tried, including riveting, combining rivets and adhesives/mastics, and setting into wet concrete with overlay type materials. All have some problems and are less than satisfactory.
- Upcoming installations will probably be cast in place as that has been most successful to date. While Metro North is working on developing the best possible plans, it is noted that there are difficulties anytime a cold joint of two dissimilar materials is installed on the platforms and exposed to the elements, particularly in elevated platform situations.
- Some tiles were installed with a cavity between the detectable warning and the base surface for sound difference, but this opens up the concrete base to more possibilities of deterioration. The setback from the platform edge also leaves a joint for water intrusion creating freeze/thaw problems.
- Setting in wet concrete was the most successful method of installation.

Maintenance and Durability

- Detectable warnings are pressure washed on no set schedule.
- Snow plows and chemicals are used to remove snow. Some chipping has resulted from the snow plow. Calcium chloride makes the surface of the detectable warning slippery.
- Domes are difficult to clean.
- Cracks have been reported as a major problem in both types of tiles used. It is believed to be from freeze/thaw, snow removal, and washing equipment.
- The installation procedures for retrofitting tiles required milling up the concrete of the platform and then installing the tiles. No matter how well sealed, this exposed the concrete base to salt and water, causing it to deteriorate.
- Fading was observed in all products but more with the SMC material.
City of Harrisburg, Pennsylvania

Detectable warnings were installed on 300 to 400 curb ramps in the downtown area of Harrisburg, PA in 1993-1994.

Materials and Installation

- Initially, a local contractor used a stamped concrete method of forming the domes. A rubber mold was pressed into the concrete; however, when removing the mold, the domes tended to stick to the mold and were removed.
- The contractor developed a better process which was to pour the concrete into a mold, and then install it into the ramp as a precast unit.

Maintenance and Durability

- Detectable warnings are not cleaned.
- Snow and ice are removed with salt, which may have contributed to dome degradation. The City Engineer stated that other methods of clearing don’t work with domes.
- Although concrete was rated at 6000 psi, domes broke off.
- Major wear is reported. Some settling is also reported.
- Individual units were replaced in a few instances where cracking occurred. Cracking was thought to be caused by garbage trucks driving over the units.

Massachusetts Bay Transportation Authority (MBTA)

Detectable warnings have been installed at approximately sixty-one stations in the MBTA system including rapid rail, light rail and commuter rail stations, indoors and outdoors. Most have been installed since 1993.

Materials and Installation

- Installations include detectable warnings of epoxy, plastic and ceramic tiles. The detectable warning materials are adhered with adhesives, fasteners and/or screws directly on the base surface and are installed at the edge of the platform.

Maintenance and Durability

- Detectable warnings are washed on a non-regular basis using a water hose.
- Snow and ice are removed by shovel, sand and broom.
- Some tiles are missing, peeled, cracked and chipped and the surface texture of a few of the tiles has degraded somewhat.
- Detectable warning products have been removed and reinstalled at several stations.
- The color of a few tiles has degraded with some discoloration.
City of Cleveland, Ohio

The City of Cleveland installed detectable warnings on curb ramps on the public square in 1996.

*Materials and Installation*

- Red brick pavers, 4 in x 8 in x 3.5 in, were installed in sand with a 4 in concrete base underneath on the entire ramped area.

*Maintenance and Durability*

- No maintenance problems reported.
- Detectable warnings are swept or hosed down on no set schedule.
- Snow and ice are removed by snow plow, shovel, or salt. Concerns were expressed about snow removal and snow building up and becoming slippery.
- No problems were reported with durability. A few bricks have broken or become loose from trucks driving over them.

Baltimore County, Maryland

Detectable warnings are used in numerous curb ramp locations in Baltimore County, Maryland. They have been installed mainly where older commercial areas are being revitalized.

*Materials and Installation*

- Dark brown brick pavers are set on a concrete substrate. Usually the concrete base is poured, then 1 in of sand, with the brick pavers set into the sand. No problems are reported with installation since it is “the same as any paver”.

*Maintenance and Durability*

- No maintenance problems have been reported.
- There has been minimal experience with snow or ice removal. Since the pavers are dark, the snow melts quickly.
- Dome wear was reported to be a minor issue.

Bay Area Rapid Transit (BART)

The Bay Area Rapid Transit (BART) has installed detectable warnings throughout the system in all of 39 stations since 1987.

*Materials and Installation*

- Early installations were Pathfinder Tile, manufactured by Carsonite, which is a resilient material that was glued to the platform.
• Installations since 1997 are Armor-Tile.
• Armor-Tile installations are attached with adhesives and mechanical fasteners. Two types of Armor-Tile materials have been used. One is a flat (1/2 in) tile, attached in a recessed fashion to the platform surface. In a few stations, a 3 in thick Armor Tile product has been used. This tile replaced the concrete on the platform edge; it was used where there were problems with the concrete of the platform.

Maintenance and Durability

• Tiles are cleaned on a weekly basis with the stations.
• There has been no experience with snow and ice.
• The Pathfinder Tile peeled up over time due to weather, platform vibration, and scrubber type cleaning. Many tiles have been replaced by Armor-Tile.

Claremont, California

Detectable warnings have been installed on a trial basis at a round about in Claremont, California in 1999.

