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16. Abstract

The report documents the research activities completed during the two years of this research project. The objectives of this research were:

- To examine how pedestrians with disabilities are being handled in temporary traffic control situations and identify if there are changes needed in this accommodation.
- To determine the information requirements of pedestrians (especially those with special needs) at temporary traffic control locations and gain input on how best to meet those requirements.
- To develop recommended guidance documents to provide TxDOT with improved traffic control methods for pedestrians in temporary traffic control locations.

Researchers approached this project from two different angles to accomplish these objectives. First was establishing the current state-of-the-practice with regard to handling pedestrians in temporary traffic control areas and the second was the administration of several human factors studies that addressed public perception as pedestrians in or near work areas. This report contains specific findings and recommendations regarding each of these activities.

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INVESTIGATING PEDESTRIAN COMPONENTS IN TEMPORARY TRAFFIC CONTROL

by

Brooke R. Ullman, P.E.
Assistant Research Engineer
Texas Transportation Institute

Marcus A. Brewer, P.E.
Assistant Research Engineer
Texas Transportation Institute

Kay Fitzpatrick, Ph.D., P.E.
Senior Research Engineer
Texas Transportation Institute

and

Gerald L. Ullman, Ph.D., P.E.
Senior Research Engineer
Texas Transportation Institute

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TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System
College Station, Texas 77843-3135

DISCLAIMER

This research was performed in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation. This report is not intended for construction, bidding, or permit purposes. The engineer in charge of the project was Brooke R. Ullman, P.E. # 95927.

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1. INTRODUCTION

When the normal function of a roadway is suspended, temporary traffic control planning provides for continuity of movement through the affected area. Proper handling of pedestrian movements around active work areas should be a significant consideration, particularly in urban and suburban work zone locations. According to statistics from the U.S. Department of Transportation, approximately 14 percent of work zone fatalities are pedestrians (*1*).

The task of accommodating pedestrians in temporary traffic control situations is challenging since conditions within these areas are constantly changing, and there is no single set of traffic control devices that can satisfy all conditions. Many variables such as type of work, location of work, road type, geometrics, traffic volumes, and pedestrian demand affect the needs at temporary traffic control areas. Additionally, the amount of time that a temporary traffic control plan will affect a pedestrian route may have a key impact on the quantity of devices employed and the level of technology that is practical for rerouting pedestrians.

Additionally, these decisions must incorporate the concerns of accommodating pedestrians with disabilities, such as vision and mobility impairments. The need to provide improved consistency and quality of pedestrian traffic control devices has become more important with the implementation of the Americans with Disabilities Act of 1990 (ADA), which was passed to eliminate barriers to employment, transportation, public accommodations, public services, and telecommunications for people with disabilities (*2*). The ADA requires that pedestrians with physical and/or mental disabilities be accommodated not only in completed facilities, but also during times of construction.

The Manual on Uniform Traffic Control Devices (MUTCD) and the Texas Manual on Uniform Traffic Control Devices (TMUTCD) support the need to establish guidelines for the handling of pedestrians in temporary traffic control areas (*3,4*). The MUTCD outlines three basic items that should be considered in the application of pedestrian accommodation in temporary traffic control zones:

- Pedestrians should not be led into conflicts with work site vehicles, equipment, and operations.

- Pedestrians should not be led into conflicts with vehicles moving through or around the work site.
- Pedestrians should be provided with a reasonably safe, convenient, and accessible path that replicates as nearly as practical the most desirable characteristics of the existing sidewalk or footpath. Where pedestrians who have visual disabilities encounter work sites that require them to cross the roadway to find an accessible route, instructions should be provided using an audible information device. Accessible pedestrian signals with accessible pedestrian detectors might be needed to enable pedestrians with visual disabilities to cross wide or heavily traveled roadways.

However, the MUTCD and TMUTCD have only a few typical applications for pedestrian temporary traffic control treatments, and these seem mainly applicable to urban intersections. Within the TMUTCD, there are two situations that are illustrated in Typical Applications 28 and 29; both of these state that where a sidewalk exists, provisions shall be made for disabled pedestrians *(4)*. However, there is little to no discussion as to what types of devices should be used in order to make these provisions. Additionally, these typical applications seem focused on urban settings, while pedestrian issues also arise at temporary traffic control zones that are in suburban, small-town, and essentially rural environments. In these instances the engineer responsible for developing the pedestrian traffic control must rely on previous experience and judgment, which can result in a lack of consistency in pedestrian traffic control treatments from region to region.

OBJECTIVES

Texas Department of Transportation (TxDOT) sponsored Project 0-5237 in recognition that additional information on how to accommodate pedestrians in temporary traffic control situations is needed to ensure the safe and effective movement of the public through these areas. The objectives identified for this project are listed below.

- Examine how pedestrians with disabilities are being handled in temporary traffic control situations and identify if there are changes needed in this accommodation.

- Determine the information requirements of pedestrians (especially those with special needs) at temporary traffic control locations and gain input on how best to meet those requirements.
- Develop recommended guidance documents to provide TxDOT with improved traffic control methods for pedestrians in temporary traffic control locations.

This report documents the research efforts that addressed these objectives. Specifically, the report contains a summary of the literature review, state-of-the-practice interviews, field evaluations of current practices, development of a guidelines checklist, and summaries of human factors studies conducted with the general public and special needs groups.

2. REVIEW OF FEDERAL AND TEXAS POLICIES

AMERICANS WITH DISABILITIES ACT

The Americans with Disabilities Act was passed on July 26, 1990. The ADA extends to people with disabilities civil rights similar to those available on the basis of race, color, sex, national origin, and religion and prohibits discrimination on the basis of disability in public accommodations and services, including transportation, provided by public and private entities (*5*).

U.S. ACCESS BOARD

The U.S. Access Board is an independent federal agency devoted to accessibility for people with disabilities. Created in 1973 to ensure access to federally funded facilities, the U.S. Access Board is now a leading source of information on accessible design. The U.S. Access Board develops and maintains design criteria for the built environment, transit vehicles, telecommunications equipment, and for electronic and information technology. It also provides technical assistance and training on these requirements and on accessible design (*6*). Under the ADA, the U.S. Access Board is responsible for accessibility guidelines covering newly built and altered facilities.

AMERICANS WITH DISABILITIES ACT ACCESSIBILITY GUIDELINES

The ADA Accessibility Guidelines or "ADAAG" (*7*) establishes design requirements for the construction and alteration of facilities in the private and public sectors. ADAAG contains requirements for new construction and alterations. The U.S. Access Board develops the requirements as "guidelines" to serve as a basis for "standards" enforced by the Department of Justice (DOJ) and the Department of Transportation (DOT).

In July 2004, the U.S. Access Board completed a comprehensive update of ADAAG. The guidelines update included access requirements for a wide range of facilities in the public and private sectors covered by the law. The new design document was the result of a comprehensive, decade-long review and update of the ADAAG, which was first published in 1991. The revised guidelines took effect September 21, 2004. The updated guidelines are based largely on recommendations from the ADAAG Review Advisory Committee, which the U.S. Access Board

established specifically for this purpose. The ADAAG Review Advisory Committee represented a cross section of stakeholders, including representatives from disability groups, the design profession, and building codes organizations. The final version was further shaped by input received from the public, including over 2,500 comments received in response to a previously published draft.

Examples of material contained in the ADAAG include:

- accessible elements and spaces
  - space allowance and reach ranges
  - accessible route
  - protruding objects
  - curb ramps
  - ramps
  - stairs
  - elevators
  - doors
  - windows
  - drinking fountains and water coolers
  - toilet stalls
  - lavatories and mirrors
  - detectable warnings
  - telephones
  - automated teller machines
  - benches
- restaurants and cafeterias
- medical care facilities
- libraries
- etc.

PUBLIC RIGHTS-OF-WAY

A separate set of guidelines is being developed for public rights-of-way that will cover pedestrian access to sidewalks and streets, including crosswalks, curb ramps, street furnishings, pedestrian signals, parking, and other components of public rights-of-way.

In 1999, the Public Rights-of-Way Access Advisory Committee (Committee) was established to make recommendations on accessibility guidelines for newly constructed and altered public rights-of-way. The Committee was comprised of representatives from disability organizations, public works departments, transportation and traffic engineering groups, design professionals and civil engineers, pedestrian and bicycle organizations, federal agencies, and standard-setting bodies. On January 10, 2001, the Committee presented its recommendations on accessible public rights-of-way in a report entitled "Building a True Community" *(8)*. The Committee's report provided recommendations on access to sidewalks, street crossings, and other related pedestrian facilities and addressed various issues and design constraints specific to public rights-of-way.

The Access Board convened an ad hoc committee of U.S. Access Board members to review the Committee's recommendations. After reviewing the report in detail, the U.S. Access Board's ad hoc committee prepared recommendations for guidelines addressing accessibility in the public rights-of-way. On June 17, 2002, the U.S. Access Board made the recommendations of the ad hoc committee available for public comment and review by notice in the Federal Register (67 FR 41206).

Over 1,400 comments were received from the public in response to the publication of the draft. Of this total, almost 900 comments were from persons with disabilities and groups representing them; the majority of comments in this category came from people who indicated that they were blind or had low vision. Respondents from the transportation industry, including design engineers and consultants, submitted slightly over 200 comments. Another 100 were received from state and local government administrative agencies. Comments are posted on the U.S. Access Board's website *(9)*.

The members of the U.S. Access Board's ad hoc committee subsequently reviewed and considered the comments received in response to the 2002 Federal Register notice. Draft guidelines were made available on November 23, 2005, on the Board's website *(10)*. The U.S.

Access Board made the draft guidelines available in order to facilitate the gathering of additional information for a regulatory assessment prior to publishing a notice of proposed rulemaking and to assist in the development of technical assistance materials. The U.S. Access Board is not soliciting comments on the draft guidelines and will solicit comments when a proposed rule is issued in conjunction with the regulatory assessment.

The U.S. Access Board identified 10 key issues for detailed analysis from the 1,400 comments received: crosswalk width; on-street parking; walking speed and pedestrian signal phase timing; elevators at pedestrian overpasses and underpasses; same-side alternate circulation routes; cross slope in crosswalks; detectable warnings; accessible pedestrian signals; roundabouts and roundabout signalization; and alterations (*10*). The 2005 draft addressed these issues. Changes included the following:

- referenced the MUTCD for crosswalk width;
- reduced scoping in on-street parking to be consistent with parking lots;
- set walking speeds of 3.5 ft/s (consistent with new recommendations currently under consideration by the National Committee on Uniform Traffic Control Devices);
- eliminated the provision requiring elevators to provide pedestrian access at overpasses and underpasses (either ramps, lifts, or elevators may be used);
- modified scoping and technical provisions for alternate circulation routes to be consistent with current MUTCD requirements and alterations requirements, which would permit opposite side routes if same-side routes are not feasible;
- allowed relief (up to 5 percent) for maximum cross slope limits in pedestrian crosswalks at midblock and through-street locations where the roadway slope will necessarily exceed 2 percent;
- clarified the placement of detectable warnings on curb ramps, landings, and blended transitions;
- clarified the scoping in new construction and alterations of accessible pedestrian signals (APS);
- limited pedestrian signalization at roundabouts and channelized turn lanes to pedestrian crossings (to the splitter) of two lanes of traffic or more; and

- clarified the scope of alterations to include only that work included in the limits, boundaries, or scope of a planned project; clarified that there is no obligation in the guidelines to expand the scope or limits of a project to include other or adjacent work.

Other changes included the addition of significant advisory material, for informational purposes only, throughout the document.

Of critical importance with relation to temporary traffic control situations were the changes included to alternate circulation path guidelines. Table 1 reproduces the text from the November 2005 draft related to an alternate circulation path.

STATE OF TEXAS

In accordance with the Texas Architectural Barriers Act, Texas Government Code, Chapter 469, the applicable state standards are the Texas Accessibility Standards (TAS) *(11)* which became effective April 1, 1994. TAS is effective until new state standards are adopted.

The Texas Accessibility Standards are not the same as the AADAG; however, they have been certified as equivalent. Each state has the option of adopting the federal guidelines or proposing its own guidelines for approval by the United States Department of Justice. The Texas Accessibility Standards are as stringent (in some instances more stringent) as the ADAAG and have been deemed equivalent to the ADAAG by the United States Department of Justice. The TAS received equivalency certification on September 23, 1996. The Texas Accessibility Standards, including the appendix, are intended to be consistent to those contained in ADAAG, and are generally the same as ADAAG, except as noted by italics.

Recently, in anticipation of revisions to the federal accessibility guidelines, the Texas Department of Licensing and Regulation (TDLR) appointed a taskforce to coordinate the review of a proposal for a new ADAAG *(12)*. The TDLR is reviewing the new ADAAG and will soon begin requesting input from interested parties, coordinating public hearings throughout the state, and initiating discussion on proposals to update the state accessibility standards.

In Texas, when a project's total estimated cost is less than $50,000, it is not required to submit the project to the TDLR for registration and review; however, the project is still required to comply with TAS. Projects with costs of $50,000 or more are required to submit a full set of

construction documents in accordance with Administrative Rule 68.20 (accessible at http://www.license.state.tx.us/AB/abrules.htm).

Table 1. Text from the Draft Guidelines for Accessible Public Rights-of-Way *(10)* on Alternate Circulation Path.

R302 Alternate Circulation Path

R302.1 General. Alternate circulation paths shall comply with R302 and shall contain a pedestrian access route complying with R301.

Advisory R302.1 General. Temporary routes are alterations to an existing developed pedestrian environment and are required to achieve the maximum accessibility feasible under existing conditions.

R302.2 Location. To the maximum extent feasible, the alternate circulation path shall be provided on the same side of the street as the disrupted route.

Advisory R302.2 Location. Where it is not feasible to provide a same-side alternate circulation path and pedestrians will be detoured, section 6D.02 of the MUTCD specifies that the alternate path provide a similar level of accessibility to that of the existing disrupted route. This may include the incorporation of accessible pedestrian signals (APS), curb ramps, or other accessibility features.

R302.3 Protection. Where the alternate circulation path is exposed to adjacent construction, excavation drop-offs, traffic, or other hazards, it shall be protected with a pedestrian barricade or channelizing device complying with R302.4.

Advisory R302.3 Protection. When it is necessary to block travel at the departure curb to close a crosswalk that is disrupted by excavation, construction, or construction activity, care must be taken to preserve curb ramp access to the perpendicular crosswalk. This may require additional pedestrian channelization if only a single diagonal curb ramp serves the corner.

Figures 6H-28 and 6H-29 of the MUTCD specify notification signage for pedestrian closings and detours. Audible signage triggered by proximity switches can provide information to pedestrians who do not use print signs.

R302.4 Pedestrian Barricades and Channelizing Devices. Pedestrian barricades and channelizing devices shall be continuous, stable, and non-flexible and shall consist of a wall, fence, or enclosures specified in section 6F-58, 6F-63, and 6F-66 of the MUTCD (incorporated by reference; see R104.2.4).

R302.4.1 Detectable Base. A continuous bottom edge shall be provided 150 mm (6 in.) maximum above the ground or walkway surface.

R302.4.2 Height. Devices shall provide a continuous surface or upper rail at 0.9 m (3.0 ft) minimum above the ground or walkway surface. Support members shall not protrude into the alternate circulation path.

3. LITERATURE REVIEW

The following sections describe relevant research findings and the current state-of-the-practice on accommodating pedestrians in temporary traffic control situations.

PREVIOUS RESEARCH

While the topic of pedestrian accommodation in temporary traffic control is an area that has gained significant interest in recent years, especially as it relates to disabled pedestrians, there has been some research related to the subject over the last two decades. As the subject becomes more critical to state and local agencies, interest in this area of research is expected to increase substantially.

Research on Temporary Traffic Control for Pedestrians

Noel et al. compiled a synthesis of research findings and current practices in controlling and protecting pedestrian traffic in temporary traffic control areas (*13*). As early as 1989, researchers recognized that there was no comprehensive national standard on pedestrian accommodation in work zones. Some states and localities relied on principles presented in the 1983 Traffic Control Devices Handbook (TCDH). The TCDH provided the following guidelines on pedestrian control in highway work zones:

- Pedestrians and vehicles should be physically separated.
- Pedestrian walkways should be maintained free of any obstructions and hazards.
- Temporary lighting should be considered for all walkways that are used at night, particularly if adjacent walkways are lighted.
- Walkways should be at least 4 or 5 feet wide, wider in areas of high pedestrian activity.
- All hazards near or adjacent to walkways should be clearly delineated.
- Walkways under or adjacent to elevated work activities such as bridges or retaining walls may require a protective roof.
- Where safe pedestrian passage cannot be provided, pedestrians should be directed to the other side of the street by appropriate traffic control devices.
- Signs and traffic control devices should not be a hazard to pedestrians.

- Signs located near or adjacent to a sidewalk should have a 7-foot clearance.
- Where construction activities involve sidewalks on both sides of the street, efforts should be made to stage the work so that both sidewalks are not out of service at the same time.
- In the event that sidewalks on both sides of the street are closed, pedestrians should be guided around the construction site.
- Reflectorized traffic control devices are of little value to pedestrians. Warning lights should be used to delineate the pedestrian pathway and to mark hazards as appropriate.

Noel et al. added that large cities and counties traditionally relied on the limited provisions of state and local building codes for pedestrian traffic control in downtown work areas. However, some cities have developed guidelines specifically for pedestrian protection in temporary traffic control situations. They cited the specific example of the Work Area Traffic Control Handbook (WATCH), which was developed especially for California cities and used by San Francisco, Sacramento, and Los Angeles. The WATCH included several paragraphs on the type and use of pedestrian control devices and mandatory requirements such as minimum walkway width (4 feet), prohibiting abrupt changes in grade, and prohibiting diversion of pedestrians onto any portion of the street used for vehicular traffic.

Despite deficiencies in pedestrian control information in various work zone manuals, the researchers identified efforts to ensure pedestrian safety through (*13*):

- building codes,
- building permits,
- coordinated management of traffic,
- traffic control plans,
- general specifications, and
- coordinated policies on construction safety.

Researchers concluded that in spite of these measures, the actual practice suffers from a general lack of policies to ensure continuing enforcement. A chronic problem at local levels of

government was the lack of training of individuals responsible for approving traffic control plans and inspecting the field setup for compliance.

After reviewing a number of traffic control manuals, conducting a literature review, and making numerous field observations, the researchers made the following assessment (*13*):

- The safe accommodation of pedestrians and cyclists in work zones was often neglected by state and local governments. This neglect was more severe locally than at the state level; however, local safety standards were more prevalent in urban areas where the majority of affected work zones are located.
- Although the TCDH presented some principles for accommodating pedestrians in work zones, many local traffic safety personnel were not aware of its existence. In addition, since the TCDH was not a national standard, there was no movement to adopt its guidelines into local practices.
- Some city officials recognized the need for accommodating pedestrians in work areas, but few localities included written guidelines in their work zone traffic control manuals.
- While state highway officials apparently routinely reviewed projects planned for areas with pedestrian traffic, researchers observed a lack of concern about the quality and maintenance of pedestrian control devices on state highway projects.
- State MUTCDs generally reflected the federal MUTCD and had a similar deficiency in their methods for managing pedestrians in work zones. State officials seemed to be cautious in adopting formal guidelines that were not detailed in the federal MUTCD.
- The actual practices of state officials did not reflect the lack of information on pedestrian safety in their work zone manuals. The traffic control plan review process allowed ample opportunity to determine how to accommodate pedestrian needs.
- There was very little uniformity in the design and application of pedestrian control devices. The impact of using different colors for the same signed message on different backgrounds was not an apparent concern among state and local officials.

- Inadequate attention was given to the geometry and surface quality of temporary pathways. The needs of pedestrians with ambulatory handicaps were often neglected.

FHWA, ATSSA, U.S. Access Board Joint Device Demonstration

The Federal Highway Administration (FHWA), American Traffic Safety Services Association (ATSSA), and the U.S. Access Board conducted a demonstration in September 2004 to look at the effectiveness of different devices with regards to the accommodation of pedestrians, and more specifically pedestrians who are disabled (*14*). Persons with visual disabilities evaluated 20 devices during this demonstration. These people were asked to walk through a simulated temporary traffic control environment and to comment on the devices that they encountered. Participants evaluated the devices for the following accommodation criteria:

- Device endpoints do not present a hazard to hand-trailing or cane or dog travel.
- Devices provide a continuous cane-detectable surface within one and a half inches of finished grade.
- Continuous devices are smoothly traversable to hand-trailing or cane or dog travel.
- Device is stable and resists tipping or displacement on contact from cane or body.
- Device base supports do not present a tripping hazard at entry or along a travel route.
- Device profile or connections do not present an injury hazard when trailed by hand.
- Device does not present an entrapment hazard in continuous cane use.
- Device is detectable using residual vision by color, contrast, or brightness.
- Device meets ADA provisions for protruding objects (no projection greater than 4 inches).
- Device meets height requirements for various standards.

While this information was not collected in a controlled experiment, the data are some of the only objective information available on the usefulness of many of the technologies on the market to aid disabled pedestrians. As the information gathered is evaluated, it will aid in the

development of changes to the MUTCD and the U.S. Access Board's *Guidelines for Accessible Public Rights of Way*.

Public Rights-of-Way Guidance

Access to the public rights-of-way is a critical disability transportation element. Public rights-of-way include components such as sidewalks, streets, crosswalks, curb ramps, crossing signals, and street parking. Almost every trip involves a pedestrian component, whether it is walking several blocks on the sidewalk or simply crossing the street. If public rights-of-way are not accessible, then people with disabilities are unable to connect to other forms of transportation such as buses or trains. An accessible pedestrian environment permits people with disabilities, especially those who do not drive, to remain independent and more involved in the community.

