# DURABILITY OF TRUNCATED DOME WARNINGS ON EXISTING CURB RAMPS

## Final Report

**SPR 304-241**

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by

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16. Abstract

In 2002 the Federal Highway Administration (FHWA) notified the Oregon Department of Transportation (ODOT) that that the state was required to use truncated dome detectable warnings on curb ramps. Products appropriate for use on cured concrete surfaces were of particular interest to ODOT. A research project was undertaken to monitor four products that appeared to be best suited for retrofitting existing curb ramps. Over a two-year monitoring period adhesion to the concrete was good, and physical damage was not a problem. Changing color and contrast over the two-year period was an issue, however. Three out of the four products in the study exhibited noticeable color fading, and contrast with the adjacent surfaces decreased in two cases, due to the accumulation of dirt on the truncated dome products.

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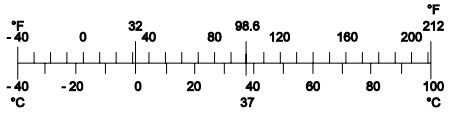
# SI* (MODERN METRIC) CONVERSION FACTORS

## APPROXIMATE CONVERSIONS TO SI UNITS

| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| In | inches | 25.4 | Millimeters | Mm |
| Ft | feet | 0.305 | Meters | M |
| Yd | yards | 0.914 | Meters | M |
| Mi | miles | 1.61 | Kilometers | Km |
| | | **AREA** | | |
| $In^2$ | square inches | 645.2 | Millimeters squared | $mm^2$ |
| $ft^2$ | square feet | 0.093 | Meters squared | $m^2$ |
| $Yd^2$ | square yards | 0.836 | Meters squared | $m^2$ |
| Ac | acres | 0.405 | Hectares | Ha |
| $Mi^2$ | square miles | 2.59 | Kilometers squared | $km^2$ |
| | | **VOLUME** | | |
| fl oz | fluid ounces | 29.57 | Milliliters | mL |
| Gal | gallons | 3.785 | Liters | L |
| $ft^3$ | cubic feet | 0.028 | Meters cubed | $m^3$ |
| $Yd^3$ | cubic yards | 0.765 | Meters cubed | $m^3$ |
| NOTE: Volumes greater than 1000 L shall be shown in $m^3$. | | | | |
| | | **MASS** | | |
| Oz | ounces | 28.35 | Grams | G |
| Lb | pounds | 0.454 | Kilograms | Kg |
| T | short tons (2000 lb) | 0.907 | Megagrams | Mg |
| | | **TEMPERATURE (exact)** | | |
| °F | Fahrenheit temperature | 5(F-32)/9 | Celsius temperature | °C |

## APPROXIMATE CONVERSIONS FROM SI UNITS

| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| mm | millimeters | 0.039 | inches | in |
| m | meters | 3.28 | feet | ft |
| m | meters | 1.09 | yards | yd |
| km | kilometers | 0.621 | miles | mi |
| | | **AREA** | | |
| $mm^2$ | millimeters squared | 0.0016 | square inches | $in^2$ |
| $m^2$ | meters squared | 10.764 | square feet | $ft^2$ |
| ha | hectares | 2.47 | acres | ac |
| $km^2$ | kilometers squared | 0.386 | square miles | $mi^2$ |
| | | **VOLUME** | | |
| mL | milliliters | 0.034 | fluid ounces | fl oz |
| L | liters | 0.264 | gallons | gal |
| $m^3$ | meters cubed | 35.315 | cubic feet | $ft^3$ |
| $m^3$ | meters cubed | 1.308 | cubic yards | $yd^3$ |
| | | **MASS** | | |
| g | grams | 0.035 | ounces | oz |
| kg | kilograms | 2.205 | pounds | lb |
| Mg | megagrams | 1.102 | short tons (2000 lb) | T |
| | | **TEMPERATURE (exact)** | | |
| °C | Celsius temperature | 1.8C + 32 | Fahrenheit | °F |