Materials and Installation

• The detectable warning is a rubber tile product that has been glued down on the surface. A slight lip of approximately ¼ in is caused by the material thickness.

Maintenance and Durability

• The material is not cleaned.
• Durability has not really been tested since the material has been installed recently.
• No problems have been reported with lifting or peeling.
CHAPTER 5: CONSTRUCTION AND INSTALLATION CONSIDERATIONS

REVIEW RECOMMENDED INSTALLATION PROCEDURES

There are many different detectable warning products available and most manufacturers provide an instruction guide for installation which should be closely followed. It is also advisable that agencies solicit help from product distributors that are willing to work closely with the agency and contractors making sure installers are well trained. Distributors should also help in the follow-up final inspection of the installed product. When reviewing the installation procedures for a detectable warning product, consideration should be given to the following:

- Is a licensed installer needed?
- Are the installation procedures readily available and are they easy to understand?
- Are instructions available in Spanish?
- Are training classes/videos available?
- Does manufacturer provide hands-on training?

CONSTRUCTION TRAFFIC DAMAGE FROM SURROUNDING AREAS

In some areas of new construction, streets, sidewalks, and curb ramps are built prior to construction of buildings and/or homes. Truncated domes which are installed on the curb ramps could be subjected to heavy construction traffic and abuse which can destroy the detectable warning products. Many products will not withstand this type of severe traffic.

INSTALLATION TIME/SIMPLICITY

Some products are very simple, one-step processes as will be discussed further in this chapter. Other processes may not be difficult but involve multiple steps to complete. These are factors to consider for particular circumstances. Another consideration may be the experience level of the contractor. Some products such as brick pavers or concrete panels may be very similar to products contractors work with routinely.

SAFETY DURING INSTALLATION

Safety to the public is also a matter to consider regarding installation for certain circumstances. The time it takes for materials to dry or cure will require that curb ramps be coned-off from the public. For new construction, some agencies require that a recess be built in the curb ramp to accommodate the detectable warning as shown in Figure 11. They also require that the concrete sidewalk and curb ramp area cure for a minimum of 28 days prior to installation of the detectable warning requiring that the recessed area be coned off for this length of time.
The following is a general and brief description of the installation steps and time required for installation of the different product types. Specific installation instructions will vary for individual products.
Stainless Steel Panel

The process shown in Figure 12 consists of embedding a stainless steel panel in fresh concrete. The installation can be performed in minutes according to the following general steps:

- Level and finish concrete per specifications.
- Embed panel into fresh concrete and work downward until the surface of the panel is level with the concrete.
- Edge around panel.

Figure 12. Installation of Stainless Steel Panel.
(Photo Printed with Permission of MetaDome®)
Fiberglass Panel

This product (Armor-Tile®) consists of a rigid composite panels which are installed in “green” concrete (Figure 13). The panels come in several different sizes and are installed similarly to the stainless steel panels as shown previously. The underside of the panel has a series of flanges with holes. The holes are intended to allow concrete to form a key with the tile. Steps to install are listed as follows:

- Panels are positioned on wet concrete and a rubber mallet is used to embed the flanges.
- Tiles are embedded so that the flat surface is roughly at the same grade as the ramp.
- Weight is placed on the panels as needed to adjust their position while the remainder of the ramp surface is finished.
- One week after installation, the ramp is ready for use.

Figure 13. Installation of Armor Tile Panels in Fresh Concrete. 
(After Kaplan, 2004)
Stamped Concrete

The process shown in Figure 14 is one that may be used for stamping concrete. The process shown is described in general below:

- Allow concrete to cure to the point it is dry to the touch.
- Apply release agent.
- Place stamp on concrete surface and tap or vibrate until fines in the mix seep through the holes in the form.
- Remove fines from top of form with brush or rag.
- Lift stamp from surface.
- Once the concrete has cured adequately, a pigmented sealer may be applied.

Figure 14. Installation of a Stamped Concrete Process.
(Photos Printed with Permission of MetaStamp®)
Surface Applied Individual Domes

- Mask off area and apply a two part epoxy sealer over entire area. Then apply glass beads to provide mechanical bonding between sealer and basecoat. Let dry 3 ½ to 5 hours.
- Apply base coat and allow to dry 30 minutes to 1 hour.
- Lay out rubber mats and squeegee dome material in the dome mold mats. Remove mat and let dry 20 to 30 minutes.
- Apply final top coat.

The process shown in Figure 15 on some ramps in Vermont was performed in 9 hours for about 50 square feet.

Figure 15. Installation of Truncated Domes.
(After Kaplan, 2004)
Surface Applied Domes

For this process, the individual domes are attached to 2-foot by 2-foot sheets. Note from Figure 16 that odd shapes can be accommodated by cutting the appropriate shape from the sheet of domes. The installation shown in Figure 16 is from Vermont. It should be noted that one of the applications was on an exposed aggregate surface. It was suggested that this product should probably not be used for an exposed aggregate surface because it was difficult for the individual domes to make adequate contact with the underlying surface. Installation time for 20 square feet was about 8 hours.