A recent study by the National Council on Disability (*15*) found that many kinds of barriers are still found in the public rights-of-way. A telephone pole or other obstacle in the center of the sidewalk can turn an accessible block into an impassable one for most wheelchair users. The absence of detectable warnings on curb ramps and accessible pedestrian signals on traffic control signals make negotiating the environment far more difficult for many people with visual impairments. Even seemingly small details such as the slope of a curb ramp have a huge impact on the mobility of people with disabilities. HolLynn D'Lil, a disability advocate from Sacramento, states that a curb ramp with a slope 1 to 2 percent steeper than recommended can have debilitating effects on the arms and shoulders of wheelchair users (*15*).

One factor that contributes to the inaccessibility of public rights-of-way is that they are often built over a long period by many different people with varying interests and motivations. Therefore, long-range concerns are not taken into account, and making the environment accessible is considered a burden rather than something that will be universally beneficial. This piecemeal process also results in inaccessible gaps in the system, which Dennis Cannon, senior transportation/facility accessibility specialist at the U.S. Access Board, describes as the biggest problem in public rights-of-way (*15*).

A second major issue is that currently there are no federal regulations defining the standards for accessible public rights-of-way. McMillen, within the recent study by the National Council on Disability (*15*), explains that Title II of the ADA requires the public environment to be accessible, but the ADAAG does not yet address public rights-of-way issues. According to

McMillen, the absence of an enforceable regulation has resulted in funds being spent on poor designs that do not truly meet the needs of people with disabilities. Although the rulemaking process by the U.S. Access Board has been restarted, it will take time before any regulations regarding public rights-of-way become enforceable. However, important progress was made when the U.S. Access Board released draft guidelines on public rights-of-way on June 17, 2002.

Given that no enforceable requirements exist today governing public rights-of-way, Cannon, as stated in the report by the National Council on Disability (*15*), believes that best practice documents provide the optimal standards presently available (*15*). He stated the following regarding this issue (*15*):

> Two design documents have been especially useful to planners, engineers, designers, and decision makers. One is *Designing Sidewalks and Trails for Access*, published by the Federal Highway Administration. The other, *Building a True Community*, was the final report issued by the U.S. Access Board's Public Rights-of-Way Access Advisory Committee. Both documents promote maximum accessibility of the pedestrian environment for all users, including people with disabilities. In addition, the U.S. Access Board's 2002 draft guidelines serve as another best practices document.

The National Council on Disability made the following recommendations in this study (*15*):

- The federal government should establish enforceable ADA standards for accessibility in the public rights-of-way as expeditiously as possible.
- Transit agencies should work with cities, counties, and states during the planning process to provide input into plans and schedules for installing accessible bus stops and curb ramps, and removing barriers in the public rights-of-way that are obstacles to transit system use.
- Planning and design curricula at the university level should include accessibility issues in public rights-of-way.
- The public rights-of-way industry, including state and municipal transportation departments and highway engineers, should follow best practice documents describing how to make public rights-of-way accessible to people with disabilities, until enforceable ADA standards are established.

Research on Space Requirements

Anthropometry, the measurement of the physical characteristics and abilities of people, provides information that is essential for the appropriate design of occupational, public, and residential environments. However, the lack of anthropometric information about many disability groups severely limits the design of environments that are usable by as many people as feasibly possible.

Recently, U.S. government agencies, particularly the U.S. Access Board and the Department of Education, National Institute on Disability and Rehabilitation Research (NIDRR), have devoted a great deal of attention and resources toward understanding the physical abilities of those with disabilities. In the summer of 2001, the U.S. Access Board and NIDRR co-sponsored an international workshop that provided new ideas about data collection, analysis, computer modeling, and use of anthropometric data in the design of environments and products. In 2002, the U.S. Access Board funded a multi-year project to provide anthropometric information that will be used to improve building guidelines and standards for making decisions.

A second workshop sponsored by the U.S. Access Board was held in October of 2003 as a follow-up to the 2001 workshop. This meeting was specifically structured to help the U.S. Access Board define its short-term and long-term research objectives in determining the space requirements necessary for users of mobility aids in built environments. At the meeting's conclusion, workshop participants provided recommendations to the U.S. Access Board about how to prioritize research needs and what activities to include in a four-year research agenda. The workshop's organizers then developed a report (*16*) to summarize the activities and major findings of the workshop. The information gathered from the papers, presentations, and discussions in the workshop was organized into the following topics:

- Guidelines and Standards,
- Trends and Issues in Technologies,
- Demographics of Wheeled Mobility Users,
- Human Modeling of Mobility Aid Use,
- Anthropometric Research, and
- Access Board's Preliminary Research Agenda.

A summary of key points from the report is given below (*16*).

Guidelines and Standards

- Anthropometric data have historically been used to develop reach limits, recommendations for maneuvering clearances, grab bar location, and ramp slope for the American National Standards Institute (ANSI) and ADAAG.
- The anthropometric data typically used by designers is extremely outdated, with many of the data sources and tools developed in the 1970s or earlier. Since this time, there have been important changes in the physical characteristics of the population, the demographics of the population, and in the technologies used by wheeled mobility users.
- Standardized methods of anthropometric study are needed for standards development. A number of important anthropometric studies have been recently completed in the United States, Australia, United Kingdom, and Canada, but these suffer from several important limitations. User groups, measurement methods, and research environments vary greatly from one study to the next, which makes comparing results or pooling results across studies extremely difficult.

Trends and Issues in Technologies

- Only 20-25 percent of people worldwide who use wheeled mobility devices report that their mobility needs are met.
- There is a high degree of variability in the turning radius and stability of powered wheelchairs. Those with rear-wheel drive typically have a larger turning radius, those with mid-wheel drive have a shorter turning radius but are more susceptible to tipping, and those with front-wheel drive offer both a tight turning radius and stability, although they are more difficult to control during straight travel.
- Market trends suggest that the space requirements for wheeled mobility will increase. For example, the market for both manual and powered “bariatric” or high weight capacity chairs is expected to grow the most rapidly of all chair categories,

and markets for power-assisted chairs and specialized seating for chairs, although currently small, is expected to also grow rapidly.

- Because environments are not standardized in their level of accommodation to wheeled mobility needs, individuals who use wheeled mobility aids adapt by, for example, owning more than one wheeled mobility device. On average, wheeled mobility users have two devices and 50 percent of wheeled mobility users also use a walker.
- The increasing size and weights associated with newer powered mobility devices need to be considered in design standards.
- While use of platform lifts has vastly improved accessibility to the built environment, their operation can be difficult and time consuming. Efforts need to be devoted to universal design alternatives that eliminate the need for lifts.

Demographics of Wheeled Mobility Users

- There are approximately 2 million users of wheeled mobility aids, and trends suggest that this number may exceed 4 million users by 2010. This growth is likely due to changing social and technological trends, such as improvements in the design of mobility aids, improved accessibility to devices, and social acceptance of device use, rather than an increased prevalence of disability or the number of elderly people.
- The effects of the growing aging population on the use of wheeled mobility devices are uncertain due, in part, to the limitations in the current national survey methods. However, those 65 and over make up 56 percent of the users of wheeled mobility aids and are more likely to use manual versus powered mobility devices.

In conclusion, workshop participants decided that the increasing prevalence of wheeled mobility device users and the trends toward larger and heavier devices suggest that the current space requirements for wheeled mobility accessibility need to be re-evaluated. The current research plans were considered to be a good start but more thought must be given to how to expand the plan. It is likely that a combination of basic anthropometric research, experimental trials, field observations, and computer-aided design analysis are needed to provide the necessary information about the physical size, function, and preference of user groups for the development

of effective design standards. More discussion is needed to determine exactly how digital human modeling and simulation can be used to inform standards development.

STATE OF THE PRACTICE

Other State Departments of Transportation

An online search of other states' design manuals, traffic engineering manuals, work zone manuals, and pedestrian guidelines revealed that the accommodation of pedestrians in temporary traffic control has not been thoroughly addressed by most states. A number of states refer to the U.S. Access Board website, or specifically to Access Board Design Guide or the current draft of ADAAG. Other states make reference to various informational guides published by FHWA, American Association of State Highway and Transportation Officials (AASHTO), or Institute of Transportation Engineers (ITE), which will be discussed briefly in a later section. Only nine states specifically addressed the issue with internal material in a manual or a set of guidelines. Table 2 provides a summary of the information found in those various states' manuals and guidelines; the following paragraphs give more detail.

Table 2. Summary of State DOT Information in Manuals and Guidelines on Accommodating Pedestrians in Temporary Traffic Control.

State	Date of Manual or Guidelines	Summary
CA	April 2004	• The needs and control of all road users through a temporary traffic control (TTC) zone shall be an essential part of highway construction, utility work, maintenance operations, and the management of traffic incidents. • Where pedestrians with visual disabilities normally use the closed sidewalk, a barrier that is detectable by a person with a visual disability traveling with the aid of a long cane shall be placed across the full width of the closed sidewalk. • TTC devices used to delineate a TTC zone pedestrian walkway shall be crashworthy and, when struck by vehicles, present a minimum threat to pedestrians, workers, and occupants of impacting vehicles.
CO	March 2004	• Colorado DOT was required to develop a policy and method to implement ADA accessibility requirements for persons with disabilities in its transportation projects.
FL	April 1999	• Removing barriers to access by disabled pedestrians is important because of the added burdens they face. • Pedestrians must not be led into direct conflicts. • Pedestrians must be provided with a safe, convenient travel path.
IN	October 2003	• Pedestrian traffic control is needed when pathways are closed or disrupted by construction or maintenance. • Pedestrians should not be led into direct conflicts. • Pedestrians should be provided with a safe, convenient travel path.
GA	July 2005	• Everyone has an inherent right to access. • Disabilities include a wide range of conditions; a single design approach may not be appropriate for all disabilities. • Many design recommendations for the disabled can be applied for older adults as well. • Eliminating barriers and assisting the disabled are vital to complete accessibility. • Work zones should be monitored at all times for pedestrian safety needs. • Temporary access and detours to pedestrian facilities should be provided to ensure safe, convenient, and accessible unimpeded pedestrian travel in and around work zones.
MO	July 2002	• Where sidewalks exist, provision should be made for disabled persons. • Where high speeds are anticipated, a temporary traffic barrier and, if necessary, a crash cushion should be used to separate the temporary sidewalks from traffic.
OH	January 2004	• Pedestrians should not be led into direct conflicts. • Pedestrians should be provided with a safe, convenient travel path.
WV	November 1994	• Pedestrians should not be led into direct conflicts. • Pedestrians should be provided with a safe, convenient travel path.
WA	January 2005	• Give consideration to pedestrians and bicycles where appropriate. • Pre-existing ADA-compliant facilities must remain compliant. • Pedestrians should not be led into conflicts.

California

The California Supplement to the Manual on Uniform Traffic Control Devices, currently being reviewed for comment as the draft California MUTCD, discusses pedestrian and worker safety in temporary traffic control in Chapter 6D (*17*). Highlights from this chapter are listed below:

- The needs and control of all road users (motorists, bicyclists, and pedestrians) within the highway, including persons with disabilities in accordance with the Americans with Disabilities Act of 1990, Title II, Paragraph 35.130) through a temporary traffic control (TTC) zone shall be an essential part of highway construction, utility work, maintenance operations, and the management of traffic incidents. A wide range of pedestrians might be affected by TTC zones, including the young, elderly, and people with disabilities such as hearing, visual, or mobility. These pedestrians need a clearly delineated and usable travel path. Considerations for pedestrians with disabilities are addressed in Section 6D.02.
- The various TTC provisions for pedestrian and worker safety set forth in Part 6 shall be applied by knowledgeable (e.g., trained and/or certified) persons after appropriate evaluation and engineering judgment. Advance notification of sidewalk closures shall be provided to the maintaining agency. Where pedestrians with visual disabilities normally use the closed sidewalk, a barrier that is detectable by a person with a visual disability traveling with the aid of a long cane shall be placed across the full width of the closed sidewalk. It must be recognized that pedestrians are reluctant to retrace their steps to a prior intersection for a crossing or to add distance or out-of-the-way travel to a destination.
- Whenever it is feasible, closing off the work site from pedestrian intrusion may be preferable to channelizing pedestrian traffic along the site with TTC devices.
- TTC devices used to delineate a TTC zone pedestrian walkway shall be crashworthy and, when struck by vehicles, present a minimum threat to pedestrians, workers, and occupants of impacting vehicles.

- Short intermittent segments of temporary traffic barrier shall not be used because they nullify the containment and redirective capabilities of the temporary traffic barrier, increase the potential for serious injury both to vehicle occupants and pedestrians, and encourage the presence of blunt, leading ends. All upstream leading ends that are present shall be appropriately flared or protected with properly installed and maintained crashworthy cushions. Adjacent temporary traffic barrier segments shall be properly connected in order to provide the overall strength required for the temporary traffic barrier to perform properly. Normal vertical curbing shall not be used as a substitute for temporary traffic barriers when temporary traffic barriers are clearly needed.
- When existing pedestrian facilities are disrupted, closed, or relocated in a TTC zone, the temporary facilities shall be detectable and include accessibility features consistent with the features present in the existing pedestrian facility.

Colorado

The *Colorado Work Zone Best Practices Safety Guide* was developed for use by the Colorado DOT (*18*). There is a small segment on pedestrian access, which reads as follows:

> For pedestrian considerations, reference Part 6 Temporary Traffic Control of the MUTCD. Typical applications, TA-28 and TA-29, are examples for pedestrian considerations and Chapter 6D discusses pedestrian and worker safety. Another consideration is Americans with Disabilities Act (ADA) requirements (4-foot wide walkways, guarded hazards, changes in elevation shall not exceed 1:12 ratio, etc.).

The Colorado Department of Transportation was required by the U.S. Department of Transportation and the Federal Highway Administration to develop a policy and method to implement ADA accessibility requirements for persons with disabilities in its transportation projects. This includes projects constructed directly by the Colorado Department of Transportation, and projects funded by the Colorado Department of Transportation that are constructed through local agency agreements. Examples of projects covered are:

- major and minor widening of roadways,
- resurfacing the entire width of the street to a depth of 1.5 inches or greater, and
- enhancement projects, such as pedestrian and mixed-use pathways.

More specifically, the Colorado Department of Transportation projects and local agency projects funded by the Colorado Department of Transportation are required to include curb ramps with landings with detectible warnings (truncated domes).

Florida

The *Florida Pedestrian Planning and Design Handbook* contains a large section on pedestrians with disabilities and another on work zone pedestrian safety (*19*). The former section begins with a review of ADA and discusses sidewalks, street furniture, parking, and bus stops in that context. It cites research conducted by the Veterans Administration, which concluded that the level of energy expended by a wheelchair user is about 30 percent higher than that needed by a pedestrian walking the same distance. Moreover, a person on crutches or with artificial legs uses 70 percent more energy to go the same distance. If a person using a wheelchair travels a full city block and finds no curb cut, doubles back and travels that same distance in the street, it is the equivalent of an ambulatory person going four extra blocks. This illustrates the importance of removing physical barriers from the street network.

The section on work zones mentions three considerations for pedestrian safety:

- Pedestrians must be separated from conflicts with work site vehicles, equipment, and operations.
- Pedestrians must be separated from conflicts with mainline traffic moving through or around the work site.
- Pedestrians must be provided with a safe, accessible, and convenient travel path that duplicates as nearly as possible the most desirable characteristics of sidewalks or footpaths.

When construction requires closing existing crosswalks and walkways, contractors and other work crews must provide temporary walkways and direct pedestrians to the safest, most

convenient route possible. Walkways must be clearly identified and wheelchair-accessible, protected from motor vehicle traffic and free from pedestrian hazards such as holes, debris, dust and mud. If required, safe crossings must be provided to the opposite sides of the street. Signing for these crossings should be placed at intersections so that pedestrians are not confronted with midblock work sites that will induce them to attempt skirting the work zone or making a midblock crossing.

Indiana

The Indiana *Work Zone Safety Manual* contains a short segment on pedestrian and worker safety, which includes two diagrams of sample sidewalk closures and a list of flagging procedures (*20*). The segment on pedestrian safety is reproduced below:

If pedestrian travel paths (sidewalks or footpaths) are closed or disrupted by a construction, maintenance, or utility operation, then pedestrian traffic control is needed. This includes the use of signs, channelizing devices, flags, etc., to direct pedestrian movement through or around the work site.

The major considerations in planning for pedestrian safety in temporary traffic control zones on streets and highways are:

- Pedestrians should not be led into direct conflicts with work site vehicles, equipment, or operations.
- Pedestrians should not be led into direct conflicts with mainline traffic moving through or around the work site.
- Pedestrians should be provided with a safe, convenient travel path that replicates as nearly as possible the most desirable characteristics of sidewalks or footpaths.
- Pedestrians need protection from potential injury and a smooth, clearly defined travel path. Obstructions should be clearly marked, especially at night.

Georgia

The Georgia Department of Transportation sponsored the development of a thorough set of "toolkits," compiled in the *Pedestrian & Streetscape Guide* (*21*). The *Guide* contains a total of 11 "toolkits" on a variety of topics, including accessibility and work zones.

In the accessibility toolkit, the *Guide* draws heavily from ADAAG and other U.S. Access Board documents. It discusses designing for all disabilities as well as for older adults. It reiterates the ADAAG measurements for Pedestrian Access Routes, especially the values for minimum widths and maximum cross slopes and grades. It also has detailed sections on curb ramps, detectable warnings, and accessible pedestrian signals. The toolkit concludes with information on tactile and visual cues, crosswalks and refuge islands, and non-traditional signing and communication aids. There is also a list of other references for further information.

In the work zones toolkit, the *Guide* emphasizes the importance of pedestrian safety and the maintenance of pedestrian mobility. Sections of the toolkit include protective barriers, covered walkways, pedestrian traffic control plans for sidewalk closures and crosswalks, accessibility issues, and maintenance. The *Guide* lists the following considerations for pedestrian safety in work zones:

- Separate pedestrians from conflicts with construction vehicles, equipment, and operations.
- Separate pedestrians from conflicts with traffic traveling around or through the construction area.
- Provide a safe, convenient, and accessible route that maintains the direction and character of the original route.
- In urban areas, avoid work vehicle traffic during high pedestrian travel times, which include mornings between 8:00 AM and 9:00 AM, lunch times between 11:30 AM and 1:30 PM, and in the evenings between 4:30 PM and 5:30 PM.
- Provide police patrol or guards for pedestrian safety when needed, especially during times of high construction and/or high pedestrian traffic.
- Communicate construction activity and pedestrian impacts through local media and pedestrian interest groups. Contact community and school officials in the area.

- Avoid using delineating materials that are difficult to recognize by people with impaired sight.
- Walkways through construction zones should be a minimum width of 5 feet.

Missouri

The Missouri DOT (MoDOT) has published the *Traffic Control for Field Operations* manual, which contains information on temporary traffic control measures on the state highway system (*22*). The manual is applicable to incident management, maintenance, permit, and utility operations performed on MoDOT rights-of-way. Figure 1 contains Traffic Application 24 from that manual which specifically details a sidewalk detour or diversion.

Sidewalk Detour or Diversion

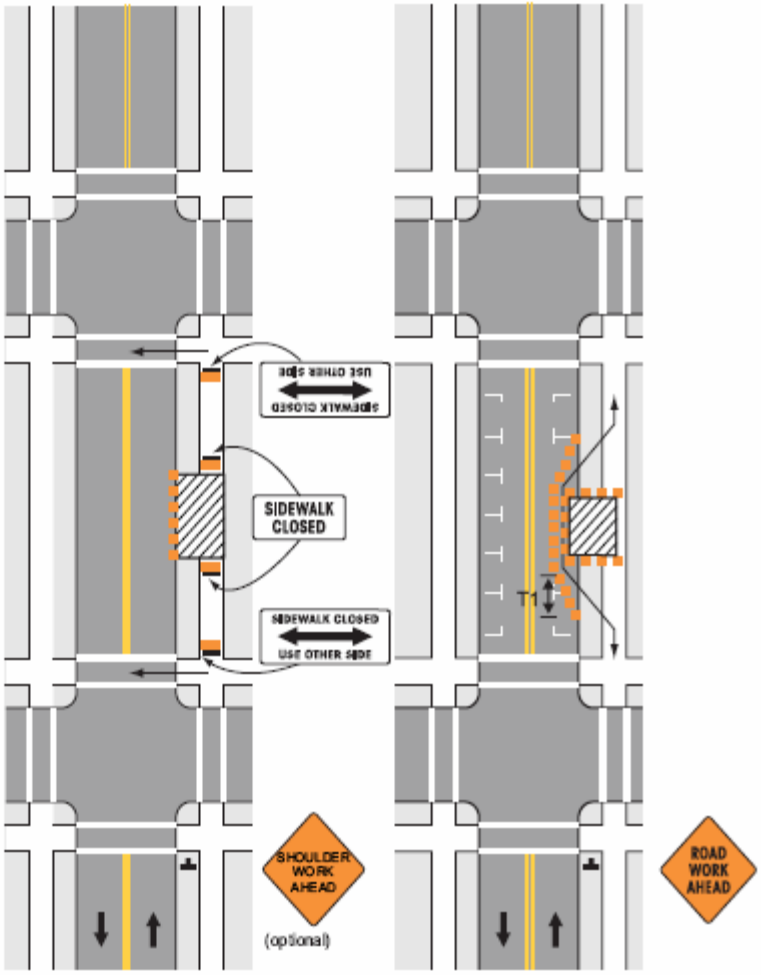
SPEED	SIGN SPACING (ft.)		TAPER LENGTH (ft.)		OPTIONAL BUFFER LENGTH (ft.) (B)	CHANNELIZER SPACING (ft.)	
	Undivided (S)	Divided (S)	Shoulder[1] (T1)	Lane[2] (T2)		Tapers	Buffer/ Work Areas
0-35	200	200	70	-	120	15	25
40-45	350	500	150	-	220	20	50
50-55	500	1000	185	-	335	50	100
60-70	1000	1000	235	-	550	60	100

1 Shoulder taper length based on 10 ft. (standard shoulder width) offset 2 Lane taper length based on 12 ft. (standard lane width) offset

Channelizer Cone or Drum

Sign

Work Space



Notes:

Where sidewalks exist, provisions **should** be made for disabled persons.

