Color and Contrast of Detectable Warnings

A technical brief from research assessing visual detection of detectable warning materials by pedestrians with disabilities **Project Report**

June 30, 2007

Authors:
James Jenness & Jeremiah Singer

Prepared for:
Federal Highway Administration
Washington, DC Prepared by:

Prepared by:
Westat
Rockville, Maryland

Background

Detectable warnings are walking surfaces that are principally intended to provide a tactile cue underfoot to pedestrians who have vision impairments. They are installed at potentially hazardous locations such as the edge of a train platform or at the transition between the sidewalk and the street to indicate the change from pedestrian to vehicular use so that a pedestrian traveling without visual cues will not inadvertently step into the road- or rail-way. The tactile properties of detectable warnings result from a grid of small truncated (flat-topped) domes raised above the walking surface. Standardized by the U.S. Access Board, this pattern has proved in research to be detected underfoot or by cane without causing a tripping hazard or obstructing wheelchairs. Detectable warnings that provide salient visual cues in addition to tactile cues can provide additional cues about the location of edges and curb ramps from a greater distance than is possible using tactile cues alone. Some pedestrians use the visual cues provided by the detectable warning to orient to a curb cut or ramp at the end of a crosswalk. Pedestrians with acute vision who are distracted from the primary walking task or otherwise impaired (e.g., cognitively impaired) and children may also benefit from the visual warning if it draws their attention and reinforces the potential hazard of walking beyond the detectable warning.

The diversity of visual abilities among pedestrians makes it difficult to specify optimal visual properties for detectable warnings. Most people who are legally blind have some functional vision, but visual abilities can vary from day to day and vision may be more or less useful depending upon the lighting level and weather. Congenital and acquired physical conditions as well as natural aging processes affect vision in different ways. Individuals may have reduced sensitivity to light/dark differences across a scene (contrast), reduced ability to see certain color differences, complete or relative loss of vision in specific directions (visual field loss), or loss of ability to see fine details (acuity). Despite this diversity of visual abilities, many people with visual impairments will see detectable warnings if there is adequate illumination (ambient lighting level) and adequate luminance contrast (difference in light reflected from a detectable warning and the adjacent sidewalk). Detectable warning color can also help to improve conspicuity and convey meaning.

The ADA Accessibility Guidelines (ADAAG 1991) require that detectable warnings '…shall contrast visually with adjoining surfaces, either light-on-dark or dark-on-light'. Draft Public

Rights-of-Way Accessibility Guidelines (PROWAG 2005) have a similar provision: 'Detectable warning surfaces shall contrast visually with adjacent gutter, street or highway, or walkway surfaces, either light-on-dark or dark-on-light.' Specifiers and agencies sought additional guidance on determining an effective contrast.

FHWA Detectable Warning Study

In 2005, a study was conducted to determine which detectable warning colors and patterns are visually detectable and conspicuous to pedestrians with visual impairments and to provide recommendations related to color, pattern, and luminance contrast of detectable warnings. Fifty individuals with visual impairments participated in separate sessions. Most participants were legally blind (though all had some useful vision) and all reported having some difficulty locating the boundary between sidewalks and streets. The study included men and women ranging in age from 24 to 92 with diverse causes of their visual impairments. The set of 13 detectable warnings (each 3 feet wide by 2 feet deep) tested included 10 solid colors (Figure 1) and three black-and-white patterns including black with white border, black-and-white stripes, and white with black border (Figure 2). Four sidewalk sections (each 4 feet by 8 feet) were fabricated to simulate the appearance of a red brick sidewalk, a dark gray asphalt sidewalk, a white concrete sidewalk, and a brown concrete sidewalk. Each combination of detectable warning color and sidewalk color was viewed outdoors under natural illumination by each of the study participants. Figure 3 shows how the testing area was arranged. Measurements included maximum visual detection distance, self-reported conspicuity rating, and self-reported description of the detectable warning color.