- After cleaning the ramp with a solvent, a base coat of material is applied to the ramp over a predetermined masked area.
- While the base coat is wet, the domes which are attached to a plastic sheet are applied to the ramp surface and pressed into place with a flat board.
- After pressing the domes down, the plastic top sheet is cut between every two columns of domes to aid in drying and to ease removal. Allow to dry about 1 to 2 hours.
- The plastic top sheet is removed. Individual domes which are pulled up at this point can be reapplied with a small amount of adhesive.
- A top coat of material is applied with a roller and let dry for 30 minutes to 1 hour.
- Apply second and third top coat. Final coat should dry from 6 to 12 hours.

Figure 16. Installation of Domes from Plastic Sheets.
(After Kaplan, 2004)
Flexible Mats

Flexible mats are intended for use on cured concrete for either new or existing curb ramps. The following procedure consists of polyurethane mats and adhesive.

- Area is cleaned and masked off. Construction adhesive is then applied with a caulking gun at the rate specified by manufacturer.
- Adhesive is spread with a notched trowel.
- Mats are placed and pressure is applied with a 1 foot square piece of plywood. The edge of the board is used to apply pressure in between rows and domes.
- Pressure is applied to the domes with the flat board and special care is taken to apply pressure around the edges of each mat.
- Adhesive is allowed to set overnight before opening ramp to foot traffic.

Installation of this system shown in Figure 17 covering a total of 10 square feet took about 2 hours.

Figure 17. Installation of Flexible Mats.
(After Kaplan, 2004)
Thin Flexible Panels/Tiles

The following (Figure 18) is a description of a retrofit installation of thin polyester resin panels (ADA Tactile Systems ®). The panels have a flange on the leading edge to help form a mechanical bond to the existing sidewalk. If a ramp is oddly shaped, the flange can be removed to make the panel more flexible.

- A power saw is used to cut a groove in existing concrete to accommodate flange in tile.
- Tiles are cut to correct size and a polyurethane adhesive is troweled on underside.
- Tiles are placed and a hammer drill is used to drill through seven domes per panel to prepare for placement of stainless steel, nylon-sleeved anchor bolts.
- Anchor bolts are hammered into place and caulking is placed around the edge of the panels.

The product is easily removed if repairs or replacement becomes necessary. Heat is applied to a tile which loosens the adhesive and allows the tile to be removed with a flat-bladed shovel.

Figure 18. Retrofit Installation of Thin Polyester Resin Tiles.  
(After Kaplan, 2004)
Concrete Panels/Tiles

The following is a ten minute installation process of concrete tiles in new concrete. The tiles shown in Figure 19 and instructions described below are for a product called Cast-In-Tact®.

- Remove wet concrete to a ¾ inch depth.
- “Mag” float area to receive tile until a smooth paste is developed.
- Wet and parge back of panel and set in place. Set second panel tightly butted to first panel with no more than 3/16” inch gap.
- Use rubber mallet to properly seat.
- Float fresh concrete around edges and check final layout.
- Edge around panel using 1/8” radius edger.
- Clean with sponge.

Figure 19. Cast in Tact Installation.
(Photos printed with permission of Cast-In-Tact®)
Thick Concrete Panels

The following describes an installation procedure of thick concrete panels as shown in Figure 20 (Hanover Architectural Tiles) as performed by the Wisconsin DOT (Kemp, 2003).

- An oiled form is inserted into fresh concrete to create the recess for the precast panel.
- Concrete is finished around the form.
- The form is removed the following day.
- After 28 days of cure time the concrete is power washed to provide a clean bonding surface.
- A thin-set mortar is applied for a bonding layer.
- Thin set material is applied to the precast block.
- Tiles are set and tape is applied to keep edge clean.
- Joints are filled with thin set material.

Figure 20. Installation of Thick Concrete Panels (Hanover Architectural Tiles).
(After Kemp, 2003)
Throughout the course of this study, researchers identified three maintenance issues which should be considered regarding detectable warnings:

- Snow and ice clearing;
- Removal of debris and/or cleaning;
- Repair.

SNOW AND ICE CLEARING

Snow and ice removal from detectable warnings can include a variety of techniques:

- Snow plow blade;
- Rotary brush;
- Snow blower;
- Deicing stone;
- Shovel (by hand); and
- Chemicals such as salt or calcium chloride.

Responsibility for snow and ice removal from sidewalk areas varies throughout the nation. This responsibility may reside with either the DOT, local city or county government, or the property owner. The entity installing the detectable warning may not be responsible for snow and ice removal. Therefore, careful consideration should be given to the anticipated techniques which will be used for snow and ice removal.

Many products will not stand up to the severe mechanical force applied by a snow plow. The effects of mechanical forces may be further exacerbated by the fact that some detectable warning materials are temperature susceptible and become more brittle at extremely low temperatures.

Some product manufacturers will admit that their product will not stand up to the forces of a snow plow and this question should be asked of the supplier if it is a concern.

Some of the above-mentioned snow clearing techniques are less likely to be as damaging as a snow plow and may provide an alternative technique for snow removal to better protect detectable warnings. However, some DOTs interviewed in this study indicated that a snow plow was the only way to effectively remove the amount of snow that they experience.

The effects of deicing chemicals take time to assess and there is not enough long-term performance information available at this time to make any type of conclusion regarding the effects of these chemicals.
If it is known that the detectable warning will be subjected to snow plows, then consideration should be given to installing very high strength materials. It is also recommended that these be products which are embedded into the curb ramp. Any type of material which is applied/adhered or attached to an existing surface has not performed well as shown in some of the photos below.