Where high speeds are anticipated, a temporary traffic barrier and, if necessary, a crash cushion **should** be used to separate the temporary sidewalks from traffic.

Only the temporary traffic control devices related to pedestrians are shown. Other devices **may** be necessary to control traffic.

Signs **may** be mounted on portable mounts at 1 ft. provided they do not interfere with pedestrian movement or be obstructed by parking. Otherwise, signs **shall** be mounted at 7 ft.

For high speed facilities, channelizer spacing **may** be reduced to ½ spacing noted in table.

Other appropriate signs **may** be used in lieu of the SHOULDER WORK AHEAD or ROAD WORK AHEAD signs.

Figure 1. MoDOT *Traffic Control for Field Operations* Traffic Application 24.

Ohio

The Ohio DOT *Traffic Engineering Manual* discusses pedestrian considerations in two sections, 603 and 640 (*23*). The text in Section 603-2 is exactly the same as excerpts from the West Virginia manual and is reproduced in this document under that section. The text from Section 640-25 is reproduced below:

> Planning and design for maintaining pedestrian traffic should consider both the characteristics of that traffic and the type of construction activities. An analysis of trip origins, destinations, and travel paths is useful for providing adequate temporary facilities.
>
> Pedestrian accommodations within work zones should be provided: where sidewalks existed prior to construction; where the work zone is located along a route to a school or park; where there is evidence of pedestrian usage (where well-worn paths exist, for example); or where existing land use generates pedestrian traffic.
>
> In residential and commercial areas, adequate pedestrian access should be provided to properties abutting a work zone.
>
> Use of increased pedestrian crossing times at signalized intersections based on a walking speed of 3 feet per second (1 meter per second) may be necessary, particularly in locations where the percentage of elderly pedestrians is expected to be significant. See Section 603-2 for additional information on pedestrian issues that should be considered.
>
> The following general principles should be followed when designing pedestrian facilities:
>
> 1. If a sidewalk or bridge that carries pedestrians is closed, provide a temporary walkway (concrete or asphalt) around the work area or direct the pedestrians to an alternate route. Do not force pedestrians to walk through the work area or into traveled lanes.

2. Passageways for pedestrians, especially the elderly and disabled, should be well defined and safe for use by these groups. Ramps should be provided for access to streets.
3. All signs or devices should be set up so that they do not cause a hazard for pedestrians. All signs mounted near or over sidewalks should have a minimum 7 foot (2.1 meter) vertical clearance.
4. Minimum width of walkways shall be 5 feet (1.5 meters). Wider walkways are required in areas of high pedestrian activity.
5. Pedestrian walkways shall be free of any obstructions or hazards (holes, debris, mud, etc.). It is especially important to cover or repair any holes and to have broken or damaged sidewalks repaired quickly.
6. Lighting should be provided for temporary walkways if the existing facility was lighted.
7. Fixed walkway and canopy-type pedestrian protection should be provided in the case of long-duration building projects involving construction, demolition, and repair activities located close to the street.
8. The design of a temporary pedestrian structure shall be approved by the Office of Structural Engineering. The following criteria shall be used:
   a. Live Loading - 85 psf (4.0 kPa)
      Maximum Allowable Live Load Deflection - 1/800 of the span with no allowable increase for temporary structure.
   b. Minimum Width - 5 feet (1.5 meters) face to face of railing.
      Railing - 5 feet (1.5 meters) high with chain link fence fabric.

West Virginia

The West Virginia DOT document *Traffic Control for Street and Highway Construction and Maintenance Operations* contains guidance for work zone operations (*24*). Section 6D describes “Pedestrian and Worker Safety” and contains the following information on pedestrians.

There are three threshold considerations in planning for pedestrian safety in temporary traffic control zones on highways and streets:

- Pedestrians should not be led into direct conflicts with work site vehicles, equipment, or operations.
- Pedestrians should not be led into direct conflicts with mainline traffic moving through or around the work site.
- Pedestrians should be provided with a safe, convenient travel path that replicates as nearly as possible the most desirable characteristics of sidewalks or footpaths.

In accommodating the needs of pedestrians at work sites remember that the range of pedestrians that can be expected is very wide, including the blind, the hearing impaired, and those with walking handicaps. All pedestrians need protection from potential injury and a smooth, clearly delineated travel path.

Therefore, every effort should be made to separate pedestrian movement from both work site activity and adjacent traffic. Whenever possible, signing should be used to direct pedestrians to safe street crossings in advance of an encounter with a temporary traffic control zone. Signs should be placed at intersections so that pedestrians, particularly in high-traffic-volume urban and suburban areas, are not confronted with midblock work sites that will induce them to skirt the work zone or make a midblock crossing. Recognizing that pedestrians will infrequently retrace their steps to make a safe crossing, ample advance notification of sidewalk closures is critically important. Refer to Cases B1 and B2 for typical traffic control device usage and techniques for pedestrian movement through work areas.

When pedestrian movement through or around a work site is necessary, the aim of the engineer should be to provide a separate, safe footpath without abrupt changes in grade or terrain. Judicious use of special warning and control devices may be helpful for certain difficult work area situations. These include rumble strips, changeable message signs, hazard identification beacons, flags, and warning lights. Flagger activated audible warning devices may be used to alert pedestrians of the approach of erratic vehicles. Also, whenever it is feasible, closing off the work site from pedestrian intrusions is preferable to channelizing pedestrian traffic along the site solely with temporary traffic control devices such as cones, tubular markers, barricades, or drums. If the possibility of vehicle impact is very low, chain link or other suitable fencing, placed well away from traffic, is acceptable. Solid fencing with plywood, however, can create sight distance restrictions at intersections and at work site access cuts. Care must be taken

not to create fenced areas that are vulnerable to splintering or fragmentation by vehicle impacts. Similarly, temporary traffic control devices used to delineate a pedestrian walkway must be lightweight and, when struck, present a minimum threat to pedestrians, workers, and impacting vehicles. Only minimally necessary ballasting with safe, lightweight materials should be used with these devices.

Movement by work vehicles and equipment across designated pedestrian paths should be minimized and, when necessary, should be controlled by flaggers or temporary traffic control. Cuts into work areas across pedestrian walkways should be kept to a minimum, because they often create unacceptable changes in grade and rough or muddy terrain. Pedestrians cannot be expected to traverse these areas willingly. They will tend to avoid the cuts by attempting non-intersection crossings.

At work sites of significant duration, especially in urban areas with high pedestrian volumes, where falling debris is a concern (such as work on overhead structures), a canopied walkway is frequently provided to protect pedestrians from falling debris. These covered walkways should be sturdily constructed and adequately lit for nighttime use.

In places where pedestrians are judged especially vulnerable to impact by errant vehicles, all foot traffic should be separated and protected by longitudinal barrier systems. Where a barrier is clearly needed, it should have sufficient strength and low deflection characteristics to keep vehicles from intruding into the pedestrian space. Further, short, noncontinuous segments of longitudinal systems, such as concrete barriers, must be avoided because they nullify the containment and redirective capabilities of the design, increase the potential for serious injury to both vehicle occupants and pedestrians, and encourage the presence of blunt, leading ends. All upstream leading ends that are present shall be appropriately flared or protected with properly installed and maintained impact attenuators. With regard to concrete barriers in particular, it is very important to ensure that adjacent segments are properly joined to affect the overall strength required for the system to perform properly.

Study and experience have determined that vertical curbs cannot prevent vehicle intrusions onto sidewalks. As a consequence, normal vertical curbing is not a satisfactory substitute for positive barriers when these are clearly needed. Similarly, contractor-constructed wooden railings, chain-link fencing with horizontal pipe runs, and similar systems placed directly adjacent to vehicle traffic are not acceptable substitutes for crashworthy positive

barriers; when struck, they are dangerous to vehicle occupants, workers, and pedestrians. In many instances, temporary positive barriers may be necessary to prevent pedestrians from unauthorized movements into the active work area and to prevent conflicts with traffic by eliminating the possibility of midblock crossings.

If a high potential exists for vehicle incursions into the pedestrian space, judgment must be exercised as to whether to reroute pedestrians or use barriers. Normally, standard traffic control devices can satisfactorily delineate a temporary pedestrian path, but fail-safe channelization can never be guaranteed with these devices because of the gaps between them. Tape, rope, or plastic chain strung between devices can help discourage pedestrian movements off the designated pathway.

Good engineering judgment in each temporary traffic control situation should readily determine the extent of pedestrian needs. The engineer in charge of temporary traffic control should provide both a sense of security and safety for pedestrians walking past work sites and consistent, unambiguous channelization to maintain foot traffic along the desired travel paths.

Washington

Washington State *Work Zone Traffic Control Guidelines* (DOT Document M 54-44) contains a section on "Pedestrians, Bicycles and Other Roadway Users" (*25*). That section contains the following information:

> Give consideration to pedestrian and bicycle traffic where appropriate. Provide alternative routes where designated walkways or bicycle routes are temporarily interrupted due to work operations. Alternative routes need to be free of obstructions and hazards (e.g., holes, debris, mud, construction, and stored equipment, etc.). Clearly delineate all hazards near or adjacent to the path (e.g., ditches, trenches, excavations, etc.). Refer to MUTCD Part VI, Chapter 6D for additional requirements.
>
> Most public highways and streets cannot deny access to pedestrians if no other route is available to them. All pre-existing ADA compliant pedestrian facilities within the work zone must continue to comply with ADA requirements for barrier-free access

during work operations. Consider the following when addressing pedestrian issues within and around work zones:

- Pedestrians should not be led into conflicts with work site vehicles, equipment, and operations.
- Pedestrians should not be led into conflicts with vehicles moving through or around the work site.
- Pedestrians should be provided with a safe, convenient path that replicates as nearly as practical the most desirable characteristics of the existing sidewalks or a footpath.
- Pedestrians generally will not go out of their way. Make alternate pathways reasonable.
- Do not place signs and other traffic control devices within the pathway that may pose a hazard.
- Placement of sidewalk closure signs shall be provided in advance of the closure point for pedestrians to make adjustments to their route. It must be recognized that pedestrians are reluctant to retrace their steps to a prior intersection for a crossing.

Other

There are other resources and guidelines available that have national applicability and are considered valuable sources of information. Among those documents are:

- Alternative Treatments for At-Grade Pedestrian Crossings (*26*), published by the Institute of Transportation Engineers;
- Pedestrian Facilities Users Guide: Providing Safety and Mobility (*27*), published by FHWA; and
- Guide for the Planning, Design, and Operation of Pedestrian Facilities (*28*), published by AASHTO.

The ITE document provides numerous examples of treatments to improve pedestrian safety and/or accessibility at crosswalks and other at-grade crossings. The FHWA guide is intended to help engineers (as well as citizens at-large) to identify pedestrian needs and determine appropriate treatments to address those needs. The AASHTO guide focuses on

identifying effective measures for accommodating pedestrians on public rights-of-way for planners, roadway designers, and transportation engineers to use when making decisions that affect pedestrian movements.

These are just a few of the references cited by state DOTs, as well as numerous cities, counties, and other jurisdictions. Other sources may be found from the Access Board, and numerous pedestrian and disability advocacy groups.

REVIEW OF TECHNOLOGIES TO IMPROVE TEMPORARY TRAFFIC CONTROL FOR PEDESTRIANS

Researchers conducted an online search of pedestrian traffic control devices. This search focused on vendors of traffic control that are affiliated with the American Traffic Safety Services Association, as well as vendors of services or devices for special-needs groups such as vision- or mobility impaired persons. Researchers identified the following devices as potential items of use in work zone areas:

- Channelizing devices, such as:
  - cones with retractable connection bars,
  - longitudinal channelizing barricades, and
  - water-filled barriers.

- Several purpose-specific barricades, including:
  - type-III barricades with a bottom rail for the use of vision-impaired pedestrians to allow tracking with a cane, and
  - manhole protection rings.

- Special-needs pedestrian-related technologies and/or strategies useful in temporary traffic control settings:
  - Surface-mounted way-finding tiles and detectable warning pavers (applied for a longer term application only).
  - Motion detector-activated (or pushbutton-activated) audible devices that can provide verbal instructions to vision-impaired pedestrians (or any pedestrian). These devices include cone-mounted or pole-mounted devices.

    - Pole-mounted prerecorded audible messages that broadcast a continuous loop, generally used at a more permanent location.
- Other pedestrian information needs may be addressed through reduced-size portable changeable message signs that can be installed and removed quickly by one person and provide specific information, particularly at high-traffic locations.

4. SURVEY OF CURRENT PRACTICES

The research team conducted three surveys to obtain information regarding the current state-of-the-practice as related to the accommodation of pedestrians in temporary traffic control situations. The surveys focused on issues including: innovations that have been adopted by the organization to address ADA requirements, past projects that have had unique pedestrian traffic control requirements, and plans for future changes. The groups contacted in these surveys were: TxDOT engineers in each of the 25 districts, transportation engineers at other state DOTs, and city traffic engineers from a sample of Texas cities.

SURVEY OF TXDOT DISTRICTS

A total of 25 districts were contacted to participate in a phone interview survey. The contact representative was usually the District Director of Construction, although other individuals were also included as respondents. Researchers were only able to interview representatives in 23 districts.

Potential participants were contacted by phone; the interviewers described the purpose and content of the survey and asked if they would be willing to participate. If necessary, the survey was rescheduled to accommodate the participant's calendar.

The survey was composed of nine questions, six of which had multiple parts. The respondents were asked to comment on procedures for accommodating pedestrians in work zones, frequency of the necessity of accommodation, desired guidelines, and current or upcoming projects that involved pedestrian accommodation.

The first question focused on districts that had or had not done any construction or maintenance that required the accommodations of pedestrians, as well as whether they have considered the impacts of pedestrians in the planning of future work. Fourteen districts (61 percent) indicated that they had work zone situations that required pedestrian accommodations. The following are examples of specific pedestrian accommodations used by the districts in work zones:

- installing and maintaining a temporary pedestrian route through the work area because the original route was impassable (four respondents),

- orange fencing as a barrier (one respondent),
- installation of truncated domes (one respondent), and
- installation of wheelchair ramps (one respondent).

The other nine districts (39 percent) reported that they had not encountered any operations where the accommodation of pedestrians was required. Of these nine districts, two indicated that they did have future work that would require the accommodation of pedestrians to be included in their planning.

For the 14 districts that indicated they had work zone situations that required pedestrian accommodations, researchers asked how often they encountered these circumstances and what types of locations have been impacted by pedestrian accommodations in work zones. Ten districts (71 percent) estimated that between 5 and 10 percent of their projects have pedestrian accommodation needs. The other four districts (29 percent) reported that a very low number of their projects require pedestrian accommodations. Figure 2 shows the locations impacted by pedestrian accommodations in work zones. The most common locations impacted were urban or downtown areas (five districts each), but work around schools and traffic signals was also mentioned.

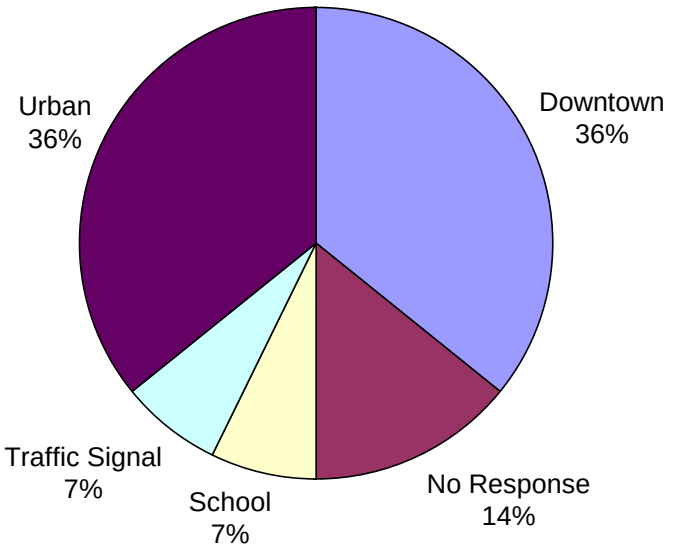


Figure 2. Locations Impacted by Pedestrian Accommodations in Work Zones.

Researchers also asked these same 14 districts if they have formalized polices for when and/or how work zones will address pedestrian access. Twelve respondents (86 percent) stated that they do not have any formal policy concerning pedestrian access in work zones and two respondents (14 percent) did not know if such a policy existed in their district.

All the districts surveyed were asked if they had experienced any specific difficulties in implementing work zones due to pedestrian concerns. Seventeen respondents (74 percent) indicated that they had experienced no difficulties in implementing work zones because of pedestrian concerns. The remaining six individuals indicated the following as issues or situations that had raised specific concerns with regard to the accommodation of pedestrians in work zones:

- building sidewalks (two respondents),
- maintaining a crosswalk (two respondents),
- parking near a sidewalk that was being replaced (one respondent), and
- work near a school (one respondent).

Districts addressed these issues through various means: public meetings with local businesses, residents, and elected officials at various phases of the project, a major change order, direct interaction with the contractor at the beginning of the project, and follow-up inspections.

All of the districts surveyed were also asked what additional policies or guidance on pedestrian accommodations in work zones would be helpful. About half of respondents (12 of 23) had no suggestion to offer with regard to additional policies or guidance. The remaining respondents preferred to have a statewide set of guidelines (not formal standards) with those guidelines containing a checklist of elements to be evaluated to ensure that pedestrian accommodation has been adequately considered. It was also suggested that the guidelines would include a list of possible treatments to use when certain pedestrian thresholds have been met and examples of pedestrian control plans (similar to traffic control plans). They believed that these guidelines would still allow the designer to have some flexibility to adjust pedestrian accommodation needs on a case-by-case basis.

When all of the districts were asked if anyone beyond their own crews and/or contractors do work on their facilities that would impact pedestrians, all 23 districts stated that others have

access to facilities and/or rights-of-way; usually these are utility and local jurisdictions. Only two districts noted that local jurisdictions had policies or regulations concerning pedestrian accommodations: one was a city policy and the other was addressed through the permitting process via the local area maintenance office.

The final question of the survey asked the districts about future work that was going to be done in the district that would include a pedestrian accommodation component. This information was gathered specifically to be used by researchers in identifying future field evaluation sites.

SURVEY OF OTHER STATE DOTS

Researchers conducted telephone interviews with engineers at 12 state DOTs in order to confirm the information found in the online search and to gain additional information on how their agency handles the accommodation of pedestrians, practices that have been used, and thoughts on future changes in these states. Each engineer interviewed was asked seven questions. Many of these interviews were completed in a single telephone call, while others included follow-up telephone calls and/or e-mail correspondence. The states who responded to this survey were California, Florida, Georgia, Illinois, Minnesota, Missouri, Montana, Ohio, Oregon, Tennessee, Utah, and Washington. These states were selected in order to:

- obtain geographic diversity across the United States,
- include variations between high and low population states, and
- focus on states that have been reported to be proactive in pedestrian issues.

The first question addressed how often each state encountered circumstances where pedestrians need to be accommodated in the area of an active work zone. There was a wide variety of responses to this question. Most of the engineers responded that in their state the rates were very low, generally less than 10 percent of active work zones included an element of pedestrian accommodation. However, in many of the more populous areas, the responses included higher percentages–from 10 to 70 percent of projects including a pedestrian-specific component. For example, in California it was thought that up to 70 percent of projects may include at least a minor pedestrian component. None of the respondents reported experiencing

any specific difficulties in getting a work zone traffic control plan implemented due to pedestrian concerns.

The following are examples of ways the states have accommodated special-needs pedestrians through an active work zone or other temporary traffic control situation.

- Bus vouchers were provided to help pedestrians bypass the work zone.
- Designation was made of specific crosswalks and/or sidewalks that will remain open throughout construction.
- Illuminated temporary ADA-compliant pedestrian paths were constructed.
- Mailings were made to special-needs pedestrians to inform them of the work zone and what to do.
- Special project schedules were created to complete construction of sidewalks prior to beginning other work.
- Modification of the construction schedule to complete pedestrian-related components near a school during summer when schools are out of session.

When researchers asked for what length of time does a work zone need to be at a location before pedestrian accommodation needs to be incorporated into the design of the temporary traffic control, almost all of the engineers stated that they have no set policy that is related to the time that a work zone will be in place. These states indicated that they follow the requirements of the ADA and the MUTCD in regard to pedestrian accommodation. This seems to imply that even a very short-lived work zone would have a well-defined pedestrian traffic control plan.

One exception to this was that the state of Washington reported a “three-day” practice, where a work zone that is only in place during the day and for three days or less can be accomplished with minimal pedestrian control. The reason for this approach is two-fold. First, this minimalist practice can be beneficial in increasing the speed of the work, as less traffic control would be required. Secondly, the accommodation for pedestrians was considered unchanged, because workers will be present and could inform pedestrians on the proper alternate routes to take if the pedestrian access path is altered.