***** SI is the symbol for the International System of Measurement (4-7-94 jbp)

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# DISCLAIMER

**DURABILITY OF TRUNCATED DOME WARNINGS ON EXISTING CURB RAMPS**

# TABLE OF CONTENTS

# 1.0 INTRODUCTION/BACKGROUND

In 2002 the Federal Highway Administration (FHWA) notified the Oregon Department of Transportation (ODOT) that the state was required to use truncated dome detectable warnings on curb ramps. This action was prompted by the end of a 10-year suspension of the requirement to allow time for research on the performance of truncated dome detectable warnings. The research found that other designs used in place of truncated domes (e.g., grooves, striations, exposed aggregate) were not detectable in the sidewalk and roadway environment because of their similarities with other surfaces. Detectable warnings are a requirement in the Americans with Disabilities Act Accessibility Guidelines (ADAAG), and FHWA is the enforcement authority for this requirement. The FHWA notification further stated that the requirement for the use of truncated domes when constructing and altering pedestrian facilities was retroactive to July 26, 2001 (*FHWA 2002*).

Sidewalks that ramp gradually down to a street crossing give little notice of the change from pedestrian to vehicular way for pedestrians with limited or no vision. The Access Board (formerly the Architectural and Transportation Barriers Compliance Board) has recognized that truncated domes of the ADAAG detectable warning specification can provide a confirming cue (*Access Board 1999*). Truncated domes give vision impaired pedestrians up to four cues that they are entering a travel way of moving vehicles: sound (cane striking domes), hand sense (through cane striking domes), foot sense (uneven surface when standing on domes) and sight (visual contrast with surrounding pavement).

At the time that ODOT received the direction from FHWA to use truncated domes, 19 proprietary truncated dome products were pre-approved by FHWA for use on curb ramps. Products appropriate for use on cured concrete surfaces were of particular interest to ODOT. ODOT had no such products on its Qualified Products List (QPL) at the time. There was a need for more information on the performance of this type of truncated dome products, in order to make better project level decisions. This information would assist ODOT in specifying truncated dome products for retrofitting existing curb ramps.

## 1.1 OBJECTIVES

The ODOT Standards Engineer and the Qualified Products Manager reviewed the list of FHWA-approved products and selected four products that appeared to be best suited for retrofitting existing curb ramps. They decided to test these products in a field installation, to monitor their durability over a two-year period:

- Strongwarn Tactile Warning (Strongwall Industries, Inc.) – latex-modified mortar domes cast in a form and coated with a latex vinyl copolymer.

- Detectable Warning Mat (Detectable Warning Systems, Inc.) – a molded polyurethane mat.

- Safti-Trax™ (Cote-L Industries, Inc.) – two similar products: 1) Safti-Trax™ Domes, which are rubber domes covered with a polyurethane coating; and 2) Safti-Trax Mat™, which is a polyurethane coated rubber mat.

- Vanguard Truncated Domes (Vanguard ADA Products of America) – resin and monomer domes cast in a form and covered with a non-skid coating containing glass beads.[1]

This report covers the installation of the selected products, the field observations over a two-year monitoring period, and the conclusions drawn from the study.

[1] Due to circumstances beyond the control of ODOT, this product was not ultimately installed and thus did not become a part of this study.

# 2.0 PRODUCT INSTALLATION

## 2.1 STUDY LOCATION

The installation of the selected truncated dome products was included as part of a highway improvement project in Newberg, Oregon. Newberg is located approximately 25 miles southwest of Portland, Oregon on Highway 99W and is situated on the northeast side of Yamhill County.

Figure 2.1 shows the study location. The climate of this area is moderate in temperature and precipitation. Average annual maximum temperatures range from 8° to 28° C (46° to 82° F). Average annual minimum temperatures range from 1° to 11° C (33° to 51° F). Average annual precipitation is 1.04 m (41 in). Typical distribution of precipitation includes about 50 percent of the annual total from December through February, lesser amounts in the spring and fall, and very little during summer. Average cloud cover during the coldest months exceeds 80 percent, with an average of about 26 cloudy days in January. During summer, average cloud cover is less than 40 percent; more than half of the days in July are clear.