**Snow Plow Damage**

The photos shown in Figures 20 through 27 represent the experience of the Vermont DOT with surface applied domes and flexible mats subjected to one winter of snow plowing (Kaplan, 2004). In Figure 21, these surface applied domes bonded well to the underlying concrete, but did not have adequate strength in the domes themselves to withstand plow impact.

![Figure 21. Loss of Domes due to Snow Plow – Surface Applied Domes (Strongwarn).](image)

*(After Kaplan, 2004)*
Figure 22 shows a polyurethane mat which also lost many of its domes and, in addition, the mat did not bond adequately to the underlying concrete.

![Figure 22. Loss of Domes Due to Snow Plow and Inadequate Bond of Flexible Mat – COTE-L Safti Trax Mat. (After Kaplan, 2004)](image)

Figure 23 shows the performance of the COTE-L plastic sheet product where the individual domes are applied to a base and coated with several applications of surfacing. The individual domes have been removed/debonded by the snow plow.

The Vanguard product in Figure 24 held up somewhat better. Some small sections of the truncated dome field peeled up completely. Most of the domes are intact although some scraping off the top has occurred.
Figure 23. Loss of Domes Due to Snow Plow – COTE-L Plastic Sheet Individual Dome. 
(After Kaplan, 2004)

Figure 24. Loss of Domes Due to Snow Plow – Vanguard Surface Applied Domes. 
(After Kaplan, 2004)
The ADA Tactile system composite tile is shown in Figure 25 after a winter of snow plowing. The majority of the domes are still intact and there is no evidence of edges peeling up or separation from the underlying concrete surface. The main damage exhibited by this product is that the texturing on the top of the individual domes has been removed. However, the product did not appear to be slippery despite this loss.

![ADA Tactile System Product After One Winter of Snow Plowing](image)

**Figure 25. ADA Tactile System Product After One Winter of Snow Plowing.**
(After Kaplan, 2004)

The Mexcon, Detecto-Tile is shown in Figure 26 after one winter of snow plowing in Vermont. Many domes were either sheared off or pulverized by plowing operations. In addition to dome loss, the product exhibited delamination of the top surface from the rest of the tile.

The Transpo – Step Safe Tiles held up well under the effects of snow plowing. Less than 5 percent of the domes were missing – mostly on the leading edge of the tiles (Figure 27).
Figure 26. Mexcon – Detecto Tile Product After One Winter of Snow Plowing.  
(After Kaplan, 2004)

Figure 27. Transpo – Step Safe Tile Product After One Winter of Snow Plowing. 
(After Kaplan, 2004)
The Armor-Tile product also held up relatively well after snow plowing (Figure 27). Although a small percentage of the domes were damaged or removed, it appears to be durable and is providing an adequate detectable warning.

Figure 28. Armor-Tile Product After One Winter of Snow Plowing. (After Kaplan, 2004)
Snow Blower Damage

The damage shown in the product in Figure 29 is due to damage from a snow blower. The presence of sand which had also been applied created the abrasive forces to cause this damage. This product is no longer available.

![Figure 29. Detectable Warning Damage Caused by Snow Blower and Sand.](Photo provided by Bob Lohse, NYDOT)

CLEANING AND DEBRIS REMOVAL

Transit authorities generally had some schedule regarding cleaning of detectable warnings; however, most highway agencies did not. Deposition of debris on detectable warnings can be a significant problem as shown in Figures 30 through 32. Much of this seems to be related to drainage issues and associated with ponding which occurs on the detectable warning. This is not necessarily a problem with the detectable warning but is related to underlying work. Some of these issues may be prevented with improved drainage designs. However, most agencies felt that routine cleaning was too costly.

Some products tend to lose their color over time or become stained as shown in Figure 33. It is unknown if cleaning might restore the product to its original color and provide the desirable color contrast with surrounding areas.
Figure 30. Debris Collection on Detectable Warnings.

Figure 31. Debris Collection on Detectable Warnings.
Figure 32. Debris Collection on Detectable Warnings.

Figure 33. Discoloration or Staining of Detectable Warnings.
REPAIR OR REPLACEMENT

Since there is little long-term performance information for many detectable warning products, questions exist regarding the effectiveness of repairing products that exhibit performance problems. The ability to repair a product may be a consideration during the selection process. Many detectable warning products provide a means (repair kit) for repair.

In addition, consideration should be given to the difficulty of removing and replacing a product should it become necessary.

Some of the maintenance repair issues may include the following:

- Some agencies have noted that set screws or anchor bolts have lifted as shown in Figure 34. It is anticipated that this may affect performance and safety but more time is needed to evaluate this problem.
- Are there methods of repairing products which delaminate from the ramp surface?
- Can individual domes be repaired/replaced for surface applied dome products?
- If color contrast is lost, can product be painted?

![Figure 34. Set Screws Beginning to Lift Above the Height of Truncated Dome.](image)
CHAPTER 7: DURABILITY CONSIDERATIONS

Some of the important durability and performance information is related to damage from snow removal and is discussed in Chapter 5. Some of the other performance and durability issues include the following:

- Delamination;
- Loose or missing tiles;
- Cracking and/or breakage;
- Settlement or shifting;
- Dome integrity;
- Placement of control joints; and
- Color fading.