Next, researchers asked whether the state has formalized policies for when and/or how work zones will address pedestrian access. All 12 engineers interviewed stated that they use the

MUTCD and their state's supplement to the MUTCD (if applicable). One state also mentioned that it is in the midst of revising the work zone rules to comply with the new federal rule on work zones, and that the accommodation of pedestrians may become a part of the measure of effectiveness in how well it is tracking safety in work zones.

SURVEY OF TEXAS CITIES

Researchers conducted a final survey of several cities in Texas to gather information on current practices concerning the accommodation of pedestrians in work zones in Texas. Researchers contacted six cities in Texas: Austin, College Station, Dallas, Houston, San Antonio, and Waco. Interviewees were engineers or construction managers from the respective engineering or public works departments.

Again, the research team contacted potential participants by phone; interviewers described the purpose and content of the survey and asked if they would be willing to participate and, if necessary, scheduled a later time to complete the survey.

When asked what written guidelines the city follows when designing the traffic control of a work zone that also needs to accommodate pedestrians, all six cities reported using the Texas MUTCD, the Texas Accessibility Standards, and the ADA Accessibility Guidelines. Only the City of Austin reported having standard traffic control plans that showed pedestrian traffic control treatments. No other city reported having formal written policies other than the state and federal policies.

Researchers also asked if pedestrian-specific traffic control varies by the duration of the work zone's presence. All of the cities reported a negative answer to this question, indicating that the duration of the work is not a formal consideration. Rather, the respondents reported that the traffic control was more a function of the type of work rather than its duration.

The last questions researchers asked addressed whether or not the city had tried any new technologies to help move pedestrians through a work zone. All of the cities indicated that they had not used new technologies for this purpose. The City of College Station did note that it was utilizing audible pedestrian signal devices at several permanent traffic signal locations, but never exclusively for work zones.

CONCLUSIONS

Based on the responses from the TxDOT survey, the following conclusions can be drawn concerning the state-of-the-practice for pedestrian accommodation in work zones in Texas:

- Pedestrian accommodation is not a common occurrence, either because there are few pedestrians near the work area (rural districts) or TxDOT does not encounter a large number of projects where pedestrians are found (urban districts).
- Most road work affecting pedestrians takes place when TxDOT performs road work in or near urbanized areas, often when TxDOT is doing work for a small city.
- Most districts do not have formalized policies for how to accommodate pedestrians in work zones.
- Most districts experience no problems in implementing work zones due to pedestrian concerns.
- Work by others (local jurisdictions, utilities, etc.) on or near TxDOT facilities is fairly common, but it is not generally perceived to affect pedestrian traffic.
- Only a few districts have historically had projects requiring special measures to accommodate pedestrians, but more districts expect to have them in the future.

Based on the responses from the other two types of surveys, the following conclusions can be made concerning the state-of-the-practice for pedestrian accommodation in work zones in other states and Texas cities:

- Similar to TxDOT, pedestrian accommodation in work zones in other states and in Texas cities is not a common occurrence. However, in states with more populous areas, pedestrian accommodation in work zones is more common.
- Most states reported using the MUTCD, their state's supplement to the MUTCD (if applicable), and ADA Accessibility Guidelines in regard to how to accommodate pedestrians in work zones. Texas cities also use the ADA Accessibility Guidelines, as well as the Texas MUTCD and Texas Accessibility Standards.

- None of the states have any other formalized policy for how to accommodate pedestrians in work zones. One Texas city did report that it has standard traffic control plans that showed pedestrian traffic control treatments.
- As with Texas, most states experience no problems in implementing work zones due to pedestrian concerns.
- All of the cities and all but one state indicated that work zone duration is not used to determine when pedestrian accommodations or pedestrian-specific traffic control in work zones needs to be included.
- Also, most states do not have a pedestrian accommodation policy that is related to the duration of the work zone.

5. FIELD EVALUATION OF PEDESTRIAN TRAFFIC CONTROL STRATEGIES

Researchers wanted to examine in more detail the characteristics of pedestrian maneuvers within temporary traffic control areas to gain insight into the behaviors related to those maneuvers. To that end, the research team designed a work plan for conducting field studies to observe pedestrian maneuvers near active work zones that required pedestrian accommodation or caused pedestrians to change their normal route.

ISSUES

The initial concern with a field study of this nature is in determining the best method for obtaining the data. In order to observe pedestrian maneuvers and their characteristics, the observers must have a clear view of the affected area around the work zone, but they must not influence pedestrian behavior. For this study, researchers determined that a combination of on-site observations and video recording would provide the best results. Using this method, one or two observers could record certain characteristics of pedestrian maneuvers as they occurred, and the video recording could be used to verify the on-site observations and provide additional information available for later review. The following sections discuss the details of the data collection process.

Associated with the issue of data collection methodology is the issue of identifying appropriate data collection sites. The study sites needed to have certain characteristics to make them viable for obtaining meaningful data. In this case, study sites needed 1) a work zone in place that involved closing one or more pedestrian access routes, 2) an active road work project comparable to that which TxDOT would perform in a similar location, 3) the potential of measurable pedestrian traffic through the area, and 4) adequate space and visibility for observers to collect the on-site data and video recordings. More details are provided in the "Site Selection" section below.

WORK PLAN TESTING

Researchers discussed appropriate methods for collecting observation data for these field studies, given the types of data available and the unique characteristics of gathering information on pedestrian maneuvers. Based on previous experiences with pedestrian maneuvers, the

research team decided the best course of action would be to collect some maneuver data as it occurred, capturing the critical elements of each maneuver in near-real time, while also recording each maneuver on video, to provide a permanent record of events and to allow collection of other maneuver characteristics in the future if necessary.

To collect data on-site, researchers developed a series of data collection worksheets to record information by hand as each pedestrian maneuver occurred. The site characteristics worksheet provided a place for researchers to note the physical conditions of the site at the time of data collection. These data included location information, a description of the road work performed, and geometric configurations as critical details that needed to be recorded. In completing this worksheet, the observer was expected to make three qualitative judgments: the overall usefulness and appropriateness of the instructions given to the pedestrian (on a scale of Excellent, Good, Fair, or Poor); the type of development in the area (Urban Commercial, Urban Mixed-Use, Suburban Residential, or Suburban Commercial); and the conduciveness of the environment for pedestrians (Friendly, Mixed, or Poor).

Using experiences from previous studies, researchers also developed a pedestrian behavior worksheet for the field studies. On this worksheet, researchers recorded eight specific characteristics about each pedestrian and his/her related maneuver during the data collection period: age, gender, physical ability, assistive device used (if any), compliance with pedestrian access route, understanding of appropriate route choice, and recognition/activation of traffic control devices.

SITE SELECTION

Researchers looked for sites based on the ability to collect sizeable amounts of pedestrian maneuver data in an active work zone. Using their knowledge of selected cities in Texas, members of the research team contacted colleagues in those cities in an effort to identify active road work projects. Based on response to these inquiries, researchers decided to focus their efforts in the cities of Austin and Houston, and developed a list of potential study sites in those cities with more detailed information about each site. Finally, to physically identify sites and determine their appropriateness, members of the research team visited each city.

In Austin, the city provided the researchers with a list of active, long-term work zones. Sites were identified in the downtown area and near the University of Texas. For example,

Figure 3 shows a site where a parking garage was being constructed along with work on the neighboring streets. The construction affected the sidewalks and the path to cross the street (see Figure 4). This site experiences a high number of pedestrians, especially when the University is in session. The covered pedestrian walkway is a reflection of the type of construction (high rise building) and the environment (urban setting) along with the expected high number of pedestrians. The sites identified in Austin were in densely developed areas with long-term construction where the temporary pedestrian treatments were more extensive.

Figure 3. Parking Garage Construction in Austin.

Figure 4. Sidewalk Treatment in Austin.

In Houston, a representative from the City of Houston Public Works Department offered to escort the researchers to several sites with active construction. They visited several sites with two sites identified for data collection.

DATA COLLECTION

Sites

Researchers found two sites in Houston with considerable pedestrian traffic that had active work zones and sufficient space to collect observation data:

- US-59 (Southwest Freeway) NB Frontage Road at Fondren, and
- Holcombe at Braeswood.

The first site, shown in Figure 5, was a partially closed roadway due to the replacement of a broken water line. The westbound lanes on Fondren were closed, and traffic was diverted to the other side of a raised median into a single lane while eastbound traffic was reduced from three lanes to two. The sidewalk adjacent to the westbound lanes was also closed near the intersection (see Figure 6), requiring pedestrians to cross Fondren upstream of the road work or travel through the work area.

Figure 5. US-59 at Fondren, Looking West.

Figure 6. Sidewalk Closed on Fondren.

The second site, shown in Figure 7, was in downtown Houston near the Texas Medical Center. Portions of westbound lanes on Holcombe were closed to replace a water main, and the adjacent sidewalk on the north side of Holcombe was also closed. Some advance signing was in place (Figure 8), and a partial alternate path around the closed sidewalk was evident (Figure 9), which pedestrians could use to plan their route through or around the work zone.

Figure 7. Holcombe at Braeswood, Looking East.

Figure 8. Advance Signing for Sidewalk on Holcombe.

Figure 9. Alternate Path for Sidewalk on Holcombe.

Collection of Data

The worksheets used in data collection were discussed above. Observers would position themselves in a location with a complete view of the work zone and adjacent sidewalk, and, using the pedestrian behavior worksheet, they would record the characteristics of each pedestrian maneuver during the observation period. In addition, an observer completed the site characteristics worksheet, along with a sketch of the site and multiple photographs of the conditions present during the observation period.

In addition to completing the worksheets, observers made a video record of the maneuvers using a video trailer. This trailer, shown in Figure 10, has two cameras mounted on a 30-foot high telescoping pole, which can capture an overhead view of the study site and its surroundings. Images from the cameras are stored digitally on a portable industrial hard drive contained within the trailer; the images are then downloaded onto a desktop computer in the office after data collection is complete. The viewing angle allows researchers to get a complete view of the study site from a distance, which allows the data collection process to be more unobtrusive and less likely to influence pedestrian behavior. This is illustrated in Figure 11.

(a) Video Trailer with Camera Pole Extended

(b) Interior of Video Trailer

Figure 10. Video Trailer.

Figure 11. Video Trailer Deployed Away from Sidewalk and Work Area.

Researchers collected data at the two study sites during three observation periods for a total of 21 hours, as shown in Table 3. During the three observation periods there were a total of 87 pedestrian groups.

Table 3. Summary of Field Study Observation Periods.

Period	Site	Date	Time	Pedestrian Groups	Number of Pedestrians
1	US-59 @ Fondren	6/13/06	7:30 AM – 2:30 PM	29	29
2	Holcombe @ Braeswood	6/14/06	8:00 AM – 3:00 PM	19	24
3	US-59 @ Fondren	6/15/06	8:00 AM – 3:00 PM	39	48

Data Reduction and Formatting

After data collection was complete, researchers took the worksheets and video recordings to the office for data reduction and formatting. The information contained in the written worksheets was transferred to spreadsheets for ease of analysis.

While collecting the on-site data, observers realized that it was necessary to add comments to each observed maneuver due to the unique characteristics of each pedestrian's actions. The direction the pedestrian was traveling, whether the pedestrian complied with traffic control devices, and the time of day (TOD) were all important characteristics that needed to be noted.

FINDINGS

After reviewing all of the video and the field study observation data, researchers evaluated the information to look for patterns and indicators of how pedestrians move through a temporary traffic control situation. In general, researchers found that in lieu of clear instructions on the appropriate path to take, reinforced by positive guidance, pedestrians will take whatever path is easiest for them to take at the point where they make their decision.

Researchers generated path diagrams for the two study sites to see what paths were taken and with what frequency. Figure 12 shows the diagram for the Holcombe site. A review of the chosen paths through the work zone indicates numerous choices, with some pedestrians choosing to walk through the closed traffic lanes and others jaywalking through the work zone, executing a midblock crossing maneuver to coincide with the north-south multi-use trail. The predominant

movements involved the use of the trail and/or the sidewalk on the bridge over the bayou, which was signed as being closed. However, without physical barricades to impede travel, or a clear description of the appropriate path to take through the area, pedestrians felt free to walk around signs and through the work zone to make their way to their chosen destination.

With no destination information provided to pedestrians, they typically proceeded as normal until coming upon a barrier (i.e., traffic control device, vehicular traffic, construction equipment, etc.) that impeded their progress, at which point they adjusted their route enough to travel around the barrier while still proceeding in the direction of their desired destination.

This task was useful in gaining an appreciation for the necessity of positive guidance for pedestrians and the tendency of pedestrians to walk wherever they are physically able to reach their destination. Researchers used the knowledge gained through this effort to develop the foundation for the activities described in Chapters 6 (Development of Guidelines Checklist) and 8 (Pedestrian Signing Evaluation).

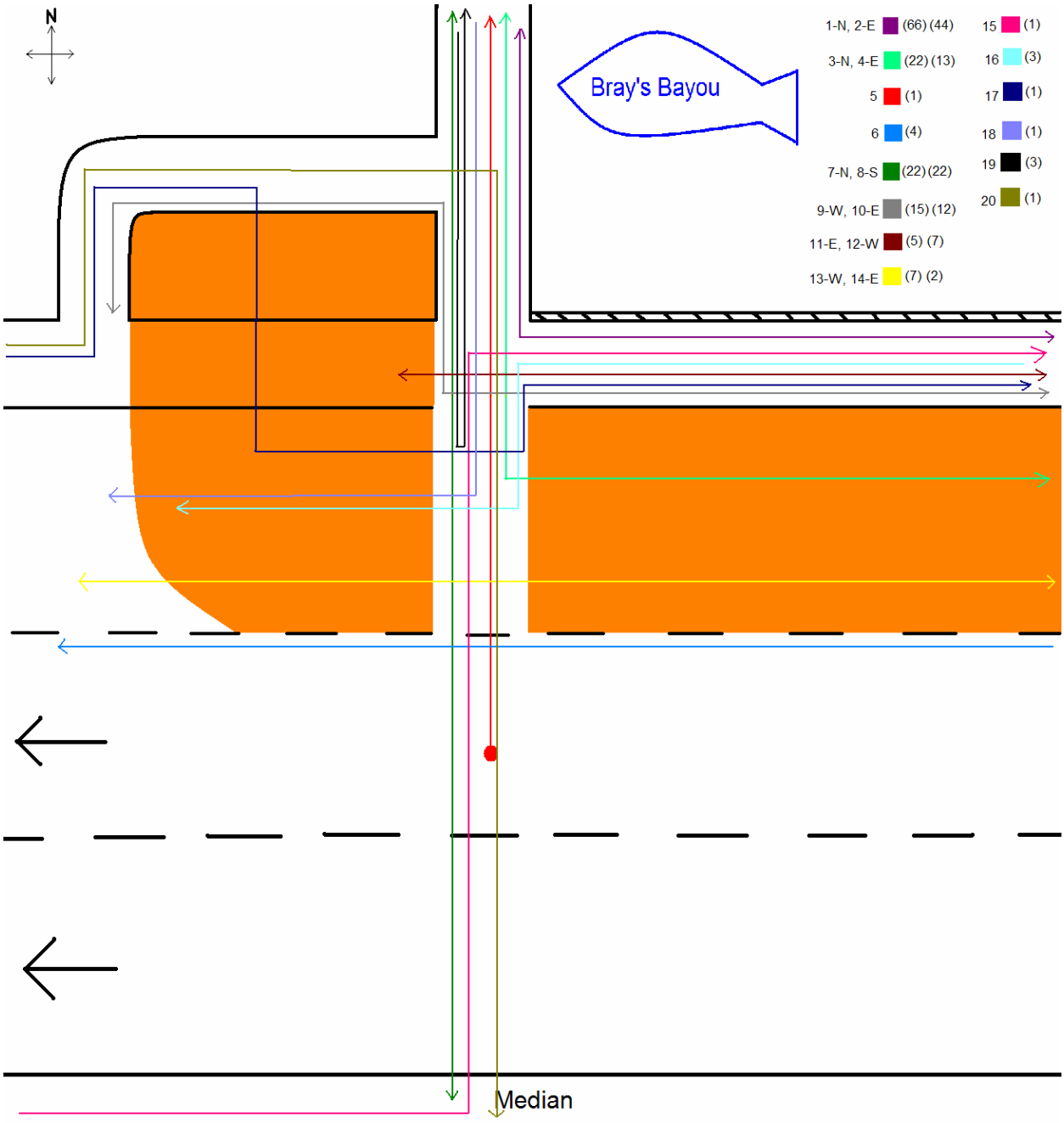


Figure 12. Path Diagram for Holcombe Site.

6. DEVELOPMENT OF GUIDELINES CHECKLIST

One of the objectives of this project was to produce recommended guidelines to improve the handling of pedestrians in temporary traffic control situations. As the project progressed, the primary issues for researchers became: 1) in what format should the guidance be presented; and 2) what material or topics should be included.

Based on the results of the state-of-the-practice survey and the site inventory, it became apparent that there was a need for specific guidance for practitioners to use in all facets of preparing and implementing the pedestrian component of temporary traffic control. With this in mind, researchers looked at possible solutions to address this need.

DEVELOPMENT OF CONTENT

Project Stages

In addition to the finished product of a construction project, which should reflect all of the vehicular and pedestrian elements in their fully operational state, there are other stages of the project, each of which have unique characteristics and elements to consider individually. Obviously, the scope of the project and the finished product have to be considered and determined early on; the project's planning phase will produce the intended result of the project and how it will be accomplished. Once that is determined, the appropriate methods and materials for maintaining pedestrian traffic throughout the project can begin to be addressed; however, these methods and materials may change as the project progresses, so personnel must reevaluate the needs at key intervals to establish the conditions of the project at that point. Researchers wanted to include guidance at each of these intervals, so they defined four stages of a project that each needed a separate review for pedestrian accommodation.

First, project managers need to determine what is feasible; that is, what are the conditions and constraints that define the project? The primary consideration is the project scope, to determine what result is desired and who will be affected by the project. The project scope will begin the definition of what strategies may be appropriate and necessary for accommodating pedestrian traffic. Outside of the specific scope of the project, however, there are other elements to consider at the outset. Pedestrian and vehicular volumes, the characteristics of those volumes, proximity of pedestrian generators and transit routes, and continuity of the pedestrian network

are all important considerations for defining the scope of the project. Figure 13 shows a fictionalized example that identifies pedestrian routes near a proposed project.

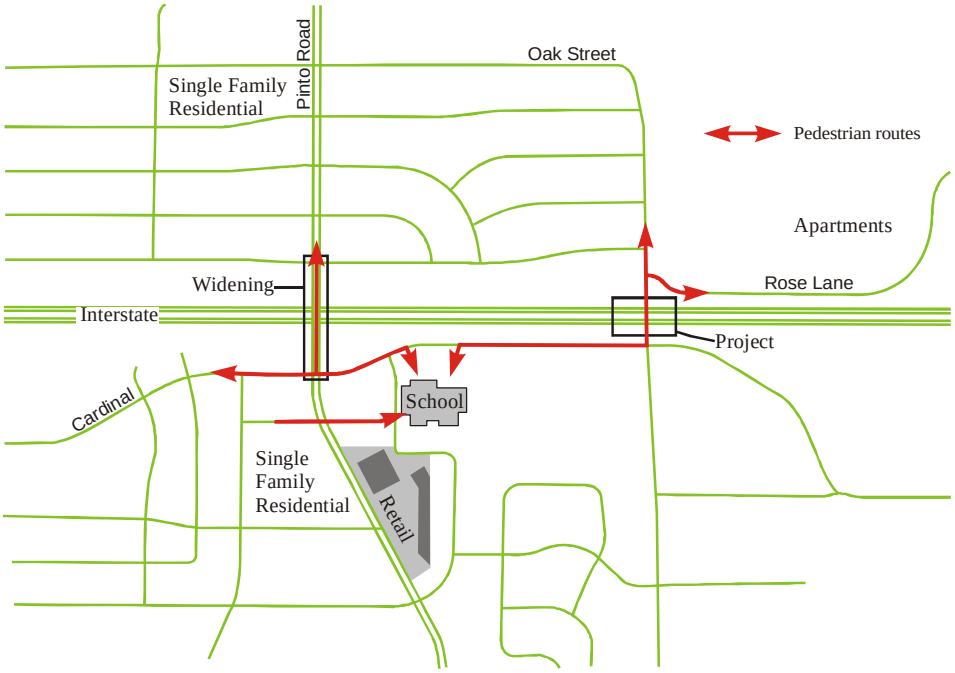


Figure 13. Map of Pedestrian Routes to Consider in Project Scope.

In the second stage, project managers need to assess the project to determine if the finished product includes all of the necessary elements that are required for pedestrian accessibility. Proper inclusion, design, and placement of sidewalks, curb ramps, and traffic control devices are all essential for a project to have the appropriate level of accessibility when it is completed.

The third assessment should consider the expected pedestrian accommodation that must be included during construction as part of the temporary traffic control plan. Maintenance of pedestrian access routes through the work area for the duration of construction is critical and project managers need to anticipate whether existing routes will be sufficient or, if not, what changes must be made. Diversion of pedestrian routes, adequate pedestrian information, protection of pedestrians from vehicular traffic and construction equipment, and special needs for pedestrians with disabilities are all important considerations in this review.