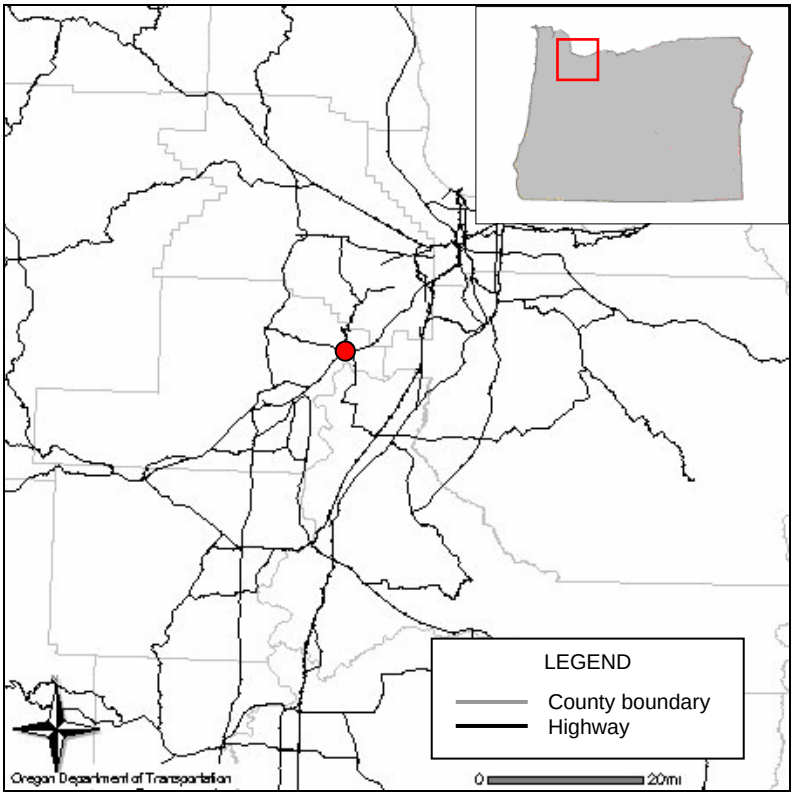


Figure 2.1: Monitoring study location – Newberg, Oregon

## 2.2 INSTALLATION NOTES

Installation of the products used in this study occurred in late September 2002. Company representatives were contacted by ODOT and asked to provide the materials and labor for installation of their products. All four firms responded favorably to this invitation, but only three completed an installation. The Vanguard product was not installed. One of the participating firms, however, went on to install two of its products, resulting in a total of four test products. Following is a list of the products installed, the test locations, and a brief summary of the installation methods:

- **Product: Strongwarn Tactile Warning** (Strongwall Industries, Inc.)

  Location: SW corner Hancock & Meridian Streets, Newberg, OR

  Installation summary: The truncated dome material (#82 carboxylated latex emulsion with a bonding agent) was first applied to the diamond grid as a filler, to create a smooth surface. A rubber form with cone-shaped holes was then laid down and the dome material was forced into the form. After a set up time of about 2 hours, the form was removed. Additional coats of other materials followed: #32 Field and #4 Sealer. Estimated time for installation was one day.

  Problems encountered: None

- **Product: Detectable Warning Mat** (Detectable Warning Systems, Inc.)

  Location: NW corner Hancock & Meridian Streets, Newberg, OR

  Installation summary: The diamond grid was subjected to a light grinding, to remove any concrete curing compound. A filler material was applied to the diamond grid, to fill the grooves and create a smooth surface. Epoxy adhesive was then applied to the prepared surface for installation of the mat. The mat was put in place and weighted. After the adhesive had set, holes were drilled through corner and side locations on the mat, and nylon anchor pins were installed. Estimated time for installation was 1¼ hours.