Some of the examples shown in this chapter are not necessarily failures of detectable warnings but are related to installation defects or problems associated with underlying or surrounding material.

DELAMINATION

The potential for delamination exists with any surface applied product. This is certainly more of an issue when outside mechanical forces such as snow plows cause this type of failure. However, it can also occur under environmental effects such as temperature changes and precipitation. The failure shown in Figure 35 occurred in a very moderate climate where temperatures never reach freezing. This type of failure is also a safety concern for pedestrians.

![Figure 35. Delamination Failure Presents Safety Hazard.](image-url)
Figure 36 shows a delamination problem for a product in Austin, Texas which receives only foot traffic at the DOT office complex.

Figure 36. Delamination Failure.
LOOSE OR MISSING TILES

The installation shown in Figure 37 below shows an example of a loose tile. This installation in Idaho is twelve years old and is now beginning to fail. The original color of the detectable warning was yellow but it has now faded to the surrounding sidewalk color.

Figure 37. Loose Tiles on 12-Year Old Installation in Idaho.
CRACKING OR BREAKAGE

Cracking or breakage can occur with some products although it has not been documented to be a serious problem at this time. This seems more likely to occur with the plastic/fiberglass/composite type materials although it could occur in other products, as well. This is shown in Figure 38 and the cause of this small failure is unknown.

Figure 38. Broken Corner on Fiberglass Tile.

SETTLEMENT OR SHIFTING

Pavers set in sand may be associated with settlement/shifting problems (Figures 39 and 40). Some agencies set the pavers in mortar to help alleviate that problem. However, installation can also create an unlevel surface as shown in Figure 41 if not done correctly.
Figure 39. Settlement of Brick Pavers.
Figure 40. Settlement and Loss of Brick Pavers Set in Sand.

Figure 41. Settlement or Poor Installation of Large Paver Panels.
DOME INTEGRITY

The truncated domes of a detectable warning must maintain their integrity to function as intended. As discussed in Chapter 5, outside mechanical forces can cause a loss of domes. In addition, poor installation, such as the stamping process shown in Figure 42, can result in loss of function. Some have reported a loss of domes or “popping out” of domes for reasons unknown. The domes shown on the concrete pavers in Figure 43 popped out prior to the first winter.

![Figure 42. Lack of Dome Integrity Associated with Installation.](image)
PLACEMENT OF CONTROL JOINTS

One issue which was identified but not resolved in this study regards the placement of control joints. Some industry representatives state that control joints should be provided as shown in Figure 44 for stress relief no matter what type of product is used. This is, however, often not the case with many products which are embedded into the concrete with no consideration for control joints.
COLOR FADING OR CHANGING

It seems that most all detectable warning products fade with time and exposure to the elements, deicing chemicals, or cleaning solvents. This is shown in Figure 45 where a new product has been installed next to an older product of the same manufacturer. Some products have not faded but have changed color or blackened as shown in Figure 46. Causes for this are unknown.
Figure 45. New Product Placed Next to Old Showing Color Fading.

Figure 46. Product Installed in Texas Turned Black.
CHAPTER 8: SUMMARY OF FINDINGS AND RESEARCH NEEDS

SUMMARY OF FINDINGS

A summary of the findings in this study are presented in Table 1.

Types of Detectable Warning Products Available

There are a number of different manufacturers of detectable warning products that meet the truncated dome geometric requirements of ADAAG. These products span a range of material and color choices. Some of these products are for installation during the construction of curb ramps and some can be applied to the surface of an existing curb ramp. Detectable warnings which can be applied to existing surfaces are sometimes called “retrofit” products. Researchers grouped these products into the categories described below:

Cast-in-Place, New Construction Installations

- Traditional size brick/concrete pavers;
- Large concrete/stone paver units/panels/tiles;
- Metal panels;
- Polymer composite/fiberglass rigid panels; and
- Stamped concrete.

Surface Applied and/or Retrofit Installations

- Flexible mats;
- Surface applied domes; and
- Thermoplastics.

Case History Performance Evaluations

Several DOTs have documented their installation and performance studies on detectable warnings as presented in this report. Most of the DOT experience reported herein is in the colder climatic regions of the northern states. However, performance information covers only one to two winters. Some of the more severe performance problems are associated with snow removal operations and some products performed better than others as described in Chapter 3. Many products will not withstand the forces of snow plows; however, some of these products have potential in milder climates.

It should be noted that there are several very promising products that are relatively new to the market and no performance documentation exists at this time.
Table 1. Summary of Findings.