The final assessment is actually a series of checks during construction; this in-field review will evaluate how well the temporary traffic control plan was implemented and the

effectiveness of the plan in accommodating pedestrian traffic. This review considers pedestrian safety, the connectivity between the work area and the adjacent permanent pedestrian network, and the ability of pedestrians to travel unimpeded by obstacles or barriers in the defined pedestrian route. Depending on the results of this review, changes may need to be made to the route itself or to any number of elements or practices that affect pedestrian safety and mobility. Repeating this review periodically during construction ensures that pedestrian accommodation is not overlooked while work is being performed.

Guidance Topics

In discussing the material to include in the guidelines, researchers identified several key topics that should be considered throughout a project, although the specific emphasis may change depending on the stage. For example, "sidewalk width" can refer to slightly different concepts: in project assessment it refers to having the required width in the sidewalk at project completion; in temporary traffic control, it describes the appropriate width of the existing or temporary pedestrian route(s) being planned; during in-field review, it is related to having sufficient width clear of obstructions and maintaining the integrity of the route. Therefore, researchers decided to include information on multiple topics with descriptions that are specific to each stage of construction.

Basic elements of pedestrian accessibility are obvious, such as sidewalks, curb ramps, crosswalks, and traffic control devices. Within those elements, however, are characteristics that need to be examined and requirements that must be met. The engineer has to answer fundamental questions of whether they should be installed and, if so, where and what type. Within each stage, the engineer is presented with these questions as appropriate for completing that stage.

In addition, there are other issues related to these fundamental questions. Pedestrian visibility, removal of landscaping obstructions, access to adjacent developments and transit routes, climatological effects, and pedestrian safety all affect the usability of a pedestrian route.

DEVELOPMENT OF FORMAT

Researchers wanted to provide practitioners with as much information as possible to assist in making informed decisions about pedestrian accommodation. However, if the

information was not in an easily accessible format, the information would not be used and would therefore be ineffective, regardless of the quality or level of detail. It quickly became apparent that putting a large amount of information into a manual would not be a practical tool for use in the field and could be a difficult document to easily use in the office as well. The information had to be summarized into the key items that practitioners would need to know in a format that was easy to use. Researchers discussed options with the project monitoring committee and determined that a checklist format is beneficial for this application.

The checklist has several advantages to improve its usability. First, it allows the engineer or technician to simply confirm whether the necessary items have been reviewed and addressed. Second, the engineer or technician only needs to use the portion of the checklist applicable to the current project phase; that is, only the Stage 4 checklist is necessary to complete in-field reviews.

The format of this checklist still provides a great deal of relevant information. Researchers provided a summary of issues, as well as examples or discussion, for each topic that should be reviewed. A practitioner can read the summary, with a description of critical issues, and then review the example/discussion for suggestions on how to address issues that need attention. Figure 14 provides an illustration of one checklist topic.

<table>
<tr><th colspan="3">STAGE 3: TEMPORARY TRAFFIC CONTROL PLAN DEVELOPMENT</th></tr>
<tr><th>CHECK</th><th>TOPIC
▪ ISSUES TO BE CONSIDERED</th><th>EXAMPLES or DISCUSSION</th></tr>
<tr><td>❑

❑</td><td>TOPIC 3: Pedestrian Diversion Route Selection Considerations

▪ If pedestrians must be diverted from their normal path, select route based on the following priorities:
1. A parking lane next to the work site,
2. A closed travel lane next to the work site (if a multilane street), or
3. Sidewalk or other path across the street.

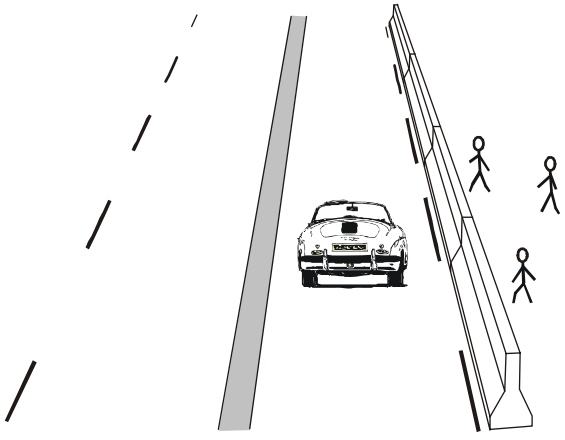
▪ If the pedestrian path is rerouted to closer proximity of traffic, a temporary traffic barrier may be needed.</td><td>In some cases, a temporary barrier between traffic and the pedestrian detour route may be needed (see Figure 3-2).
 
Figure 3-2. Example of Temporary Barrier.</td></tr>
</table>

Figure 14. Example of Topic in Checklist.

For each topic, researchers included applicable references to relevant manuals, plan sheets, and guidance documents, so that practitioners could read the supporting information and/or obtain more details if desired. Researchers also included graphic illustrations wherever possible; sketches, schematics, and photographs are all instrumental in conveying the information contained in each topic. The complete checklist has been developed as a stand-alone document:

- Fitzpatrick, K., M. Brewer, B. Ullman, and G. Ullman. *Checklist for Accommodating Pedestrians in Temporary Traffic Control Areas.* Report No. FHWA/TX-07/0-5237-P1. http://tti.tamu.edu/documents/0-5237-P1.pdf.

7. FOCUS GROUP SUMMARY

The research team conducted focus groups to gain an improved understanding of what information and guidance pedestrians require from temporary traffic control technologies and strategies. Researchers also specifically incorporated special needs pedestrians into these groups to obtain an understanding of the unique obstacles temporary traffic control areas can present to these pedestrians.

STUDY APPROACH

Locations

Researchers selected three locations within Texas to conduct the focus groups: Austin, College Station, and San Antonio. The discussions were held at the Texas Transportation Institute (TTI) facilities in College Station and San Antonio and at the Criss Cole Rehabilitation Center within the Division for Blind Services of the Texas Department of Assistive and Rehabilitative Services in Austin.

Participants

Participants in San Antonio and College Station were recruited using an advertisement flyer that was posted in each city prior to the scheduled focus group discussions. For this methodology, researchers recruited 7 to 10 pedestrians at each location. In this study, there were a total of 18 participants, 8 in San Antonio and 10 in College Station. The goal was to select a sample of pedestrians based on a demographic sample of the population of Texas with regard to gender, age, and education level. Additionally, researchers focused on the recruitment of mobility impaired pedestrians for participation in these groups. Researchers recruited seven participants for this study who were mobility impaired.

The focus group that was conducted in Austin was aimed specifically at vision-impaired pedestrians. These participants were recruited through contacts at the Criss Cole Rehabilitation Center. There were 11 participants that participated at this location; however, one of these participants was not visually impaired. This individual was an instructor at the school and participated in the group both to contribute her opinion and to assist researchers if any difficulties should arise in communication with other members of the group. Although

researchers believe that age, education, and gender are still critical to achieving a diverse sampling of opinions for a focus group, in this case participation was primarily based on the fact that participants were visually impaired.

The additional recruiting factors used for this study (i.e., emphasis on inclusion of pedestrians with mobility and visual impairments) made it such that the demographic sample did not exactly match the demographic population. However, it was believed that persons with disabilities were a critical element of the population to include in the discussions. Specifically, there was an over representation of women in the Some College+ demographic. Also, there was a slightly higher than desired number of participants in the 40-54 age group. Table 4 shows the demographics of focus group participants with the desired percentages for each group specified in the headings of the rows or columns. There were 29 people who participated in these groups.

Table 4. Number of Participants by Age and Education Level.

Age	High School Diploma or Less (50%)		Some College+ (50%)		Total
	Male	Female	Male	Female	
18-39 (47%)	5	0	2	5	12 (41%)
40-54 (29%)	2	3	3	3	11 (38%)
55+ (24%)	1	0	1	4	6 (21%)
Total (100%)	8 (28%)	3 (10%)	6 (21%)	12 (41%)	29

Discussion Techniques

The primary discussion technique employed for this study was the use of photographs to simulate a situation that pedestrians might encounter in a work zone. After pedestrians had viewed the photograph, they were asked questions related to that situation. Additionally, participants were asked to draw any additional temporary traffic control devices that they believed should be included for that situation. Obviously, this approach had to be revised for the vision-impaired focus group. In this discussion, the scenarios were described verbally by the moderator to the participants such that they could comment on the scenario from their perspective. Copies of the photographs were provided to the participants who had limited sight for their review prior to questions being asked.

Focus Group Protocol

Two TTI research project team members participated in each focus group session. One served as the facilitator (moderator) while the other took notes and interjected questions when appropriate.

Upon arrival, participants were given a verbal explanation of the study and a subject information form to complete which included questions related to their experiences of walking through temporary traffic control areas. The objective of this latter request was for the TTI researchers to obtain the participants' initial feelings regarding their experiences prior to the introduction of different situations in the discussion.

The focus groups were started by the TTI facilitator asking each participant if they had ever been a pedestrian in or around a work zone area and what problems they had encountered. This question was used to help motivate the participants to think of past experiences or events when they had encountered this type of situation.

Following this initial lead-in for the discussion, the researchers introduced eight different scenarios that a pedestrian might encounter in a work area through the use of a focus group guide. The focus group guide was adapted for the visually impaired discussion such that it addressed the unique issues that this group of pedestrians may encounter. A second section that introduced specific pedestrian technologies was also included in the discussions. The focus group guides were developed to set the agenda for the group discussions and provide direction for the TTI facilitator. The scenarios were approached such that each situation allowed the participants to participate in an open discussion of the topic.

RESULTS

Open Sidewalk Scenarios

The first three scenarios discussed during the focus groups were road work situations that were located near or adjacent to the sidewalk, but that did not require the sidewalk to be closed to pedestrians or indicate what direction pedestrians were to take. The following sections discuss the results of these three scenarios.

Scenario 1: Drop-off near a Sidewalk Edge

The first situation introduced to the participants was a drop-off of approximately 8 inches near the edge of a sidewalk they are walking on. Figure 15 shows the photograph used in this scenario.

Figure 15. Drop-off near a Sidewalk Edge.

Initially, pedestrians were asked what they would do if they encountered this situation. In this situation, since the obstacle was not in the pathway, the participants agreed that they would stay on the sidewalk, possibly moving further away from the drop-off area. Participants were then asked what other information they thought should be provided to pedestrians. All of the participants agreed that there needed to be a fence or barricade used in this situation that would block the edge of the pavement near the drop-off. Also, the San Antonio and College Station groups stated a desire to have a warning sign of this condition. Possible text for this sign was suggested as "Caution, Drop-off" or that the sign be a guide sign to identify the path that pedestrians should take to avoid the drop-off. For these signs, the College Station group specified that the signs should be orange and black to represent that it is in a work zone. For the visually impaired participants, they believed that no additional information would be necessary because the obstacle was not in their path.

Researchers questioned participants as to how the duration of this situation would impact the information they thought should be provided to a pedestrian. They indicated that barricades or fences were needed in this situation no matter how short the time of the temporary traffic control was. However, the San Antonio and College Station groups agreed it was not necessary to post a warning sign for anything less than a day (a short-duration situation). They believed that anything over a day would require this sign. The groups felt that this situation would be tolerable to pedestrians as long as it was necessary for the work that was being accomplished.

Scenario 2: Paving Removed

The next situation shown to participants was that the paving of a sidewalk ended or had been removed due to work being conducted in the area. Figure 16 illustrated this situation for the groups.

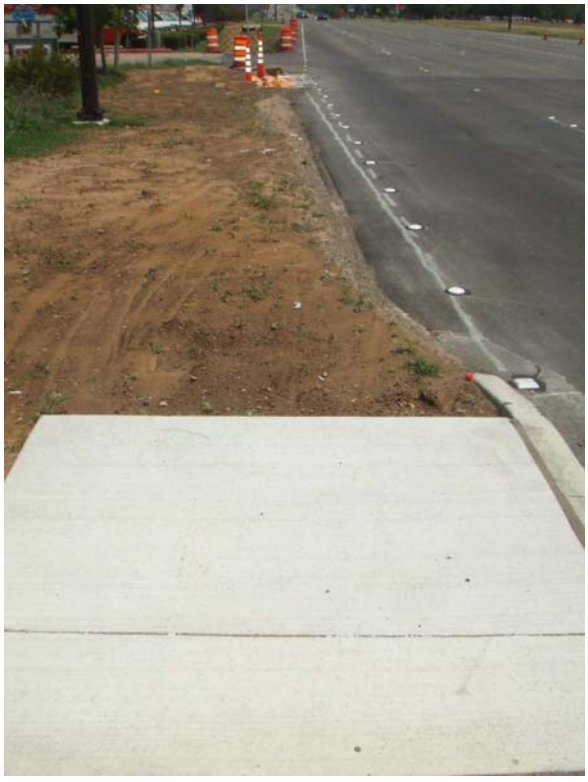


Figure 16. Pathway Paving Removed.

In this situation, the majority of the participants in San Antonio and College Station agreed that they would walk in the street to avoid the dirt area past the end of the pavement. All

of the visually impaired participants, and several of the other participants, agreed that they would continue ahead since there was no barricade blocking the path onto the dirt. Specific problems that were identified by the mobility impaired (i.e., wheelchair bound) participants were that in this situation there was not enough room to turn a wheelchair around and therefore they would be forced to continue straight ahead. However, the participants stated that it would be very difficult to continue in the dirt, particularly if there was mud. Suggestions for avoiding this type of situation, and for informing any pedestrian of the upcoming situation, were the inclusion of advance warning signs that stated the sidewalk would be ending, that it was closed at the previous intersection, or detour signing to take pedestrians around this area. Specifically, participants suggested sign wording of "Sidewalk Ends, XX Feet." Again, it was suggested that this signing should be orange because it would be located in a work zone (this time by the San Antonio group). The visually impaired pedestrians did not believe that anything needed to be changed if it was okay for pedestrians to continue ahead onto the dirt area. If not, they believed there should be a barricade at the end of the sidewalk so people could not continue in that direction.

Again, the participants did not believe that the information requirements for this situation were based on the duration of the work activity. However, the San Antonio group indicated that if the situation was only present for a short time a flagger could give pedestrians directions of what they should do. Again, participants agreed that the situation would be accepted by pedestrians as long as it was necessary to accomplish the work.

Scenario 3: Alternative Path Provided in a Roadway

In this situation, participants were shown the image contained in Figure 17. In this circumstance, researchers were hoping to portray a scenario where a designated pathway had been established along the curb for pedestrians; however, this was not initially explained to the participants in order to garner their unbiased reaction on what they would do if they encountered this situation. For the visually impaired group, the setup was explained as the cones being set away from the curb by approximately 2 feet.

Figure 17. Alternate Path Provided in Roadway.

There were 11 participants (38 percent), including four visually impaired participants, who indicated they would go around the work area by walking in the street. Six of the participants (21 percent) stated that they would go to the right side of the work area, walking in the dirt around the area (opposite the street side of the sidewalk), and 12 participants (41 percent) indicated they would turn around.

Following this initial response, it was explained to the participants that the setup was intended to have people go around the area in the street. When asked, all of the participants stated that they would be uncomfortable going into the street with this type of setup. Researchers asked what other information they would need to help them make this decision. Several people commented that the area was not handicap-accessible, and that a wheelchair ramp was necessary. Other participants thought this would also help to identify the intended path for pedestrians. Several participants suggested the use of advance warning signs so that people would have an option to cross the street prior to reaching this closed area. Another person thought that the addition of a sign which directed which way pedestrians should travel would be helpful. Participants in all locations suggested a better separation between the vehicles and the pedestrians. In College Station and San Antonio, participants suggested that a barrier wall be used, and in Austin (the visually impaired group) they suggested the use of an orange plastic

barrier fence as a separation device and they believed this would also help in identifying the edge of the path with their cane.

Other options were suggested for how to better handle this situation instead of having people enter the street; these included closing the sidewalk and creating a wooden walkway to the right of the work area (i.e., on the side opposite the street). It was thought then that "pedestrian detour" signs could be used to guide people onto the new path.

The visually impaired group indicated that they would like to have standardized devices used that would alert them to the presence of the temporary traffic control situation and to tell them what they should do. Suggestions were made that different types or shapes of cones could be used to show the beginning or end of a work area and also to indicate that pedestrians should get off the sidewalk, take an alternate route, or cross the street. Another suggestion was that detour or route change information could be provided by audio recording at a location prior to reaching the closure. Several participants liked this idea.

When asked how the duration of the temporary traffic control situation would change the information that they would like to have, the San Antonio and Austin groups indicated that there would be no changes based on duration. However, the College Station group believed that one week was a change point for the amount of accommodation that needed to be provided to pedestrians. If the closure was going to be present for less than one week, they believed that the sidewalk should just be closed. However, if the sidewalk was going to be closed for longer than a week, they believed that an alternate wooden path around the work should be created.

Closed Sidewalk Scenarios

The final five scenarios discussed with the groups presented different situations and signs that could exist when sidewalks were closed due to road work. The visually impaired focus group only discussed the final two scenarios in this section due to their different perspective. These two situations introduced an advanced closure where the sidewalk was not blocked and a closure where the sidewalk was completely blocked and located very near to the work area. The other three situations discussed below were only appropriate for inclusion in College Station and San Antonio as they were investigating the use of different signs to indicate a sidewalk was closed.

Scenario 4: Walking Man Sign with Double-ended Arrow

In this scenario, researchers displayed the picture shown in Figure 18 and discussed with the group their interpretations of the situation.

Figure 18. Walking Man Sign with Double-ended Arrow.

When presented with this information, the majority of the participants in College Station (90 percent) stated that they would continue along the sidewalk because the sign did not indicate closed to them, but was only giving pedestrians options about other paths they could take. However, all of the participants in San Antonio indicated that they would leave the sidewalk because the sign meant that pedestrians had to go either right or left, but could not continue straight on the sidewalk.

Several suggestions were made as to how this situation could be improved. Specifically, College Station participants thought that a barricade or fence was needed that would block the

sidewalk if people were not supposed to continue. Also, both groups indicated that different warning signs were necessary to show that the area was closed. Either "Sidewalk Closed" or "Construction Keep Out" was suggested. Participants in College Station also indicated that the color of the sign (black on white) did not imply a need for caution and should be changed.

Participants were again asked how the duration of the work affected their opinion of the information needed. In this situation, both groups agreed that there was no change needed based on duration of work. They also agreed that people would accept the situation as long as there work was being done.

Scenario 5: Pedestrian Text Sign

The next sign replaced the graphic representation of a pedestrian with the word "pedestrian" on the sign. Also, the arrow shown on the sign indicated a single direction. Figure 19 shows the picture used for this scenario

Figure 19. Pedestrian Text Sign.

In this scenario, the participants of both groups were split with half indicating that they would cross the street to the left and the other half indicating that they would continue going straight on the sidewalk. One participant in College Station indicated that at this particular location there was no wheelchair ramp provided to the left and therefore they believed that this could not be the intended action for pedestrians (particularly mobility impaired pedestrians). The group thought that in situations like this, there may need to be signs that differentiate between what actions are required if a pedestrian needs wheelchair access and what pedestrians should do if they do not need wheelchair access because there may be cases where there are different actions needed for different mobility requirements. Interestingly, the San Antonio group all agreed that the previous sign with the walking man symbol was preferable to them because "pedestrian" would be a large word that many people would not be able to read and understand.

Again, suggestions were made that there needed to be a barricade that would block the path if pedestrians were not allowed to continue on the sidewalk. Also, College Station thought that there should be further direction provided to the pedestrian as to what action to take, specifically "cross street" should be included on the sign. They also believed that the sign should be orange since it is part of a work zone.

Scenario 6: Sidewalk Closed but No Visible Work

In the next scenario presented to the group, the temporary traffic control situation pictured was very short in length and showed no visible work occurring in the closed area. Figure 20 shows the image used for this scenario.

Figure 20. Sidewalk Closed but No Visible Work.

Given this situation, the majority of the participants in both College Station and San Antonio indicated that they would walk in the street around the closed area. These participants indicated that since the closed area shown was only a short distance, they felt it would be easiest to just go around the closure instead of having to cross the road. Only two participants in San Antonio indicated that they would cross the street at the previous intersection crossing. The two participants based their response on knowledge of the pictured area (the photo had been taken in San Antonio) as a busy street that they would not want to walk in as a means of detouring around the area.

Participants at both locations stated that advance warning of the sidewalk closure ahead at the previous signalized intersection would have helped them to make a decision to cross the street before reaching the closed area. College Station participants also suggested that detour signs with an alternate route for pedestrians should be used. Again, they believed orange was an appropriate color for all of these signs.

Scenario 7: Sidewalk Closed, Cross Here

The research team presented the next scenario to all three focus groups. It illustrated a situation with advance warning of an upcoming sidewalk closure. Figure 21 shows the image used for this discussion.

Figure 21. Sidewalk Closed, Cross Here.

When presented with this situation, all of the participants in San Antonio and Austin (visually impaired) and 60 percent of the College Station participants indicated that they would continue on the sidewalk. In San Antonio, the participants indicated that they would continue because they could not see any work and therefore thought the sign might have just been forgotten and didn't need to be followed. In College Station, the participants felt that they would continue until something was obstructing the path. Many of these participants indicated that they were hesitant to cross the street because they didn't know if they would be able to get back across to access businesses on this side of the street once they had detoured. Obviously the visually impaired had a much different perspective on this situation. Given that there was nothing blocking the path, there would be nothing detectable to them to indicate that they should

not continue. The remaining College Station participants indicated that they would cross the street as indicated on the sign.