  Problems encountered: Due to an error in the choice of filler used, the surface had to be re-ground, because the filler material expanded above the level of the concrete.

- **Product: Safti-Trax™ Domes** (Cote-L Industries, Inc.)

  Location: NW corner Hancock & Center Streets, Newberg, OR

  Installation summary: The diamond grid was subjected to 4-5 minutes of grinding. The Durabak™ coating was applied, covering the entire surface. The plastic backing sheet holding the domes was laid in place. After about 30 minutes the plastic backing was peeled off, leaving the domes attached to the Durabak™ coating. Two to three Durabak™ coatings with pigment were then applied over the domes. Estimated time for installation was one day.

  Problems encountered: None

- **Product: Safti-Trax Mat**™ (Cote-L Industries, Inc.)

  Location: NE corner Hancock & Meridian Streets, Newberg, OR

  Installation summary: The diamond grid was ground down completely to create a smooth surface. The Safti-Trax Mat™ was cut to fit the area. The Durabak™ adhesive was applied, and the mat was put in place. Care was taken to force out pockets of air, which can get trapped between the mat and the adhesive. Estimated time for installation was two hours.

  Problems encountered: The company representative reported that upon later inspection one small air pocket was observed under the mat. The remedy for this was to puncture the mat and force adhesive into the space to remove the air.

The ODOT inspector for the highway improvement project inspected all of the installations to determine that they had been done according to specifications.

# 3.0 FIELD OBSERVATIONS

Inspections of the products were conducted at 3-4 month intervals over the course of two years, from the installation in September 2002 to October 2004. The inspections addressed the following factors – adhesion to the concrete, visible damage, and color/contrast.

## 3.1 ADHESION

All products showed good adhesion to the concrete during the test period. The only instance of debonding was immediately following the initial installation of the Safti-Trax Mat™, as mentioned in Section 2.2. Other than this, there were no instances of physical debonding or dislodging of any part of the products from the concrete surface during the two-year period.

## 3.2 DAMAGE

All but the Strongwarn Tactile Warning showed no damage during the two-year period, either to the domes or the surface beneath the domes. The Strongwarn product showed some damage after about 15 months, with parts of three domes broken at the left edge of the warning surface, presumably from a physical impact. (See Figure 3.1 below.)

## 3.3 COLOR AND CONTRAST

The greatest variation in the performance of the products over the two-year period was in their color and their contrast with the surrounding surfaces. Although the original colors of the products were yellow, they varied in hue. Figures 3.1 – 3.4 show the products at six months and at 24 months after installation.

The Strongwarn Tactile Warning exhibited considerable fading over the two-year period (Figure 3.1). Thus, while the product did not retain its original color, the contrast with adjacent surfaces was increased. This fading of the color, combined with aging of the concrete, actually produced a reversal of the contrast between the detectable warning and the surrounding concrete surface over the two years. When new, the detectable warning was a darker color surrounded by the relatively lighter new concrete; and after two years the detectable warning was a lighter color surrounded by a relatively darker concrete surface.