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Manufacturers</th>
<th>Installation Notes, Problems, Challenges</th>
<th>Information on Durability, Performance, Maintenance*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick or Concrete Pavers</td>
<td>Endicott Clay Products</td>
<td>Can be placed in running bond, stack bond, or herringbone pattern. Set in mortar or sand.</td>
<td>City of Austin reported problems with settling when installed in sand, but setting in mortar solved problem. No problems with wear reported, except possibly some fading. No experience with snow and ice removal. Contact: Ken Zimmerman, 512-499-7138.</td>
</tr>
<tr>
<td></td>
<td>Whitacre-Greer</td>
<td>Sometimes installed in sand with concrete base underneath. Contractors generally familiar with setting pavers, even on sloped surface. Some problems related to cutting pavers to fit curves, and maintaining the distance between domes when materials need to be cut to fit a curve, such as at the base of a blended curb ramp.</td>
<td>Baltimore Co., MD uses brick pavers set in sand with concrete base. Minimal experience with snow &amp; ice removal. No problems. Contact: Richard Calkins, 410-887-3734.</td>
</tr>
<tr>
<td></td>
<td>Pavestone</td>
<td></td>
<td>New Hampshire DOT reports that pavers performed well with only seven percent of the domes damaged or removed after subjecting to 20 snow plowing cycles. Contact, Denis Boisvert 603-271-3151</td>
</tr>
<tr>
<td></td>
<td>Oaks Concrete Products</td>
<td></td>
<td>New York DOT reports good performance after at least one winter. Snow removal varied by community and was not documented. Contact: Robert Lohse, NYDOT.</td>
</tr>
<tr>
<td></td>
<td>CASTinTact</td>
<td>Some products can be placed in a ten-minute process by embedding panel into wet concrete. Some products require that a recess be formed into the concrete to accommodate the panel. Usually requires 28 days of concrete curing time prior to installing detectable warning panel in thin-set mortar.</td>
<td>WDOT reports that the Hanover Concrete panels performed well after a winter of snow plowing, snow blowing, residential shoveling and salting. Contact: Peter Kemp, 608-246-7953.</td>
</tr>
<tr>
<td></td>
<td>Cold Spring Granite</td>
<td></td>
<td>NHDOT reports the Hanover tiles performed well (after 20 plow cycles) with only the first row of domes encountered by snow plow showing progressive wear. The Step-Safe tile also exhibited good durability with ten percent of the domes showing damage. Contact: Denis Boisvert, 603-271-3151</td>
</tr>
<tr>
<td></td>
<td>Hanover Architectural Products</td>
<td></td>
<td>VTRANS reports that after one winter of snow plowing, the Step-Safe tile performed well with less than 5% of the domes exhibiting damage. Most of the domes were removed on the Mexcon tile, and it also exhibited delamination of the top surface from the rest of the tile. Contact: Jon Kaplan, 802-828-0059.</td>
</tr>
<tr>
<td></td>
<td>Interlock San Diego</td>
<td></td>
<td>NYDOT reports that an early prototype of the Mexcon product performed very well over two winters but a later version (EMACO T415) has performed poorly. After one winter, Step-Safe has performed well. Contact: Robert Lohse, NYDOT.</td>
</tr>
<tr>
<td></td>
<td>Steps Plus, Inc.</td>
<td></td>
<td>Note that some of these available products are relatively new and haven’t been through an evaluation process but appear to be very promising.</td>
</tr>
<tr>
<td></td>
<td>Step-Safe (Castek/Transpo)</td>
<td>WDOT found that installation of the Hanover concrete panels was too labor intensive to be cost effective. In the future, they intend to develop a specification to allow a full-depth panel that is mechanically anchored to the sidewalk.</td>
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<tr>
<td></td>
<td>Mexcon Detecto Tile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large Concrete or Stone Paver</td>
<td>CASTinTact</td>
<td>Some products can be placed in a ten-minute process by embedding panel into wet concrete. Some products require that a recess be formed into the concrete to accommodate the panel. Usually requires 28 days of concrete curing time prior to installing detectable warning panel in thin-set mortar.</td>
<td>WDOT reports that the Hanover Concrete panels performed well after a winter of snow plowing, snow blowing, residential shoveling and salting. Contact: Peter Kemp, 608-246-7953.</td>
</tr>
<tr>
<td>Units, Panels, or Tiles</td>
<td>Cold Spring Granite</td>
<td></td>
<td>NHDOT reports the Hanover tiles performed well (after 20 plow cycles) with only the first row of domes encountered by snow plow showing progressive wear. The Step-Safe tile also exhibited good durability with ten percent of the domes showing damage. Contact: Denis Boisvert, 603-271-3151</td>
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</tr>
<tr>
<td></td>
<td>Mexcon Detecto Tile</td>
<td></td>
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</tr>
<tr>
<td>Metal Panels</td>
<td>MetaDome, LLC</td>
<td>These products are installed in fresh concrete and installation seems simple and quick.</td>
<td>No formal evaluations have been conducted on these types of products but early indications show good durability.</td>
</tr>
<tr>
<td></td>
<td>East Jordan Iron Works</td>
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<tr>
<td>Product Type</td>
<td>Manufacturer</td>
<td>Installation Method</td>
<td>Problems &amp; Observations</td>
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</tr>
<tr>
<td>ADA Armor Tile</td>
<td>ADA Fabricators/Tactile Systems Transit-Tile</td>
<td>Some of these products have flanges for embedding into fresh, finished concrete or they may be embedded into saw cuts on hardened concrete for retrofit applications. Mechanical fasteners are sometimes used. WDOT has installed the Armor Tile in both a cast-in-place and retrofit application. The cast-in-place application was pushed into wet concrete and satisfactory installation took less than 15 minutes. The Armor Tile retrofit installation took about 30 minutes per ramp. VTRANS installed ADA Tactile System products in retrofit applications in 30 minutes. Setting in wet concrete is generally preferred over retrofit applications. Metro North Railroad has installed Armor-Tile along platform edges in 29 stations from 1995 – 1997. Various installation method have been tried, including riveting, combining rivets and adhesives/mastics, and setting into wet concrete with overlay type materials. Setting in wet concrete is most successful. Bay Area Rapid Transit has installed Armor-Tile in retrofit applications using adhesives and mechanical fasteners.</td>