Researchers again asked participants how to improve the situation. The visually impaired group stated a need for either a sign or barricade to block the path so that something was detectable for them to encounter and realize that they could not continue. The College Station group also suggested that the path be blocked with the sign or a fence because they thought this would encourage people to cross as indicated on the sign. Other improvements to the sign suggested by College Station and San Antonio are inclusion of "last crosswalk" to show the need to cross, "ahead" if work isn't visible, a date the sidewalk is closed, or how far ahead the sidewalk is closed so that people could make a decision about crossing based on if the closure was before or after their destination.

Researchers also discussed the use of Braille on signs with the visually impaired participants in Austin. The group believed that this might help some people, but that the visually impaired community would not know that the Braille was present unless it was standardized. Also, they indicated that many visually impaired people do not know how to read Braille. Finally, they informed researchers that visually impaired persons are instructed to use their cane to detect elements in their environment and not to use their hands. This would make Braille use on signage contradict their standard mobility training.

Again researchers questioned the groups about duration of the work and received the same response that the information needed for this situation was not dependent on time and that the sidewalk closure would be accepted by the public as long as work was being done.

Scenario 8: Sidewalk Closed with Visible Construction in Path

The final scenario presented to the groups involved a sidewalk closure near a very active work area. Figure 22 shows the image used for this situation.

Figure 22. Sidewalk Closed with Visible Construction in Path.

Given this scenario, none of the focus group participants would continue ahead into the work area. The majority of participants from all locations indicated they would cross the street and continue along the opposite side of the road. However, four of the visually impaired participants (40 percent) indicated that they may have to turn around because of the activity at the location that would drown out traffic noise making it impossible for them to assess traffic conditions for crossing. The other participants who were visually impaired agreed that this is a concern, but believed they would cross the street given this situation if they were familiar with the area.

When asked what other information participants thought they would need to make a decision at this point, all of the San Antonio group agreed that nothing else was needed because the action necessary was very clear (i.e., cross the street). However, the College Station group thought that the additions of either more barricades to block the area or signs such as “do not enter” or “use caution” would help to keep pedestrians out of the restricted area. A suggestion was made by the visually impaired group that one way to overcome the obstacle of construction noise at this site would be to have a flagger at this location to help people cross the street when there is a high level of construction noise.

Sign Comparisons

Following the discussion of the sidewalk closed scenarios, researchers asked participants to compare the different signs that were used in these situations. This comparison was only conducted with the College Station and San Antonio groups. Researchers first asked the participants to consider a situation such as the last one discussed where a pedestrian could see the work area when they encountered the sign. In this discussion, all of the San Antonio participants agreed that they liked the inclusion of both the walking man symbol and a text message that says "sidewalk closed" to provide a clearer message. Several of these participants (50 percent) also liked the inclusion of text that gave them direction about the action to take (e.g., use other side). The College Station group all preferred the message that stated "Sidewalk Closed, Use Other Side." They felt that the phrase "Use Other Side" was more descriptive of what to do and more definite in instructing people that they could not continue than the other alternatives.

Next, researchers asked participants to consider a situation of advance warning signs where a pedestrian could not see work ahead. In this situation, all of the San Antonio participants agreed that the sign should say "Sidewalk Closed Ahead." Two of the participants (25 percent) also thought that the sign message should include the direction "Cross Here." All of the College Station participants agreed that the sign should say "Sidewalk Closed" and that the text should include directions (either "Cross Here" or "Use Other Side") for the pedestrian to follow. Finally, the College Station group believed that the advance warning signs should include a distance of how far ahead the work area is located. When asked specifically, all of the participants at both groups agreed that it is better to provide directions to pedestrians if the sidewalk is going to be closed.

Technology and Device Evaluation

The final section of the focus group looked at a few specific technologies or devices that could be used in temporary traffic control areas to help guide pedestrians. Researchers showed pictures of each of the devices and then asked the focus groups questions regarding the use of these devices.

Braille Signs

Although it had briefly been discussed earlier in the discussion, researchers queried the visually impaired group of participants about the use of Braille on signs. Again, the group stated

that not all visually impaired people are able to read Braille and therefore this use would have limited effectiveness. Also, they were concerned that this went against their standard teaching to not touch objects in their environment with their hands, but to investigate the object with their canes. They indicated this application may be of some help to visually impaired pedestrians, but to be effective there would have to be standardized application of the Braille wording on all signs so that the visually impaired community would know to expect the Braille wording to be present.

Other methods of information dissemination to visually impaired pedestrians were discussed to try and identify alternatives that would better suit this community of users. Audio information was by far the most preferred information source. One method of delivery that was discussed was the use of a pushbutton system that would have an audible signal to assist with detection of the device. Again, the participants emphasized that the tone would have to be standardized so that visually impaired pedestrians could recognize it was an information providing device. Another method that was suggested was the use of an audio system that would be motion or touch activated to provide information about the work area ahead. Once more, participants stressed the need to standardize how this information would be provided so that visually impaired pedestrians would know how to activate the system.

Cones with Connecting Bars

The image shown in Figure 23 was introduced to the groups as a new device that could be used in temporary traffic control areas.

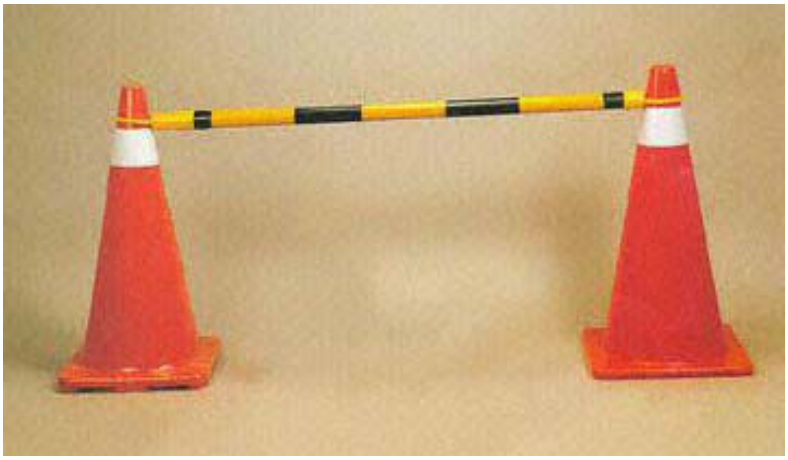


Figure 23. Cones with Connecting Bar.

Upon viewing this picture, both the San Antonio and College Station groups believed that the device may have limited application within short duration work areas. However, they were concerned that it would be a tripping hazard for pedestrians. A suggestion was made in both groups to increase the height of the device (e.g., use barrels with a connecting bar) to reduce the tripping hazard and make the device more effective in blocking the area from pedestrians.

The visually impaired group liked the idea of a continuous line connecting the cones, as long as the bar was not too high for them to detect. They suggested that the bar be no more than 6 inches off ground level. They also informed researchers that the lower the bar is to the ground, the greater amount of time they have to react to the situation because of an earlier detection of the device with their canes.

Talking Cone

Another device discussed in the focus groups was the use of a voice recording that would repeat on a continuous loop to provide pedestrians with further information about the upcoming temporary traffic control situation. All of the focus group participants felt this recording would be a good addition to the temporary traffic control setups because it provided more detailed information to all pedestrians. Specifically, they thought it should be used to give alternate route information and to tell pedestrians how long the area will be affected. College Station particularly liked the idea that the information could be on a continuous loop so if pedestrians were not paying attention they would still hear the recording and be alerted about the situation. However, the visually impaired group was concerned about the noise level of the device if it was continually repeating. They thought that this might obstruct the traffic noise and not allow them to detect traffic when trying to cross the street.

The visually impaired participants made several suggestions to improve the use of this device. First, they suggested using the device as an advance warning and to place it upstream of an intersection so that pedestrians can hear the message, yet not be distracted by construction noises. Another suggestion was to have the audio recording be motion or touch activated. They believed that the device could be placed at a location where the cane would hit it to touch activate the device such as in the middle or at the edge of the sidewalk.

Pushbutton Activated Voice Recordings

In this situation, researchers introduced a pushbutton device that would use an audible signal for detection. The Austin and College Stations groups both agreed this device would be good for providing a pedestrian with further information about the work areas. However, the San Antonio group did not believe that this device would be helpful in a construction situation because the tone might not be detectable over the street or work noise.

The Austin group raised concerns that the audible tones might be difficult to locate, and that the tones are often imitated by birds and not always reliable. Again, participants made suggestions that the device could be motion activated to provide pedestrians with information. The San Antonio group also indicated that it believed a continuous message would be better (as discussed previously) so that pedestrians did not need to find a box to activate the information. Another improvement suggested by the College Station focus group was that a sign should be included near the pushbutton to indicate that it should be used to get construction or crossing information.

SUMMARY

Researchers formed three focus groups in an effort to gain a better understanding of the issues and concerns of the public when pedestrians are in a temporary traffic control area. Specifically, researchers concentrated on recruiting different types of pedestrians within the discussions including those who are mobility or visually impaired. In this process, researchers recruited a total of 29 participants, 7 were mobility impaired, and 10 were visually impaired.

During the focus group discussions, researchers introduced different scenarios and technologies to the participants and asked them for their reaction to each different situation. Through this process, it was determined that there are several key issues that need to be addressed with regard to the handling of pedestrians in a temporary traffic control area. First, advance warning for pedestrians is critical, particularly to mobility impaired pedestrians as their access may be compromised as they approach a work area (i.e., a wheelchair ramp may not be available or enough room may not be provided for them to adequately maneuver around the situation). Also, many comments were made throughout the discussions that pedestrian signage related to work zones should be orange with black text to ensure that pedestrians recognize these signs as part of a work zone situation. Information that was specifically mentioned as desirable

by the participants as part of advance warning of work areas was the distance to a closure and what action a pedestrian should take. Also, the discussions indicated that although advance signing is desirable, there are credibility issues for the responsible agency if the work is not visible from the location where the pedestrian encounters the signs (i.e., if the pedestrian can not see work ahead they are not likely to react to the signs).

Another concern identified by the groups was the need for a greater separation of pedestrians from the active work areas. Ideally for pedestrians, participants believed that all work areas should be barrier separated from the pedestrian access way. A common element that was suggested was the use of orange plastic barrier fencing as the simplest effective means of separating pedestrians from the work areas. To the participants, this provided a "solid" barrier that they knew should not be crossed and provided a clear message to pedestrians.

The duration of work was discussed to determine if the public thought this was a factor in the amount of information required for pedestrians. Overall, duration was not considered to be a key factor in information needs by the participants. However, the participants indicated that, in an active work area where workers are present, they believed pedestrians required less advisory information. They also suggested that in short duration situations, a flagger could be used to inform pedestrians of where they should be walking.

Finally, the visually impaired participants had some key issues that were not discussed in the other groups. Primarily, they were concerned with the detection and identification of a work area. The group stated that in general they would like more information about the upcoming conditions and more protection from the active work areas. Also, they had a major concern that the noise generated at work areas would overwhelm the traffic noise making it impossible for them to assess traffic conditions and cross streets. One element that was discussed at length for this group was the use of audio information to provide advance warning of a situation. Again, the group was concerned about this added noise level and its impacts on assessing traffic conditions; however, they did feel that the information provided would be helpful to them in making decisions. They thought the best application of this technology would be in advance of a crossing to provide alternate route information and to let them know what action they should take. It should be noted that audio technologies were also discussed with the other groups and that they believed this would be helpful to all pedestrians in obtaining alternate route information.

Based on these results, researchers conducted human factors studies described in the next two chapters of this report. The first activity was to study different advanced warning signs that could be used to provide information to pedestrians in temporary traffic control situations. The second task will be to further investigate what information should be included in audio messages if they are used in temporary traffic control as assistance for visually impaired pedestrians.

8. PEDESTRIAN SIGNING EVALUATION

Researchers conducted human factors studies to evaluate different sidewalk closed signs that could be used to provide information to pedestrians when work zones are near or in sidewalk areas. The results of the focus group, along with input from other state departments of transportation and major cities inside and outside of Texas, were used as a basis for the experimental design of this study.

During this study, researchers evaluated several specific features identified during the studies discussed earlier in this report. These included:

- shape (rectangle versus diamond),
- color (white versus orange),
- symbol use (text directions versus symbol, arrows versus no arrows),
- action phrasing ("Cross Here" versus "Use Other Side," required alternate route wording), and
- distance wording (measured distance versus landmarks).

STUDY DESIGN

Study Instruments

The primary objective of the human factors study was to gauge general public interpretation and comprehension regarding current and innovative signs for use in guiding pedestrians in and around work zone areas. The study was conducted looking at the signs from two different perspectives: a driver and a pedestrian. The driver's perspective study was divided into two sections: comprehension and comparison. The pedestrian's survey also included a third section focusing on evaluating wording of various phrases to be used on pedestrian signs.

In the pedestrian's survey researchers evaluated a total of eight advance signs. Each participant saw three advance signs and gave their interpretation. They did not evaluate all of the signs due to time constraints in administering the survey. Additionally, they saw other signs or alternate elements in five comparisons and the three wording option evaluations. The driver's survey included a total of five signs in the comprehension section with each participant viewing three of these signs (again, due to time constraints). They also viewed three comparison

questions that compared design features to determine if they thought elements like color or shape had different meanings.

There was a total of six surveys used in each selected city. Four of these were for the pedestrian's perspective and two were for the driver's perspective. The different versions of the survey were created because not all of the signs were included in each version of the survey due to time constraints in the survey administration. Appendix A lists examples of the study instruments for each survey.

The eight signs evaluated are shown in Figure 24; note that only five of these were used for the driver's perspective survey. Also included in this figure is the number of participants who viewed each sign for the pedestrian study and for the driver study when appropriate. The numbers vary due to the randomization of the signs assigned to each version of the survey. Some of the signs were viewed more often because there were less alternatives being examined within their design category (such as white signs or symbol signs). The intended meaning of the signs are all the same; the sidewalk ahead is closed, and pedestrians are to cross the street at the location of the sign.

Study Locations

Researchers conducted the studies in the following six cities in Texas: Dallas, Houston, Laredo, Paris, San Antonio, and Waco. These cities were selected to provide a geographical range in Texas. Study participants were approached at random through direct person-to-person contact at various Texas Department of Public Safety drivers licensing offices in the selected cities.

 **Sign 1** **Pedestrian: n = 85** **Driver: n = 333**	 **Sign 2** **Pedestrian: n = 85**
 **Sign 3** **Pedestrian: n = 83**	 **Sign 4** **Pedestrian: n = 82**
 **Sign 5** **Pedestrian: n = 167** **Driver: n = 167**	 **Sign 5a** **Pedestrian: n = 168** **Driver: n = 166**
 **Sign 6** **Pedestrian: n = 167** **Driver: n = 167**	 **Sign 6a** **Pedestrian: n = 168** **Driver: n = 166**

Figure 24. Pedestrian Signing Alternatives.

Demographics

The research team recruited a total of 668 participants in the six selected cities. There were 120 participants in each Dallas, Houston, San Antonio, and Waco. However, due to fewer individuals in the Laredo and Paris Department of Public Safety drivers licensing offices, the research team was only able to recruit 103 and 85 participants, respectively. The only criterion for the participants recruited was that they be over the age of 18. While there was no initial quota for demographics, researchers did attempt to select a sample of pedestrians based on a demographic sample of the population of Texas with regard to gender, age, and education level. Table 5 shows the actual demographics of the participants with the desired percentages for each group specified in the row "2001 Texas License Data." Overall, the sample did approximate the Texas driver demographics reasonably well, with the study sample being only slightly younger and slightly more educated than the statewide driving population.

Table 5. Participant Demographics.

	Gender		Age				Education			
	M	**F**	**< 25**	**26-39**	**40-54**	**55+**	**< HS**	**HS Grad**	**Some College**	**College Grad**
Study Sample	45%	55%	23%	35%	29%	13%	10%	27%	36%	27%
2001 Texas License Data	50%	50%	15%	32%	29%	24%	24%	25%	27%	24%

Note: HS = High School

In addition to obtaining their gender, age category, and last level of education completed, the participants were also asked two questions regarding how often they walk on a sidewalk and what percent of this time is spent in or near a work zone. From the information collected it was determined that the participants had little real-world experience walking in or near work zones. The responses varied from "never" to "everyday" on how often the participants walked on a sidewalk or near a road; however, 75 percent stated they walked on sidewalks once a month or more. With regard to walking in work zones, 40 percent of the participants stated that they had never walked in or near a work zone area. Researchers believe that the range of sidewalk use and work zone exposure of the participants will help to ensure that the results of this survey are well understood by all users, including those unfamiliar with pedestrian signage.

Study Protocol

Participants were told to assume they were either a pedestrian or driver (depending on which survey was being conducted) when they viewed the signs in the survey. In the comprehension section of the surveys, the signs were displayed using a laptop computer where the test sign was embedded into a real-world picture from either the pedestrian or driver point of view. This was done to give the participants a more realistic visual approach to the signs. Each participant could view the sign for as long as they felt they needed to; however, the picture was taken off the screen prior to researchers asking questions regarding comprehension. The researchers followed up by asking if they would improve anything about the sign.

In the comparisons portion of the survey, the participants viewed two similar signs shown side-by-side; the signs stayed on the screen while researchers asked several questions about the signs to determine their preference and understanding of the signs. Part three was only in the pedestrian survey. In this section several different phrases were given to each participant, and researchers asked their preference related to their use for alternate pedestrian routing or distance measurements.

Data Analysis

Data analysis was divided into sections according to the perspectives (pedestrian or driver) evaluated in this study. The initial phase of the analysis was to determine participant comprehension of the signs. Researchers used a standard understanding level of 85 percent as the baseline criteria for a sign being within an acceptable comprehension level for use in the field. Additionally, researchers performed confidence interval tests ($\alpha = 0.05$) and a Bernoulli test of proportions to determine if the identified differences both from 85 percent and between two comprehension levels were statistically significant.

RESULTS

Pedestrian Perspective

Sign Interpretation

The initial evaluation that was conducted for the study signs was to determine how pedestrians would interpret the information provided for the given situation. This study was conducted to ensure that pedestrians could quickly interpret the given sign and use the information to effectively travel to their destination. Table 6 shows how participants interpreted the given sign.

Signs 1, 2, and 3 ("Use Other Side" with arrow, "Use Other Side" without arrow, and "Cross Here" with arrow) had the best results with 94 percent of the participants correctly interpreting each of these signs. Signs 6 and 6a (symbol signs) had the lowest comprehension levels at 80 and 74 percent, respectively. Researchers believe that the lack of wording regarding what action should be taken was confusing to many of the participants. In addition, the arrow included on these signs without routing directions influenced participants to believe that the opposite sidewalk may be closed and had them doubting what route they should take. This would imply that the inclusion of an action phrase with the arrow (such as in sign 3) is critical to ensuring that pedestrians can use the provided information.

All of the signs except 6 and 6a have a comprehension percentage that is over 85 percent. Additionally, sign 6 is not statistically different from this comprehension level based on a confidence interval test. A test of proportions was also used to determine if the lower percentage signs were statistically different than signs 1, 2, and 3 (which were the best understood). From this test, researchers determined that signs 6 and 6a are significantly different than the best comprehension level. Based on this analysis it is not recommended that either of these signs be used in the field.

Table 6. Pedestrian Interpretation.

Sign Options	Interpretation Percentages					
	Sidewalk Closed and Cross Road	Opposite Sidewalk Closed	Crosswalk Closed	Sidewalk Closed – Don't know what route to take	Do Not Know	Other
Sign 1 	94 %		2 %		2 %	2 %
Sign 2 	94 %		2 %	2 %	2 %	
Sign 3 	94 %	1 %	1 %	4 %		
Sign 4 	89 %	1 %	1 %	6 %	1 %	2 %
Sign 5 	87 %	5 %	5 %	2 %		1 %
Sign 5a 	89 %	4 %	4 %	2 %	1 %	
Sign 6 	80 %[a]	9 %	2 %	7 %	2 %	
Sign 6a 	74 %[b]	8 %	4 %	11 %	1 %	2 %

[a] is statistically different from highest comprehension level

[b] is statistically different from highest comprehension level and 85 percent

Action

The second component of having a sign that will be effective in the field is to identify if pedestrians will take the desired actions (e.g., cross the street) based on the information they gain from the sign. Table 7 shows the responses of pedestrians who correctly interpreted the signs to determine what action people would take if the sign was understood.

From this information, it can be seen that once people understand the sign, there is a very high level of compliance with the direction or implied action to cross the street. However, two signs (Signs 4 and 6) showed much lower levels of appropriate action than the others. These signs have some fairly obvious flaws that would make them less understood than others with regard to what action a pedestrian should take. With Sign 4, there is no directional arrow provided with the instruction "Cross Here" to assist people in understanding where they should cross. Consequently, a significant number of the participants, 17 percent, indicated that they would continue ahead on their original sidewalk.

For both Signs 6 and 6a, it was noted in the previous section that these signs had lower levels of understanding. Although 6a was found to have an acceptable level of compliance, this may be due to the much lower number of participants represented since researchers are only examining participant's actions if they correctly interpreted the sign. However, for Sign 6 the correct action indication was very low indicating to researchers that not including suggested directions with the pedestrian symbol and arrow did not provide an acceptable level of information for people to decide what action they should take. In this case the incorrect responses were split mainly between people who would find a different route entirely and those who would continue straight. One additional difference between these signs was the color. From results that will be discussed later in this chapter, researchers believe that some of the increased compliance with Sign 6a over Sign 6 is due to the orange color. Participants indicated in later questions that orange was a more attention getting sign and a color that must be complied with.

Table 7. Pedestrian Actions.