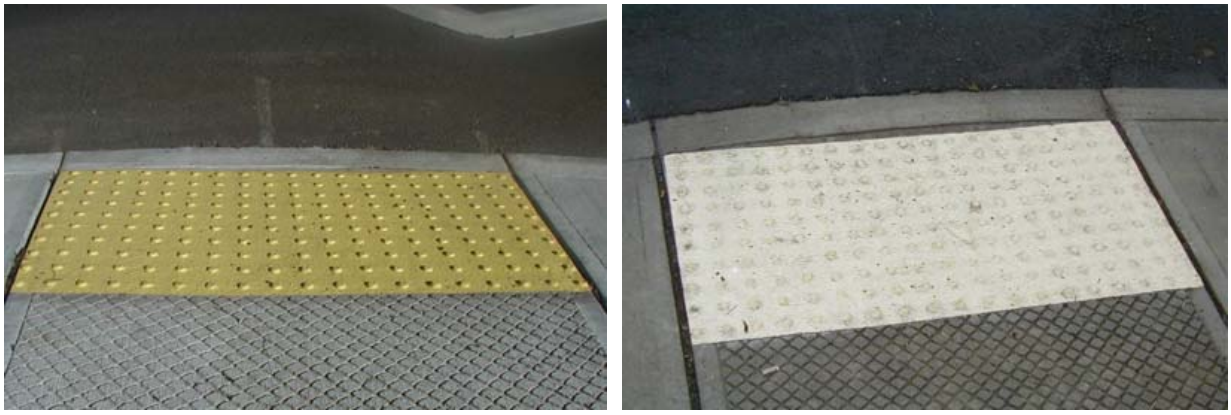

Figure 3.1: Strongwarn Tactile Warning – a) February 2003; b) October 2004

Over the course of the test period the color of the Detectable Warning Mat changed little, although some staining of the mat occurred, and the heads of the anchor pins faded noticeably (Figure 3.2).

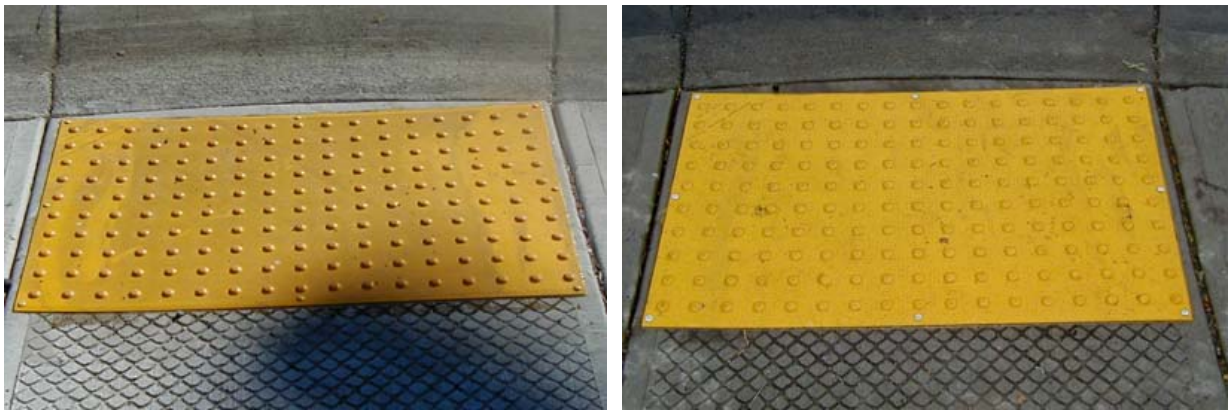

Figure 3.2: Detectable Warning Mat – a) February 2003; b) October 2004

Both the Safti-Trax™ Domes and the Safti-Trax Mat™ exhibited fading, and the contrast of the surfaces with the surrounding concrete was degraded over time, due to the accumulation of dirt on the detectable warnings and the darkening of the concrete surface (Figures 3.3 and 3.4). The field inspections determined that a likely reason for the accumulation of dirt was storm water collecting at the base of the ramps and poor drainage.