<td>WDOT’s evaluation of Armor Tile is that it has performed well in terms of ease of construction, slip resistance (subjective), aesthetics, and durability. Contact: Peter Kemp, 608-246-7953. Montana DOT reports that three retrofit installations of ADA Fabricators Tactile Systems Tile are in good condition with no noticeable loss of adhesion or deterioration. Contact: Craig Abernathy, 406-444-6269. NHDOT reports that a cast-in-place installation of the ADA Fabricators Tactile Systems tile exhibits eight percent dome loss (after 20 plow cycles). After 11 plow passes, water would squeeze out from beneath the tile, perhaps indicating a debonding. Contact: Denis Boisvert, 603-271-3151 VTRANS’ retrofit application of ADA Fabricators Tactile Systems tile has performed well with the majority of domes intact. One corner of one of the panels has been removed by the plow. For the cast-in-place Armor Tile, a small percentage of the domes were damaged by plows. Some of the slip-resistant dots on top of the individual domes were removed, but overall it is very durable and providing and adequate detectable warning. Jon Kaplan, 802-828-0059 NYDOT reports that a cast-in-place ADA Fabricators Tactile Systems tile has weathered very well. Mechanical damage from plow or snow blower has damaged about 10% of the domes. Cast-in-place Armor tile is in excellent condition. Contact: Robert Lohse, NYDOT. City of Roseville, CA has installed hundreds of cast-in-place Armor Tile since 1997. Color has faded somewhat but no problems with the panels. Contact: Rick McCarter, 916-774-5481. Metro North Railroad reports some chipping of the Armor Tile from snow plow. Calcium chloride makes surface slippery. Domes are difficult to clean. Cracking has been reported and is believed to be from freeze/thaw, snow removal, and washing equipment. Fading has been observed. Contact: Kurt Ziegler 212-499-4417. Bay Area Rapid Transit has many installations of Armor Tile since 1997. Performance is satisfactory. Tiles are cleaned weekly. No experience with snow and ice. Contact: Ike Nnaji, 510-464-6173.</td>
</tr>
<tr>
<td>Surface Applied Domes</td>
<td>COTE-L Industries, Inc. Strongwall Industries (Strongwarn) Vanguard ADA Systems</td>
<td>Surface-applied domes are detectable warning systems where the individual domes are affixed to the existing surface and can usually conform to any surface irregularities. The domes are resilient and different manufacturers have different types of systems. The Vanguard product requires a licensed installer. WDOT reports that the COTE-L and Strongwall installations were labor intensive taking two days.</td>
<td>WDOT reports that neither the COTE-L or Strongwall products withstood winter snow removal. Contact: Peter Kemp, 608-246-7953. Montana DOT in an initial post-construction evaluation reports that the COTE-L and Strongwall products were performing well. Contact: Craig Abernathy, 406-444-6269. VTRANS reports that after one winter of snow plowing, about 20% of the Vanguard domes are missing and some of the domes which were present were scraped off at the top. The Strongwall domes bonded well to the underlying concrete but did not have adequate strength within the domes to withstand the shear forces of the plow. Almost all of the COTE-L domes were removed by snow plowing. Contact: Jon Kaplan, 802-828-0059 Alaska DOT reports that the Strongwall domes chipped off and that the grout used for these domes may not be resistant to the extreme cold temperatures in Alaska. Contact: Clint Adler, 907-451-5321. Oregon DOT reports a few broken domes on the Strongwall product and color fading. The COTE-L domes have experience discoloration but no damage in this mild climate.</td>
</tr>
<tr>
<td>Flexible Mats</td>
<td>Cape Fear Systems (Alertmat)</td>
<td>These products can be applied directly to an existing curb ramp using adhesives and anchors around the perimeter. A sealant is also usually applied around the perimeter of the mat</td>
<td>WDOT reports that the Detectable Warning Systems mat showed good durability with no apparent field damage. The COTE-L flexible mat did not stand up to winter snow removal. Parts of the mat had debonded prior to any snowfall.</td>
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<tr>
<td>COTE-L Industries, Inc. (Safti-Trax)</td>
<td>Detectable Warning Systems</td>
<td>Montana DOT reports the post-construction initial product evaluation of the COTE-L flexible mat showed some of the domes being torn or damaged with the cause unknown. The Disability Devices mat installations were in good condition, but some of the plastic setting pins were pushed up. Note that there was no winter maintenance performed on these installations.</td>
<td></td>
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<tr>
<td>ADA Armor-Tile</td>
<td>ADA Retrofit Kit</td>
<td>VTRANS found that entire sections of the COTE-L mat were torn from the surface and there was significant damage to the domes as well after winter snow plowing.</td>
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<tr>
<td>Disability Devices Distributor</td>
<td></td>
<td>In Oregon (under mild climatic conditions) the DOT found that the Detectable Warning Systems mat showed little change after two years of service with no damage or problems with adhesion to the concrete. The COTE-L mat experienced considerable discoloration due to deposits left by dirty water. No damage or adhesion problems.</td>
<td></td>
</tr>
<tr>
<td>Stamped Concrete</td>
<td>Increte</td>
<td>WDOT reports that the Increte Stamping System yielded inconsistent results (average of 25% of the domes were deformed or missing). The forms were prone to clogging of the vent holes and required frequent cleaning. They report stamping success is very sensitive to concrete consistency and substantial effort is needed to train contractors on the use of this system and other similar stamps which are available. One installation was painted with a waterborne paint which was worn off after a few months. A powdered colored hardener was troweled into the fresh concrete on another installation but was found to be labor intensive and not cost-effective.</td>
<td></td>
</tr>
<tr>
<td>Stampcrete International</td>
<td></td>
<td>NHDOT reports that the Stampcrete has lost about 18 percent of the domes from snow plows. The ADA Retrofit Kit has lost 75% of its domes; however, installation crew think the concrete mix may not have been stiff enough at the time of installation.</td>
<td></td>
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<tr>
<td>MetaStamp</td>
<td></td>
<td>City of Austin tried stamped concrete installation in 1992 but discontinued use due to difficulty associated with stamping concrete and the poor durability of the painted surface.</td>
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<tr>
<td>ADA Retrofit Kit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermoplastic</td>
<td></td>
<td>The thermoplastic product is the same type of product that is used for pavement markings and is applied in much the same manner.</td>
<td>No performance information available.</td>
</tr>
</tbody>
</table>
Construction and Installation Considerations