Sign Options	Interpretation Percentages				
	Cross Street	Continue Straight	Take a Different Alternate Route	Do Not Know	Other
 Sign 1	85% [a]	11%	4%		
 Sign 2	91%	3%	5%		1%
 Sign 3	95%	3%	1%		1%
 Sign 4	75% [a]	17%		7%	1%
 Sign 5	88%	8%	4%		
 Sign 5a	93%	2%	4%		1%
 Sign 6	81% [a]	9%	8%	2%	
 Sign 6a	91%	4%	3%		2%

[a] is statistically different from highest level

All of the other signs had very high levels of compliance, indicating that if the comprehension levels are sufficient, agencies should expect to see very good compliance with the directions indicated. For this analysis, it was found that Sign 3 had the highest level of compliance in pedestrian action; however, this number was not statistically different than any of the other levels except for Signs 1, 4, and 6 based on a test of proportions. This would indicate that if compliance was being used as a deciding factor for the selection of signs, any of Signs 2, 3, 5, 5a, or 6a would be acceptable. However, the recommendations from this report will be based on multiple deciding factors (not least of all the comprehension levels discussed previously).

One final design change that should be noted is the development of signs that include action phrases without the inclusion of arrows. In this case, it was shown that the phrase "Use Other Side" had higher levels of compliance than "Cross Here" when an arrow was eliminated.

"Use Other Side" versus "Cross Here"

There are several specific design variations within these signs that researchers were explicitly evaluating to determine which would be better for use. First, wording of the action term was evaluated, considering whether it would be better to use "Cross Here" or "Use Other Side" within pedestrian signing. Researchers found that, when an arrow was included on the sign, there was very little interpretation difference between the two phrases. The "Cross Here" sign had a higher number of participants who stated they would follow the given action. However, closer analysis of the responses for the "Use Other Side" sign showed that the greatest number of people indicating that they would not cross the street were continuing straight because they did not see a problem ahead or they didn't feel that the absence of a sidewalk would influence their actions (they could walk in the grass), not because they didn't understand the given action. Given this interpretation, neither of these phrases is significantly better understood than the other when an arrow is included. However, when an arrow is not included on the sign, "Use Other Side" was much better understood and complied with than "Cross Here." Again, the actions stated for the "Cross Here" sign were primarily to continue ahead; however, in this case it was not as clear that people were just ignoring the sign, but that they were unsure of their route choices.

Signs 2 and 4 ("Cross Here" and "Use Other Side" without an arrow) were also evaluated in a direct comparison of preference. For this analysis, it was found that the participants were split with regard to which phrase they preferred (51 and 49 percent, respectively). In both cases, the participants who preferred the option thought that that form of the instruction was more descriptive or clear as to what action they should take. This comparison does not reveal a distinct observation as to which phrase should be used based on preference; therefore, comprehension should be used for this decision. In that case, the findings imply that "Use Other Side" is more intuitively understood by pedestrians.

Arrow versus No Arrow

The general difficulty with the use of arrows for sidewalk closed messages is that pedestrians can interpret these to be directed at the sidewalk that is closed and not at the route they should take. In this case, the interpretation of both signs with or without arrows was relatively similar; however, there were some differences with regard to the participants' described actions. In the case of the arrow and non-arrow versions of the sign that had "Use Other Side" as the directions, there was not a statistically significant difference in the actions people would take. However, it was noted that more people chose to disregard the sign with the arrow than without implying that it did not improve people's willingness to comply. Conversely, the signs that contained the phrase "Cross Here" as direction found a significantly better compliance when an arrow was included on the sign. For the people who did not comply with the non-arrow sign, the majority of the participants indicated that either they did not know what action they should take or that there was no direction given as to where they should cross. This analysis would imply that the need for an arrow is directly tied to the phrasing used on the sign. In cases where "Cross Here" is the desirable phrasing, an arrow must be used; however, in the case of "Use Other Side" the arrow does not improve signing interpretation.

However, a direct comparison of preference was also performed using Signs 1 and 2 ("Use Other Side" with and without an arrow) for the evaluation. In this case, 95 percent of the participants indicated that they preferred the sign with the arrow. Based on their preference, the participants stated that they believed the inclusion of the arrow gave them more direction as to what action they should take. Nevertheless, this indication of better direction was not reflected

in the interpretation portion of the survey. Therefore, researchers would not suggest that the arrow would be required with this phrasing.

Words versus Symbols

An additional format of sign that was evaluated included the use of a symbol (Signs 6 and 6a) versus traditional wording as a means of indicating what action the participant should take. Given interpretation of both Signs 6 and 6a as compared to the other signs evaluated, the symbol was not as well understood as the traditional wording. Looking back at Table 6, when the action direction was removed to include the symbol, pedestrians more often stated that the sign provided them the information that the sidewalk was closed but did not tell them a different route to take. Also, participants had a higher rate of confusion that the arrow was pointing to the closed sidewalk instead of the direction they should travel than for the traditional text signs.

For a direct comparison of these features, researchers used Signs 5 and 6 (white versions of the traditional and symbol signs). Within this comparison, only 27 percent of the participants stated that the signs had different meanings when asked. Most of these participants believed that Sign 6 did not provide them with an action to be followed. However, 62 percent of the participants indicated a preference for the symbol sign format. These people stated that they liked the symbol because it was recognizable. Unfortunately, again the participant preference is in direct conflict with the observed results of the interpretation portion of this study. Some of this could be due to the fact that although people indicated that they liked the pedestrian sign, they did not understand that it was intended to provide them with a direction or route to follow based on the given arrow and therefore did not fully understand the intended meaning. This may indicate that if the symbol was incorporated differently such that the action required was more obvious (i.e., inclusion of action text) the sign may have been better understood as well as preferred by the participants.

Color

Currently, pedestrians signs included in the MUTCD are primarily white with black text. However, based on the focus group results, researchers had reason to believe that a change to orange signs with black text may inspire a better understanding and particularly compliance based on the fact that orange is an identifiable color for work zones. For this study, both colors were used to identify if participants interpreted the intended meaning of the signs differently

based on color or if they thought one color was more likely to have them comply with the suggested action. For this analysis, participants interpreted two different signs with both white and orange coloring (Signs 5/5a and 6/6a).

For these given sign pairs, researchers did not find a significant difference in the interpretation of the signs; however, when the participants' perceived actions are evaluated, there is an increase for the compliance levels of both the orange signs over their white alternatives. In both cases, participants were more likely to identify the intended action (cross the street) for the sign when it was presented as an orange sign versus a white sign. This finding is particularly significant when looking at some of the direct comparison information for this sign feature. Researchers asked participants which color would imply that they were breaking the law if they disobeyed the instruction given. Sixty-six percent of participants stated that orange was the color that implied they were breaking the law. Figure 25 below shows the breakdown of responses for this question.

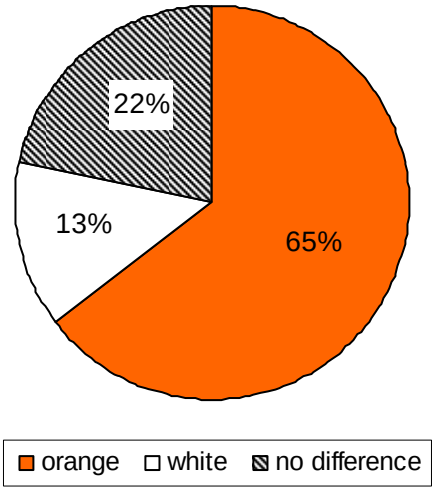


Figure 25. Interpretation of Regulatory Nature Based on Color.

Shape

The final aspect of the signs that researchers were trying to directly evaluate was what effect shape has on driver interpretation or reaction to signs. Again, this evaluation was based on focus group results indicating the participants believed the signs for pedestrians should be shaped as diamonds (much the same as most signs directed at motorists in work zones). Therefore, this survey included both rectangular- and diamond-shaped signs to evaluate if there was a difference

in how they were interpreted. Interestingly, the difference in the interpretations was not statistically significant. Similarly, although there was a small difference in the actions stated by the participants, it was not significant. This would imply that the shape of the sign did not overly influence the interpretations of motorist but were based on other factors of the study signs.

Additionally, within the direct comparisons of these signs 90 percent of the participants did not believe that there was a difference in the meanings of the two signs. This supports their interpretations given in the comprehension portion of the study. Therefore, shape should not be a deciding factor in the design of pedestrian signage with regard to whether or not the information will be understood by the user.

Wording Alternatives

Researchers included a final section to the pedestrian perspective survey that looked specifically at different options related to alternate route and distance wording. Researchers wanted to identify how pedestrians perceive different wording that could be used in the field.

For the alternate route wording, researchers looked at a group of five terms to evaluate if pedestrians believed they were required to use a different route to reach their destination. These terms were:

- Detour,
- Alternate Route,
- Alternate Path,
- Cross Here, and
- Use Other Side.

Participants selected as many of these options as they believed applied. Table 8 shows what percentage of participants selected each option.

Table 8. Percent Selecting Alternate Route Options.

Options	Percent
Detour	87
Alternate Route	64
Alternate Path	52
Cross Here	43
Use Other Side	62

For this evaluation, researchers found that "detour" was the most common response with 87 percent of the participants selecting it to mean they were required to use a different route. This was followed by "alternate route" (64 percent) and "use other side" (62 percent). However these were significantly lower than "detour" with regard to the number of responses. The lowest percentage selecting an option was for cross here. Indicating that cross here is largely believed to be a suggestion to pedestrians.

Lastly, based on focus group suggestions, researchers investigated different ways to provide information to pedestrians regarding how far ahead a temporary traffic control area is located from their current location. Figure 26 illustrates the sign that was shown to participants when they were asked to identify what information should be included in the blank where the "?" was located.

Figure 26. Distance Question Sign.

They were given four alternatives to select from for this task, two giving landmark points and two giving distances. Table 9 shows the results for which option participants felt would be best to include on the sign.

Table 9. Percent Selecting Distance Alternatives.

Categories	Options	Option %	Category Total %
Landmarks	After Green St	12	19
	Past McDonalds	7	
Distances	1 Block Ahead	44	81
	200 ft Ahead	37	

Researchers noted while administering the survey that most participants were assuming that they were unfamiliar with the area. Therefore, the landmark category options were less well received. For the distance category options, the preference was greater for "1 Block Ahead"; however, this was not statistically different than the "200 ft Ahead" option based on a test of proportions. For both cases, the participants who selected each option primarily indicated that it was easier to figure out how far it was. Based on these findings, researchers would suggest the use of distance references over landmarks for use in pedestrian signing based on user preference. As for the format of that distance, often this is determined more by the location than by preference. If there are regular blocks within the area, blocks would most likely garner the best results regarding pedestrian comprehension; however, when this is not true of a site, feet distances should be effective in communicating with pedestrians.

Sign Improvements

Following the interpretation of each sign, participants were asked what improvements they would suggest for the sign they had just viewed. The signs with the greatest number of suggestions offered were Signs 6 and 6a. In both of these cases, the most common improvement given by the participants (17 percent for each sign) was to indicate what action should be taken.

Sign 4 had the highest percentage of participants who selected a single improvement. Twenty-seven percent of the people suggested the addition of an arrow, echoing strongly the findings of the interpretation and actions for this sign where participants were having difficulty interpreting "Cross Here" without further guidance (i.e., an arrow). Sign 2, which also provides

an action (use other side) without an arrow direction, also had a suggested addition; however, it was at a much lower rate of 13 percent.

Other suggestions that were common across all of the signs were to add information as to why the sidewalk was closed or to clarify or add an action to take. Color suggestions were also commonly made for the signs; however, there was no clear consensus of what color to make these signs. White signs were suggested to be orange, and vice versa; additionally, a few participants suggested that signs should be yellow, green, or red.

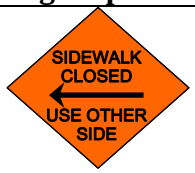
Driver Perspective

Researchers were greatly concerned that the innovative pedestrian signing being evaluated did not affect a motorist's ability to differentiate between signs that are intended for driving versus those intended for pedestrians. Most specifically, researchers were concerned about the incorporation of orange coloring into these signs and the use of the diamond shape which is typically used only in motorist signing in work zones. Also, researchers wanted to evaluate the wording "Use Other Side" to ensure that drivers could interpret this to mean pedestrians and not that they should change lanes. To this end, researchers developed a survey instrument to evaluate motorist understanding of different signing alternatives.

Sign Interpretation

The signs included in the interpretation evaluation for drivers were Signs 1, 5, 5a, 6, and 6a. This allowed researchers to analyze driver reaction to traditional signing (Sign 5), orange signing (Signs 1, 5a, and 6a), diamond shape (Sign 1), "Use Other Side" (Sign 1), and pedestrian symbol (Signs 6 and 6a). Table 10 shows the driver comprehension level for each of these signs that the sign was intended for pedestrians.

Table 10. Driver Understanding.

Sign Options	Intended for Pedestrians	Construction	Change Lanes	Stop	Don't Know
Sign 1 	95%	1%	3%		1%
Sign 5 	98%		1%	1%	
Sign 5a 	96%	1%	1%		2%
Sign 6 	100%				
Sign 6a 	98%		1%		1%

As shown in the table, all of the signs evaluated had very high levels of comprehension and very little confusion that they were intended for anything other than as pedestrian information. This indicates that none of the variables being examined (as outlined above) had an adverse impact on motorist understanding. Therefore, the design of pedestrian signs with relation to shape, color, text, or symbol can be based on the results of the pedestrian perspective survey.

Comparisons

To gain additional information regarding how motorists would interpret the sign variables, researchers conducted direct comparisons of shape, color, and symbol use to determine if these changes had different meanings. This was done by showing two signs side by side on

screen and having the participant give their interpretation of how the sign differences influenced the sign meaning.

Regarding shape, 84 percent of the participants did not believe there was a difference in the meaning of the signs based on their shapes. For the 16 percent who did believe that there was a difference, there were many different ideas as to what this difference meant. Primarily, they believed that the diamond sign was implying more caution/warning or that it was construction; whereas the rectangular sign was seen as strictly providing information. Since these differences were not such that they are endangering the motorist by giving them a false impression of the situation (and actually follow what would be intended with diamond meaning caution), it is not believed that a change in shape for pedestrian signs would have an impact on drivers. This echoes the results that would be expected based on the comprehension study mentioned earlier in this report.

The comparison of the difference between orange and white signs showed that 52 percent of the drivers did believe that the difference in color had different meanings. However, there was not a great deal of agreement as to what that difference would be. For the orange, the highest portion of participants stated that it would mean construction (16 percent) or caution/warning (19 percent). While for the white sign, participants believed it to be informational (6 percent) or a permanent sign (6 percent). Additionally, only 2 percent of the participants thought that the white sign would mean that it is a law or enforceable. Overall, participants were giving a greater significance to information provided on orange signs. This would imply that if agencies are looking for compliance with signs or for pedestrians and drivers to recognize that the problem ahead is related to a work zone, they would have better results with an orange sign.

The final comparison done looked at the use of a symbol versus providing text (Sign 6 versus 5). In this instance, 34 percent of the participants believed that there was a difference in what the signs mean. In this case, the greatest number of participants felt that Sign 5 provided them with specific actions to take (17 percent) whereas Sign 6 did not tell them what they needed to do (14 percent). This implies that using a symbol and arrow alone to represent what direction people should take may not be as effective as the use of text for this same information. However, drivers did not appear confused as to the fact that both signs were providing information to the pedestrian in this analysis.

RECOMMENDATIONS

During this survey, researchers evaluated several different design elements:

- shape (rectangle versus diamond),
- color (white versus orange),
- symbol use (text directions versus pedestrian symbol, arrows versus no arrows),
- action phrasing ("Cross Here" versus "Use Other Side," required alternate route wording), and
- distance wording (measured distance versus landmarks).

Based on the findings detailed above, researchers would recommend the signs in Figure 27 and Figure 28 to be used as closure and advance warning signs, respectively.

Figure 27. Recommended Sidewalk Closed Sign.

Figure 28. Recommended Advance Warning Sign.

These recommendations are based on the following key points from the analysis:

- It was found that none of the evaluated changes affected driver understanding that signs were intended only for pedestrians and did not require them to take specific driving actions.

- From the pedestrian perspective, the use of an orange background with black text for signs was found to garner a higher level of compliance from the pedestrians with regard to the actions they would take upon encountering the sign without adversely affecting their comprehension of the sign meaning.
- Shape had little to no impact on the interpretation of the sign; therefore, researchers are recommending continuing with a standard rectangular layout for the sidewalk closed signs.
- Action phrasing “Use Other Side” was found to be more intuitively understood by the participants and is therefore recommended for use as the better option when directing pedestrians to an alternate route across the street.
- The inclusion of a distance reference on the sign was found to be preferable to participants in the survey over the use of nearby landmarks. Therefore, researchers would recommend including “1 Block Ahead” on advance warning signs when there are regular blocks in the area as this would most likely garner the best results regarding comprehension of the distance. However, when blocks are not appropriate for the site, feet distances should be used to express the distance to the closure area.

9. VISUALLY IMPAIRED AUDIO MESSAGE STUDY

The MUTCD and the TMUTCD support the need for establishing guidelines on accommodating pedestrians in temporary traffic control areas (*3, 4*). The MUTCD outlines three basic items that should be considered:

- Pedestrians should not be led into conflicts with work site vehicles, equipment, and operations.
- Pedestrians should not be led into conflicts with vehicles moving through or around the work site.
- Pedestrians should be provided with a reasonably safe, convenient, and accessible path that replicates as nearly as practical the most desirable characteristics of the existing sidewalk or footpath. Where pedestrians who have visual disabilities encounter work sites that require them to cross the roadway to find an accessible route, instructions should be provided using an audible information device. Accessible pedestrian signals with accessible pedestrian detectors might be needed to enable pedestrians with visual disabilities to cross wide or heavily traveled roadways.

Although the guidance clearly states that speech messages and audio devices should be used whenever pedestrians with visual disabilities are anticipated, there is no guidance as to what information should be provided through the audio messages. To this end, researchers tested nine messages to identify key components or phrases that should be used within audio messages to provide visually impaired pedestrians with information regarding work zones that would affect their travel. Researchers investigated three different categories of messages:

- directions to negotiate an alternate route on opposite sidewalk,
- directions to negotiate an alternate route in the roadway, and
- warning only of events (the pedestrian can continue on route).

The design of the messages for this study was based on previous research that had been done regarding highway advisory radio (HAR) message design (*29, 30*). Researchers identified

several key issues in these documents that were incorporated into the design of messages for this study:

- Messages should be adjusted so that they are heard twice by the user.
- Language should be concise.
- Drivers can generally recall up to eight units of information in a message (only route information units, for example turns and street names, that would be used for navigation were counted in this number).
- Messages should include an attention statement, problem statement, a reason to follow directions, the action to take, and the location to take the action.

PHASE 1

Study Design

For each of the nine messages in this study, visually impaired participants listened to the test messages twice and were then asked questions regarding a) what action they would take based on the information provided and b) specific components included in the message, such as a suggested path to follow. Finally, after the participant had listened to and answered questions about each of the messages, they were asked some general questions about their impressions of the importance of the message elements and specific wording within the messages. Appendix B contains an example of the survey.

Participants

Study participants were recruited at the Criss Cole Rehabilitation Center in Austin, Texas. However, the residents at this center were from locations across Texas. They were staying at the center for educational purposes. All of the study participants were required to be visually impaired to participate in the study. There were a total of 50 participants recruited for this study. Table 11 shows the educational and age demographics.

Table 11. Demographic Information.

Age	No High School Diploma		High School Diploma		Some College		College Degree		Total
	Male	Female	Male	Female	Male	Female	Male	Female	
18 – 39	2	0	6	6	4	4	1	1	24
40 – 54	1	1	4	4	5	6	1	1	23
55+	0	0	0	0	0	1	1	1	3
Total	3	1	10	10	9	11	3	3	50

Additionally, researchers recorded data regarding how long the participant had been visually impaired. Within the study, 36 percent of the participants had been visually impaired since birth or early childhood. Conversely, 36 percent had lost their sight fairly recently (within the last five years). The final 28 percent had become visually impaired some time during their teen or adult years but had had a significant number of years living as a visually impaired person. This information is significant in that the participant group had a good mix of experience levels with navigating as a visually impaired pedestrian.

Data Analysis

Alternate Route on Opposite Sidewalk

Researchers evaluated five messages in this category. These messages and the equivalent units of information are listed below. Researchers identified the number of units of information in each message based on highway advisory radio message design principles as outlined in previous research by Huchingson, Dudek, and Dorsey (*29*).

M1: (7 units of information)

Attention northbound Clark Ave. pedestrians. Sidewalk Closed. To avoid closed area, cross Clark Ave. at next intersection. Turn right and continue 6 blocks on opposite side of street. Return to original side of street if desired.

M2: (5 units of information)

Attention eastbound Orchard Rd. pedestrians. Construction ahead. To avoid construction area, cross at Green Street and turn left. Continue on opposite side of street for the next ½ mile.

M4: (10 units of information)

Attention westbound College Dr. pedestrians. Sidewalk closed. Alternate path, cross College Dr. at Elm Rd. Turn right and continue past 4 intersections to Terrace Dr. Turn right to cross College Dr. and return to north side of the road.

M5: (9 units of information)

Attention eastbound Brady Street pedestrians. Sidewalk closed. Detour turn left at 2nd Avenue. Turn right and proceed past 3 cross streets to Quarter Street. If desired, turn right and cross Brady Street to original side.