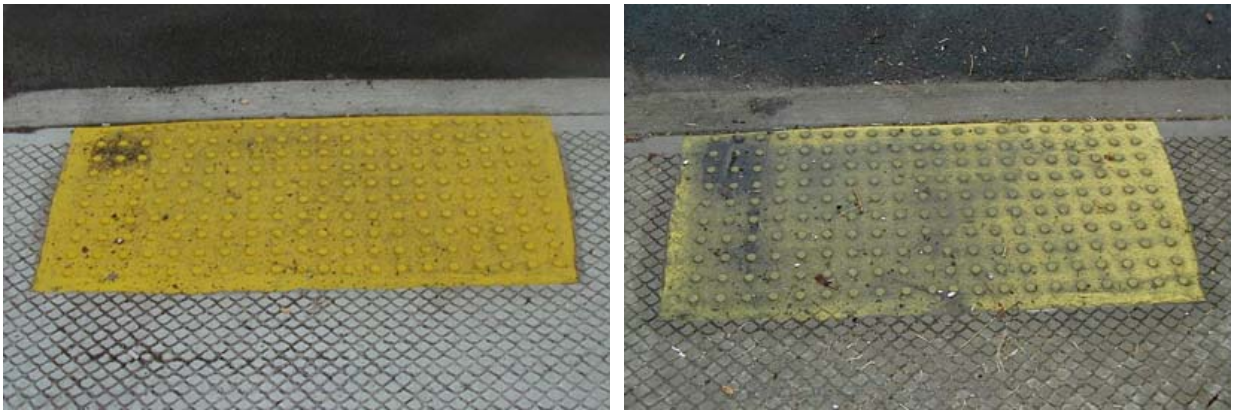

Figure 3.3: Safti-Trax™ Domes – a) February 2003; b) October 2004

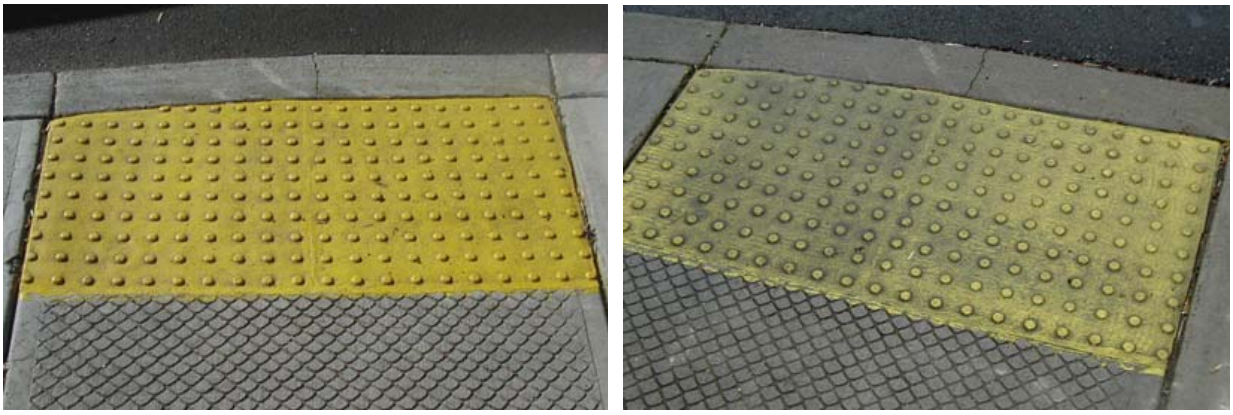

Figure 3.4: Safti-Trax Mat™ – a) February 2003; b) October 2004

## 3.4 SUMMARY OBSERVATIONS

A summary of the performance of each product is shown in Table 3.1.

**Table 3.1: Summary of performance of truncated dome products**

| Product Name | Performance Criteria | | | |
|---|---|---|---|---|
| | **Adhesion** | **Damage** | **Color/contrast** | **Photo** |
| Strongwarn Tactile Warning | Good | Three domes damaged | Poor; extreme color fading over 2-year period; contrast increased | Figure 3.1 |
| Detectable Warning Mat | Good | None | Good; some staining, but substantially retained original color and contrast | Figure 3.2 |
| Safti-Trax™ Domes | Good | None | Poor; color fading; dirt adhered to much of surface, dulling the color and reducing contrast | Figure 3.3 |
| Safti-Trax Mat™ | Good | None | Fair; color fading; dirt adhered to much of surface, dulling the color and reducing contrast | Figure 3.4 |

# 4.0 DISCUSSION AND CONCLUSIONS

In the spring of 2002 ODOT received the FHWA notification that state and local governments were required to install truncated domes as a standard design requirement when constructing and altering curb ramps. At that time there were a limited number of products that were judged to be viable candidates for retrofitting curb ramps, and ODOT had no such products on its Qualified Products List (QPL). This field test was a first step for the agency in determining the performance of some products. Since then several new products have come onto the market. As of July 2004 ODOT had eleven truncated dome products approved for use on cured concrete.