When selecting a detectable warning product for a particular circumstance, some of the considerations which should be given to the decision-making process include the following:

- Is a licensed installer required?
- Are installation instruction procedures available and easy to understand?
- What is the likelihood of construction traffic damage from surrounding areas?
- What is the length of time needed for installation?
- How difficult is the installation?
- What are the safety considerations during installation?

Maintenance Considerations

Researchers identified three maintenance issues which should be considered regarding detectable warnings:

- Snow and ice clearing;
- Removal of debris and/or cleaning;
- Repair.

Snow and ice removal can cause severe damage to many detectable warning products. If snow plows will be used to remove snow and ice from detectable warnings, then consideration should be given to selecting very high-strength materials.

Deposition of debris on detectable warnings can be a significant problem. Much of this seems to be related to drainage and associated with ponding which occurs on the detectable warning. Some of these problems may be prevented with improved drainage designs. However, most agencies felt that routine cleaning was too costly.

Some products tend to lose their color over time or become stained. It is unknown if cleaning might restore the product to its original color and provide the desirable color contrast with surrounding areas.

Since there is little long-term performance information for many detectable warning products, questions exist regarding the effectiveness of repairing products that exhibit performance problems. The ability to repair a product may be a consideration during the selection process. Many detectable warning products provide a means (repair kit) for repair.

Durability Considerations

Some of the other performance and durability issues include the following:

- Delamination;
- Loose or missing tiles;
- Cracking and/or breakage;
Settlement or shifting;
Dome integrity;
Placement of control joints; and
Color fading.

RESEARCH NEEDS

The following research needs have been identified:

• There is very little documented performance information on detectable warnings used on curb ramps. Much of the performance information provided by DOTs is over a very short period of time (about 2 years). In addition, it is limited to only some of the products which are available. There are new and promising products which should also be evaluated for performance. Many DOTs are only beginning to evaluate products and cannot provide performance data yet.

• Detectable warning products range in cost and labor required for installation. One DOT employee stated that he views detectable warnings (such as the surface applied products) in the same manner as he views paint striping on highways: as a maintenance item that must be replaced about every three years. Life-cycle costs for the different products need to be developed.

• Research is needed to determine which colors are preferred by the visually impaired community and how readily available they are from the various manufacturers.

• Research is needed to determine the ease and cost of replacement of the different product types and manufacturers. For example, the MetaDome representative claims that his cast-in-place product can be re-used if a ramp is torn up and replaced. Other manufacturers may have similar claims.

• Research is needed to determine if color and slip resistance can be restored to different detectable warning products if a loss occurs.

• Research is needed to determine how effective various repair techniques are to damaged products.

• Jean Tessmer with Space Options, Inc of Kula, Hawaii pointed out to researchers that ADA requires that there not be more than ¼ inch vertical transition from the surrounding surfaces. This means that a plastic mat (usually 3/16” thick) with domes that are 0.2 inches in height can create a vertical transition of 0.4 inches when mats (and domes) are cut to fit curb ramps. Research is needed to investigate this potential problem.

• There are many different products and each one meets a different set of specifications. Performance-based specifications need to be developed that could be applied to any product. However, prior to development of such specifications, functional performance criteria are needed for detectable warning systems. Until there are clear criteria established for how the detectable warnings are expected to perform, it will be difficult to develop any performance-based specifications. Color or contrast requirements should be established. Detectable warning systems should be evaluated to determine if they impede wheel chairs or affect the safety of other pedestrians. Do some products which are fixed directly to an existing surface create enough height above the surface to pose a tripping hazard? Dimensions of the dome need to be evaluated to determine if they are appropriate. Are there configurations or shapes other than truncated domes that would...
work? Once functional performance criteria are developed, then it should be determined how these criteria will be evaluated. When methods or tests for evaluation are determined, these can be used to evaluate products in the field. For example, loss of a few domes may be okay, but how many? What if part of the dome is removed? What is an acceptable loss of height for the dome? What color loss is acceptable?
REFERENCES