Figure 1. Photographic samples of the 10 single-color detectable warnings tested in the FHWA study

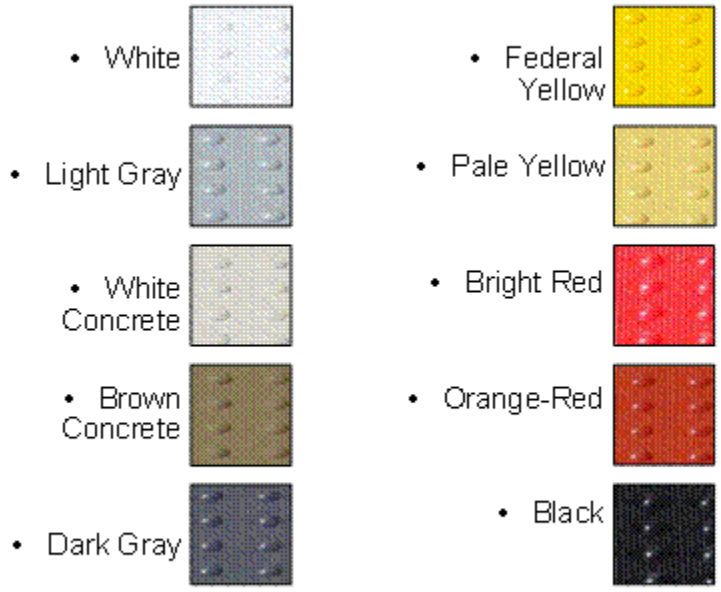


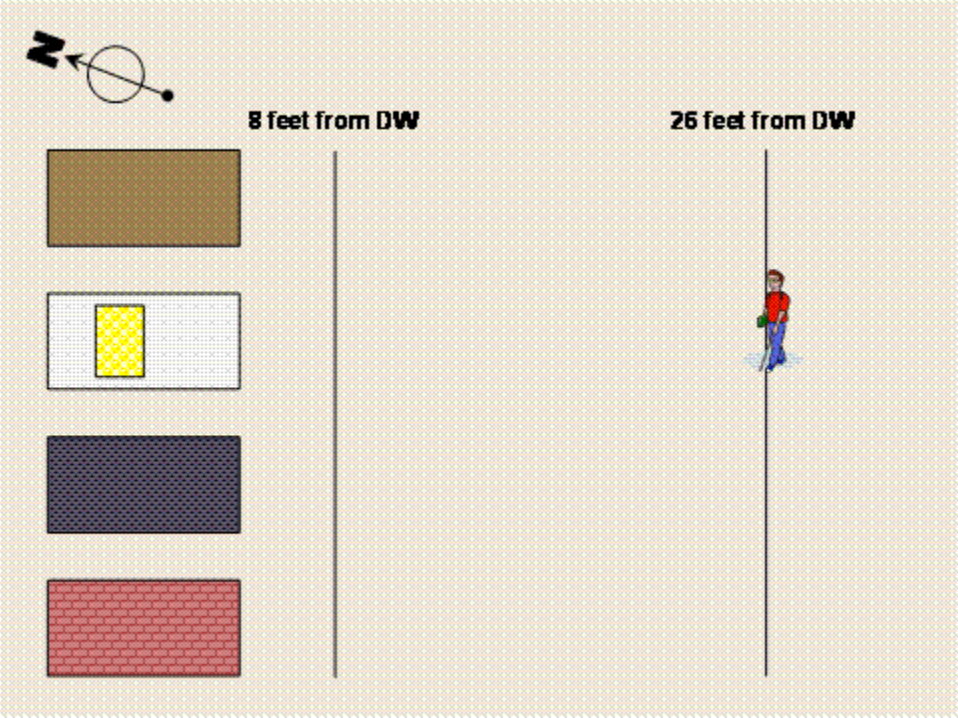
Figure 2. Photographs of three black-and-white patterned detectable warnings on red bricks

Black with White Border
(4-inch wide border)

Black/White Stripes
(4.5-inch wide white stripes)

White with Black Border
(4-inch wide border)

Figure 3. Plan view of outdoor testing area where participants viewed Detectable warnings on four simulated sidewalk sections



Based on the results of the study, including visual detection rates at 8 feet and 26 feet, conspicuity ratings, and participants' subjective comments, the following detectable warning colors are recommended for use on asphalt, red brick, and concrete walking surfaces (Table 1). It should be noted that although black-and-white patterned detectable warnings performed very well under the limited conditions tested, additional research is needed to determine if detectable warnings with light/dark patterns (rather than single color detectable warnings) tend to cause visual disorientation or confusion for some people when walking over the surface, particularly when such patterns are installed on a slope.