As Oregon's climate is relatively mild, the products in this study were not subjected to severe conditions in temperature, solar radiation or physical treatment. Thus it is of particular interest which products fared well and which did not. While adhesion to the concrete and physical damage were not problems in the environmental conditions of this study, changing color and contrast over the two-year period was an issue. Three out of the four products tested exhibited noticeable color fading. Only the Detectable Warning Systems product substantially retained its original color, although it exhibited some staining.

No studies have been found which evaluate these truncated dome products under similar conditions as western Oregon. Evaluations have been conducted in several other states under more severe conditions. The departments of transportation in New Hampshire, Wisconsin, Vermont and Montana have field-tested various products in freezing conditions and with snow removal equipment. Following are some findings related to the products discussed in this report:

- Strongwarn Tactile Warning: Both the Wisconsin and the Vermont studies found that this product did not withstand winter plowing (*Kemp 2003; Kaplan 2004*). The Montana study reported good performance but with some damage after one winter (*Abernathy 2004*).

- Detectable Warning Mat: The Wisconsin study found that this product showed good durability. There were some problems with staining from dirt in the pores of the material (*Kemp 2003*). This finding is consistent with observations in this report, Section 3.3 (Figure 3.2).

- Safti-Trax™ Domes: All four studies found that this product did not stand up to winter snow plowing (*Boisvert 2003; Kemp 2003; Kaplan 2004; Abernathy 2004*).

- Safti-Trax Mat™: All four studies found that this product did not stand up to winter snow plowing (*Boisvert 2003; Kemp 2003; Kaplan 2004; Abernathy 2004*). Both the Wisconsin and the Vermont studies found that this product had areas which failed to bond with the underlying concrete (*Kemp 2003; Kaplan 2004*). The Wisconsin study noted "a bubbled look to the product." A similar problem was encountered in the installation of this product for this study (see Section 2.2).

On the basis of this two-year monitoring period, it appears that all four of the test products have substantially retained their structural integrity and adhesion to the concrete. The Detectable Warning Systems product shows much better color retention than the other three products, however. Its comparatively short installation time is also a positive attribute.

It should be noted that the observations from this study are based on only one installation of each product, and this installation was done by a manufacturer's representative. Further research on the durability of truncated domes in the field would be better served by the observation of each product at ten or more sites in a given climatic environment. In addition, it is suggested that the installations be done by construction contractors, as in the real-world circumstances in which such products are likely to be used.

As ODOT considers what truncated dome detectable warning products are suitable for use in highway improvement projects, the agency will also benefit from the information that research in other locations of the country can provide. The substantial investment that is entailed in providing safer pedestrian crossing environments makes it important that these products are both durable and effective.

# 5.0 REFERENCES


Abernathy, Craig. *Post-Winter Evaluation Report. Detectable Warning Devices (Truncated Domes) for use by the Visually Impaired.* Project No. STPU 5201(11). Montana Department of Transportation. Great Falls, MT. March 2004.

Access Board. *Accessible Rights-of-Way: A Design Guide*. Washington, DC. November 1999.

Boisvert, Denis M. *Durability of Truncated Dome Systems*. New Hampshire Department of Transportation. Report No. FHWA-NH-RD-MPS2002-2. Concord, NH. April 2003.

Federal Highway Administration. INFORMATION: ADAAG Detectable Warnings (Truncated Domes). Memorandum HIPA-20. May 6, 2002.

Kaplan, Jon. *Report on the Performance of Detectable Warning Products in Burlington, VT.* Vermont Agency of Transportation. Report No. FHWA-VT-RD-0401. Montpelier, VT. August 2004.

Kemp, Peter. *Truncated Warning Dome Systems for Handicap Access Ramps.* Wisconsin Department of Transportation. Report No. WI-04-03. Madison, WI. November 2003.