Table 1. Detectable warning contrast effectiveness assessments based upon FHWA study data

Detectable Warning Color[1]	Surface material surrounding detectable warning		
	Asphalt	**Brick (Red)**	**Concrete**
Bright white [e.g., FS 37875] R = .74; (x = .333, y = .347)	Good	Good	Not recommended for light colored concrete[2]
White (beige sand texture) R = .64; (x = .352, y = .364)	Good	OK	Not recommended[2]
Pale yellow [e.g., FS 23594] R = .47; (x = .412, y = .414)	Good	Good	OK
Federal yellow [e.g., FS 33538] R = .46; (x = .511, y = .454)	Very good	Very good	Good
Light gray [e.g., FS 26280] R = .24; (x = .326, y = .341)	Not recommended	Not recommended	Not recommended
Brown (beige sand texture) R = .17; (x = .390, y = .386)	Not recommended	Not recommended	OK
Orange-red [e.g., FS 22144] R = .13; (x = .533, y = .356)	OK	Not recommended	Good
Bright red [e.g., FS 31120] R = .11; (x = .587, y = .323)	Good	OK	Very good
Dark gray [e.g., FS 36118] R = .09; (x = .320, y = .331)	Not recommended	Not recommended	OK
Black [e.g., FS 17038] R = .02; (x = .324, y = .338)	Not recommended	Not recommended (may be perceived as a hole)	Not recommended (may be perceived as a hole)
Black (or dark gray) and white pattern (minimum 4 in. wide stripes)	Very good[3]	Very good[3]	Very good[3]
Black (or dark gray) and yellow pattern (minimum 4 in. wide stripes)	Not tested, but likely to be very good[3]	Not tested, but likely to be very good[3]	Not tested, but likely to be very good[3]

1. Numbers next to each detectable warning color name specify the color tested by [approximate match to Fed-STD-595B color number], R = reflectance factor, and (CIE1931 chromaticity, in daylight).
2. White detectable warnings may be good for use on dark pigmented concrete.
3. Although black-and-white combinations tested well under the limited conditions of this research, use of a pattern rather than a solid color will require additional testing to be sure that the dark areas aren't seen as depressions and light areas as raised surfaces. Orientation and mobility specialists caution that patterned surfaces may cause some visual disorientation or confusion when walking over the surface, particularly when installed on a slope.

Recommended Minimum Luminance Contrast Values for Detectable Warnings

In general, a minimum luminance contrast of 50 percent is recommended. Lower levels of luminance contrast, however, may be effective if there is a pronounced color difference (i.e. hue, saturation) between the detectable warning material and the adjacent walking surface. For example, if the detectable warning has a highly saturated red or yellow appearance, then installations with luminance contrast as low as 20 percent may be effective for most pedestrians. Adequate luminance contrast also may be achieved with detectable warnings that provide internally contrasting elements (such as from a two-color stripe pattern). In this case the pattern elements should be large (i.e., stripes that are a minimum of 4 inches wide) and should provide a minimum of 60 percent luminance contrast.

- If the detectable warning and sidewalk are both dark (reflectance less than 10 - 20 percent), even relatively high luminance contrast will not ensure visual detection or conspicuity. Tip - When viewed at the installation location, either the detectable warning or the surrounding surface should appear noticeably lighter than a photographer's Gray Card (which has approximately 18% reflectance).
- For a given level of luminance contrast, reds and yellows generally provide higher conspicuity than achromatic colors and many people tend to associate reds and yellows with the need for caution. Tip - A brick red color detectable warning may perform better on light concrete than black (or dark gray) because it is less likely to be mistaken for a hole or change of elevation.
- Consider how visual contrast between the detectable warning and sidewalk surfaces may change over time as the materials age. For example, concrete generally darkens over time. Asphalt is generally darkest when it is new and lightens over time. Detectable warnings may fade or darken over time depending on the material. To the extent possible, these changes should be anticipated so that visual contrast is maintained.
- Consider how visual contrast between the detectable warning and sidewalk surfaces may change when the surfaces are wet. Tip – The reflectance of some materials changes much more than others when wet. Concrete usually darkens considerably when water is absorbed, unlike plastic composite detectable warning materials that shed water. Therefore, the contrast of a light-colored plastic detectable warning on darker concrete will increase when the concrete is wet while the contrast between darker plastic detectable warnings and lighter concrete will decrease when the concrete is wet.
- Consider how visual contrast between the detectable warning and sidewalk surfaces may change with changes in illumination. For outdoor installations, luminance contrast and color appearance will remain approximately constant over a wide range of changes in natural illumination. However, the color appearance of a detectable warning and luminance contrast between a detectable warning and sidewalk may be quite different under artificial illumination (e.g. low pressure sodium lamps). It is not

known how such lighting changes affect pedestrians' use of detectable warnings. Anecdotal reports suggest that some pedestrians with low vision often do not rely on visual cues at all when lighting conditions are not adequate for them to believe that their vision is reliable.

Simple Procedure for Making Field Measurements of Luminance Contrast for Detectable Warnings

Photometric field measurements of luminance contrast between an installed detectable warning (or sample of detectable warning material) and the adjacent sidewalk may be made with a luminance meter (such as Minolta LS-100) with a one degree measurement field.

1. Secure the luminance meter on a tripod to make measurements at a 45 degree viewing angle to the surface. Be sure that the surface to be measured completely fills the measurement field, and align the measurement field to avoid specular reflections (highlights) such as those that may be visible on the sides of glossy truncated domes.
2. For outdoor measurements, the illumination on the surfaces can change very rapidly as clouds move through the sky, etc. To compensate for illumination changes, each contrast determination should consist of three luminance measurements of detectable warning and adjacent surface (AS) done as quickly as possible: detectable warning – as – detectable warning, measuring from the same spot on the detectable warning both times. The area of sidewalk surface measured should be immediately adjacent to the area measured on the detectable warning.
3. Average the first and second detectable warning measurements and then compare this average detectable warning luminance to the AS luminance in order to calculate luminance contrast. Contrast may be specified in several different ways. In the U.S., luminance contrast for Detectable warnings has been specified as:
   Contrast = (L1 – L2) / L1 x 100,
   where L1 is the greater of the two luminance values being compared.
   Following the procedure above make several contrast determinations at different locations along all sides of the detectable warning and average them.

Full Report

The complete research report, Visual Detection of Detectable Warning Materials by Pedestrians with Visual Impairments, is posted to the Access Board's website at **www.access-board.gov/research/detectable warning-fhwa/report.htm**. The report also includes appendices that provide detailed information on visual impairments and their prevalence in the U.S.; the current state of Federal regulations and guidance on detectable warnings; a review of previous research on the visual detection of detectable warnings; a summary of the methods used to measure reflectance, luminance contrast, and chromaticity; a description of the vision tests used to assess the visual capabilities of study participants; a summary of color names used by participants to describe each detectable warning; and a list of unsolicited comments provided by participants regarding the detectable warnings.

Other Useful Resources

- Other information on detectable warnings can be found at **www.access-board.gov/prowac/index.htm**

- A federal standard containing color samples, Fed-STD-595B, may be obtained at **http://apps.fss.gsa.gov/pub/fedspecs/**
- To visualize (a rough approximation of) Federal standard colors from Fed-STD-595B on your computer screen, visit **http://www.colorserver.net/**