M6: (8 units of information)

Attention northbound Carolina Avenue pedestrians. Construction area ahead. Alternate route turn left at Legend Street. Turn right on opposite sidewalk and proceed past 3 streets to Palm Drive. Return to original sidewalk.

The first part of the analysis done on this information was to determine if participants were able to understand the intent of the message. Table 12 shows the number of participants who understood that they were being instructed to use a sidewalk on the opposite side of the street. These numbers are based on an overall interpretation of the responses given for the action they would take based on the message and their ability to recall the path suggested.

Table 12. Alternate Route on Opposite Sidewalk Comprehension.

Message	Units of Information	# Correct	Percent Correct
M1	7	36	72%
M2	5	29	58%
M4	10	19	38%
M5	9	18	36%
M6	7	25	50%

Looking at the information provided in each of the messages as compared to the ability of the participants to identify the intended path, there are a few key components that can be identified within the test messages. First, it is critical that the message clearly state that the path

will lead them to the sidewalk on the opposite side of the street. When this was not plainly stated within the message (messages M4 and M5), there was greater confusion as to where the path was leading. For these messages, researchers noted that a significant number of participants believed it might be instructing them to travel around a block or to a different parallel street.

Also, the use of blocks or intersections as an identifier of distance was much better received by the participants than the use of either feet or miles for distance identification. Researchers noticed that when the miles reference was used in the message (i.e., message M2), the overall understanding of the message was lower. This occurred even though the number of units of information in the message was estimated to be the lowest of this group (five units total). From this finding, researchers believe that this unfamiliar or difficult distance reference may have "distracted" the participant from the other information provided in the message and therefore adversely affected the overall understanding. When looking at information the participants remembered from this message, 80 percent of the participants were able to identify that a distance had been given in miles.

One of the most significant findings of this study is that although participants were not always able to understand the message, most of the responses indicated that they would try and follow the suggested route. Table 13 shows for each message the percentage of people who indicated that the action they would take was to follow the route suggested in the message.

Table 13. Action Stated – Follow Suggested Path.

Message	Percent – Follow Suggested Path
M1	94%
M2	74%
M4	66%
M5	84%
M6	80%

The most common reasons given by the participants for taking the action of "following the suggested path" were that the sidewalk was closed or it would avoid the construction, that the directions were clear or simple to follow, and that the given path would lead them back to their destination.

It can be seen that message M4 had the lowest number of people that indicated they would follow the suggested path. It should be noted that this was the message with the highest

number of units of information. In general, it appeared that people were so overwhelmed with the information that they would not even try to follow the directions given.

Of the participants who would not follow the suggested path, the most common reasons given were that the directions were confusing or that there was too much information provided in the message. This suggests that, had the message been clearer or better understood, a greater percentage of the participants would have desired to follow a designated route for the situation. This speaks directly to the importance of designing a clear and concise message to relate the needed information about the work zone through audio messages.

Part of the analysis of pedestrian understanding of the messages included a breakdown of what units of information they could remember from the given path. This also allowed researchers to begin to determine how many units of information a person can remember when traveling as a pedestrian. When looking specifically at what components of the messages were best understood or remembered, researchers found that the initial instruction (either to cross or turn left) and the distance they would have to travel on that alternate path were the most commonly recalled elements of the message. Researchers believe this has a direct correlation to what information the participant found to be most valuable to them as they are trying to follow the alternate route to their destination.

For most of the messages, the lowest percentage element to be remembered was the street names or locations given. Researchers believe this is a result of the street names being unfamiliar locations to the participants and therefore of very little use to a visually impaired pedestrian in navigating the route as they could not easily identify an unfamiliar street while traveling. Phase 2 of this study will examine routes that are familiar to the pedestrian and try to identify if familiar locations or street names within the message take on a more important function to the participants and are therefore better remembered.

Because of the nature of the messages as preliminary design considerations it will be difficult to find a definite number of units of information that should be used based on this analysis. In many cases the participant gave back the essence of the message (walk on other side) without giving the specific turns they needed to take or street names. However, researchers do believe that the number of units of information will be lower than expected from HAR guidelines which were used as the basis for the preliminary message design. Some of this

could be related to the fact that the messages were using unfamiliar locations and therefore unfamiliar street names within this study.

Overall, the majority of the participants did not have suggestions to make for changes to the messages. However, of the people who did make suggestions one of the primary problems was how distance to travel was specified. There was a variety of suggestions that were very contradictory for use in the messages. Street names or blocks were suggested most commonly, depending on what information was already included in the message. It would appear that the use of both of these indicators was the best received option, such as was done in Message 4; however, when the comprehension was evaluated for this message only 10 percent of the people recalled the street name while 54 percent recalled the number of blocks to travel. In general, it would appear that the use of street names as indicators is still a factor of the person's familiarity with the area in which they are traveling.

The second common issue that was raised for change in the messages was that the messages were too long or the directions were unclear. With regard to this problem, researchers are attempting to use the revision suggestions made by different participants, such as "just say use opposite side," to revise the messages. Most of these suggested messages included simpler forms of "use opposite side" and directions on where to cross without as many left or right turn directions and more use of cardinal directions in the message.

Alternate Route in Roadway

One message was evaluated in this category. Originally, researchers had included this in a broader category of alternate route messages, but ultimately decided that it deserved a separate analysis as there was a significantly different response to this message than for the other alternate route messages. For this case, the message informed the pedestrian that they would need to travel on a temporary path which had been established in a closed travel lane. Below is the exact message used which had seven units of information:

> *<u>M3 (7 units of information):</u>*
> *Attention Southbound Maple Ave. pedestrians. Work area ahead. Alternate path in roadway to left begins in 200 feet. Edge of pathway has construction barrels. Alternate path ends after 300 feet.*

Only 10 percent of the subjects understood from this message that the pedestrian would need to walk in the roadway. Researchers believe that this may be due to the fact that this action is significantly different than "typical" pedestrian travel behavior (i.e., they would not choose to walk in the street). Consequently, there is a need to improve the information provided in this type of message to overcome this natural aversion by pedestrians. When components of the message were analyzed individually, the "in roadway" portion of the message had a recall rate of only 4 percent.

Despite not actually comprehending where exactly they were being instructed to travel, it is interesting to note that 60 percent of the participants still indicated that they would "use the given alternate path" when asked what action they would take (even though they did not remember or understand the instructions for the path). Obviously, visually impaired pedestrians strongly desire accurate and credible guidance information when they are being instructed to violate typical travel path expectancies. Additional analysis is still needed to determine how to improve this type of information to such pedestrians.

Participants did indicate that the use of "feet" as a distance indicator was distracting to them. When asked what they would change about the message, 21 participants (42 percent) gave suggestions that would eliminate the need to navigate using feet measurements. Interestingly, participants indicated a preference for other navigational cues such as using landmarks, block information, or street names. Still, it was the distance (feet) measurements and that there were barrels at the edge of the path that were recalled by the greatest percent of participants (recall rates were still below 50 percent). The recall of the distance measurements without understanding of the general instructions adds to the idea that this information was distracting within the overall message for the participants. The distraction is believed to be because of the difficulty in judging feet distance for a visually impaired pedestrian. Also, the analysis would suggest that the use of specific landmarks on the route, such as the barrels along the edge of the path, was considered to be part of the critical information for navigation, since it had better recall than other elements such as turn directions or that the path was in the roadway.

Warning Messages

Three messages were evaluated that looked at information that could be provided to pedestrians when they can still continue ahead on the same path, but that there is a work zone

that may disrupt the expected elements within that path. The elements that were used in the messages were: loud noises, construction activity near path, uneven path, and step down information. The messages also included elements specific to the temporary traffic control situation, such as the presence of barriers (fencing or barrels) and location of the work activity. The messages used in this portion of the study and the equivalent units of information are listed below:

M7: (5 units of information)

Attention eastbound Military Rd. pedestrians. Construction area ahead. College Ave. to Texas Ave. Construction activity will be between walking path and traffic lanes. Use caution.

M8: (6 units of information)

Attention northbound Turtle Ave. pedestrians. Road work ahead. Loud noises possible Hollow St. to Georgia Dr. Work area is on your left and is separated by traffic barrels.

M9: (9 units of information)

Attention southbound Main St. pedestrians. Approaching construction area. Uneven path ahead. Step down required in 100 feet. Walkway separated from work area by plastic fence on left. Paved surface begins again after Village Dr.

Table 14 shows the comprehension of participants that they could continue on the path ahead, but the message was providing them with additional information regarding work activity. These numbers are based on an overall interpretation of the responses given for the action they would take and what information the message was providing them about the situation.

Table 14. Comprehension that Pedestrian Could Continue on Path.

Message	Units of Information	# correct	Percent Correct
M7	5	33	66
M8	6	36	72
M9	9	41	82

Looking at the information provided in each of the messages as compared to the ability of the participants to identify that the path ahead was still accessible, there are a few key components that can be identified. The more specific the information was regarding the path ahead (either how it was separated or obstructions to expect), the more likely participants were to identify that they could continue if desired. Of the people who did not interpret the message to mean that they could continue, the most common response was that they would avoid the construction or difficult conditions ahead. This would imply that although they did not correctly interpret the information as being able to continue through the area, they were using the message warning as a means to make route decisions. This interpretation may be particularly true in message M8 where the pedestrian was provided with a warning of loud noises in the area. For this circumstance, it is understandable that a visually impaired pedestrian would interpret this information as meaning that they should not continue, since their navigational cues (i.e., the sound of traffic) would be obstructed, and therefore the path would be difficult to continue on.

When analysis was conducted to determine what types of information were most commonly remembered about the situation ahead, details or instructions were identified most often by the participants. Within the first message, the most easily remembered element of the message was the instruction to "use caution," while in the second message it was an indication that pedestrians should expect "loud noises." Finally, the third message had two components remembered by a significant number of participants. These elements were that the path was uneven, and that there would be a step down. Again, these were elements that visually impaired pedestrians would find critical when making route decisions as they would directly impact their travel ability. The least recalled elements within these warning messages were the street names in the final two messages. In message M7, the least remembered component was that the construction would be between the walking path and the traffic lanes (30 percent). It is also significant to note that several participants misinterpreted this information as indicating that the construction was on or disrupting both the sidewalk and the traffic lanes. This implies that great care needs to be taken to be clear as to what path is accessible at all times.

Overall, the analysis indicates a need within warning messages to be more concise in the information provided. This is particularly true for the walking path, noting that it is clear or available for use. Without this information, people assumed that the path was not accessible, and the area should be avoided. Although it may be the desired action of a visually impaired

pedestrian to avoid these areas, they should not be led to believe that this is a required action when a path is available. Encouraging an incorrect assumption such as this could lead to issues with user confidence in the messages if they are continually interpreting them to mean that the path is inaccessible when it is not. In cases where it is possible for a pedestrian to continue on the same route, it appears that the information must be very specific if provided for additional warning of particular path obstacles (such as steps or noise levels).

Finally, researchers asked participants what changes they would make to the warning messages to improve the information provided. There were several changes that were common across the three messages. The first of these is that an alternate route should be suggested for participants to use. This could be a direct relation to the fact that it was not always understood that the path ahead was clear and they could continue. Alternately, it was suggested by a couple of the participants that information should be given that the sidewalk is clear and/or that they could continue. In this message set, this information may be more valuable as a means of clarifying the intent of the message and may have changed the idea that an alternate path was needed. This assumption should be checked in Phase 2 of the study.

The second recommended change that was common to all of the messages was to shorten the messages and make them less detailed. Although the details seemed to help the pedestrian in identifying that the path was open, many participants considered it difficult to remember all of this information. This suggestion relates directly to the idea that messages should be succinct and only provide information that is critical to pedestrians' navigation through the work area. This again points to a need to determine the number of units of information that can be remembered by a visually impaired pedestrian in this audio format.

Thirdly, participants indicated that distances should be given in blocks or based on landmarks. In message M9, this was particularly a problem because it used feet to describe the location of the different conditions. Participants repeatedly indicated that they could not identify the number of feet they had traveled. Other suggested distance considerations were the length of the temporary traffic control area (in blocks) and designating specific points by landmarks that could be identified through cane use and/or familiarity with the area.

Overall Preference Questions

After the participants had listened to all of the messages and responded to the related questions, researchers asked them to identify the most important information included in that message and why it was important. The items that were commonly given as being most important were:

- alternate route information (32 participants),
- obstacle descriptions (15 participants),
- construction description or closed path (7 participants), and
- construction location (5 participants).

Primarily, participants gave their reason for these items as helping them in making route decisions or reaching their destination safely.

Also, the participant was asked to identify if there was any information that was given in the messages that was not needed or if there was information that was missing. Overall, 30 percent of the participants felt unnecessary information was included in the messages. Most commonly given responses to this question were: step downs (4 participants), distance in feet (4 participants), and street names (3 participants). There were many different items that were mentioned as possibilities to include in the message, the most common of these were: clearer or more detailed directions (5 participants), type of construction (4 participants), obstacles in or near path (4 participants), construction location (3 participants), and cardinal directions (3 participants).

Alternate Route versus Detour Researchers also evaluated several specific phrase components directly. First, researchers asked participants if they believed there was a difference between the phrases "alternate route" and "detour." Sixty-six percent of the participants did not believe there was a difference between these two phrases. However, of the 34 percent who did see a difference, there was no clear consensus as to the different meanings. Most commonly, the participants related the difference to either 1) the route was specific versus undefined, or 2) how far out of their original path they would have to go. However, even within these categories there is no agreement as to which option has which meaning.

Distance Descriptions Next, researchers attempted to identify what form of distance description was best or easiest for the pedestrian to use. Overall, participants liked the use of blocks (or intersections) best as a descriptor (56 percent). The second most-preferred option was street names (28 percent). Participants were also asked if their preference would be affected depending on whether it was a short versus long distance being described. Sixty-four percent of the participants believed that such a difference would affect their response. Of these people, Table 15 shows the number of participants who preferred the different short versus long distance descriptions.

Table 15. Description Preference for Short versus Long Distances.

Descriptions	Short Distance	Long Distance
Feet	15	0
Blocks	2	17
Paces	4	1
Street Names	3	8
Landmarks	1	1
Miles	0	3
Other	7	2

From Table 15, you can see that although the participants had previously stated they did not like the use of feet measurements, they did think that it could be useful for very short distances. Conversely, their preference for describing a longer distance would be to use blocks or intersections as reference points.

Use Caution The next series of questions posed to the participants related to the use of the phrase "use caution," and whether the inclusion of this phrase would affect the actions of the participants or would otherwise be helpful to them. The majority (96 percent) of the participants did believe that the statement "use caution" would affect their actions. Additionally, 94 percent of the participants also thought this type of warning statement would be helpful to them as they traveled. The most common responses given as to how this would affect their actions and to why it is helpful were:

- slow down,
- be more alert,

- be more careful,
- would know to expect different conditions, or
- use better cane skills when traveling.

Given that all of these actions would be desirable for visually impaired pedestrians traveling through a work zone area, the use of the phrase “use caution” would seem to be a good addition to these audio messages. Participants were also asked to identify other warning statements that they thought could be used to improve the audio messages. From this question the following statements were identified:

- identification of obstructions/holes,
- loud noises, and
- construction ahead.

All of this information had been included in the information that was used for the messages used in the study. It would appear that beyond what researchers had already identified for inclusion in this study, there would not be other warning statements that need to be investigated for use.

Cardinal Directions Finally, researchers questioned participants regarding the use of cardinal directions in messages. All of the participants thought that the use of cardinal directions in the initial audience identification statement (e.g. “northbound Wallace Ave. pedestrians”) did help them to determine if the message applied to their travel path. When further questioned as to how this helped, many of the participants stated that they had learned to travel through the use of cardinal directions or a compass.

PHASE 2

Based on the results of the study described above, researchers conducted Phase 2 of this study to validate revisions to the messages above in a more real world environment. This portion of the study is a limited endeavor specifically targeted at monitoring the ability of a pedestrian to navigate based on information provided in audio messages. The bullets below outline the ideas generated from Phase 1 that were incorporated into Phase 2.

- There is a need to examine recall of familiar street names as being useful to a visually impaired pedestrian for navigation.
- Messages will incorporate wording suggestions to make them shorter and more concise (both with alternate route and when path is clear to use).
- Researchers will re-evaluate the concept of a pathway in the road through where the temporary path is better emphasized and distracting elements (i.e., feet measurements) are not present.
- Distances expressed as blocks or landmarks were favored by the participants and will therefore be incorporated into the revised messages as the primary descriptors of distance.
- Researchers will use the insights gained as to important versus unimportant information to better revise the message elements.
- Researchers will further investigate the ability of visually impaired pedestrians to use cardinal directions in navigation.

Study Design

During the Phase 2 study, the first message of the experiment was presented to visually impaired participants while they were traveling on a sidewalk near an active roadway. Researchers observed the participant's ability to follow a designated alternate route provided in an audio message to a known destination to determine the effectiveness of the message. For this portion of the study, participants started at a designated point and began their trip as normal. Approximately ½ block into the trip, they encountered a motion-activated audio message device as shown in Figure 29. The audio message device was playing one of two messages evaluated during this portion of the study. Two messages were included in the study to determine if the combination of both street names and distance identifiers (i.e., blocks) improved the ability of visually impaired pedestrians to follow the information in the message.

M1a:

Attention westbound University Dr. pedestrians. Sidewalk closed. Alternate path on opposite side of road. Cross at next intersection, Spence St., and continue 2 blocks to Asbury St.

M1b:

Attention westbound University Dr. pedestrians. Sidewalk closed. Alternate path on opposite side of road. Cross at next intersection and continue 2 blocks.

Figure 29. Phase 2 Wayfinding Task.

After listening to the message, pedestrians continued their trip based on this new sidewalk closure information provided to them. As each pedestrian walked the instructed route, a researcher would walk with them to record their actions as well as to ensure the safety of the pedestrians. The researcher would in no way lead or give the pedestrian's information about the route they were to take; they would, however, provide assistance, if needed, in crossing sidewalk areas and intersections safely. Upon reaching a destination (approximately four blocks away), researchers asked the participants questions regarding their reactions to the message and their recall of specific elements.

Additionally, researchers had participants listen to two subsequent messages while standing on the sidewalk at this destination point, but did not require them to travel the described path in these subsequent messages. This portion of the study was conducted to evaluate different message elements not incorporated into the initial scenario. Participants were not asked to travel the given route to limit the amount of travel required of the pedestrians and to be able to incorporate elements that would not be appropriate in a mock temporary traffic control situation that we will be using (e.g., traveling on a path in the roadway). After listening to each of these messages, researchers asked the participants' questions regarding the actions they would take and had them identify specific components of the messages to determine their recall and comprehension. An example of the study instrument used for this evaluation is contained in Appendix C. The messages used for this portion of the study are listed below. Each participant evaluated one of the three warning messages M2a, b, or c (variations were created to study different obstacle elements) and all of the participants evaluated the final message M3.

M2a:

Attention eastbound University Dr. pedestrians. Construction ahead from College Main to Nagle St. Sidewalk is open. Loud Noises expected in area.

M2b:

Attention eastbound University Dr. pedestrians. Construction ahead from College Main to Nagle St. Sidewalk is open but uneven through area.

M2c:

Attention eastbound University Dr. pedestrians. Construction ahead from College Main to Nagle St. Sidewalk is open. Step down required 20 feet ahead.

M3:

Attention westbound University Dr. pedestrians. Sidewalk construction ahead. Pedestrians use protected path in street beginning here at Loupots Bookstore. Rejoin original sidewalk in one block before Boyett St.

Participants

Participants for this study were recruited in the Bryan-College Station, Texas area. This was done to ease data collection by using a familiar site that researchers could easily access for the study. There was a total of seven participants recruited. All of the participants were required to be visually impaired to participate in the study. However, not all were completely blind. Four of the participants had some limited sight abilities (primarily shapes or movement). The other three participants were completely blind. One important note with regard to the navigational portion of this study is that the participants who were completely blind used canes to help with their navigation and orientation, while the participants with limited sight did not. For this study, the use of navigational devices (such as canes or guide dogs) was the choice of the individual participant and was based on their normal travel habits.

Additionally, the amount of time that the participants had been visually impaired was noted by researchers. Four of the participants had been visually impaired all of their lives, while the other three had lost their sight as an adult. Although this was a limited sample, researchers did obtain a range of ages for the participants from 25 to 60 years of age and also included both male and female participants.

RESULTS

Due to the limited number of participants included in this validation study, the primary focus of the data analysis was to recognize the qualitative information provided by the visually impaired pedestrians to determine the effectiveness of the audio message system and the included message elements.

Field Navigation Exercise

The largest focus of this study was the wayfinding exercise that was conducted with the first message. As described in the study design, approximately ½ block into the trip the pedestrians encountered a motion-activated audio message device. After listening to the audio message provided by this device, pedestrians continued their trip based on the new information provided to them. During the study, five of the seven pedestrians stopped on their own when passing the device to listen to the message. The remaining two pedestrians had to be instructed to stop and listen to the message by a study administrator when they appeared to be continuing

without regard for the information. Participants could listen to the information provided as many times as they needed to feel comfortable with the information provided. Four of the pedestrians listed to the message twice, while the other three listened to it one, three, and four times, respectively. However, based on the results of this exercise, there was no indication that the number of times a pedestrian heard the message affected the accuracy of their route selection. Several comments were made after listening to the message that the audio was hard to hear due to other noise in the environment or that the sound was distorted. This will be a critical issue to address and resolve prior to widespread use of such devices.

Upon resuming their trip, all of the pedestrians correctly crossed over to the opposite side of the street at the first intersection as instructed in the audio message. One participant was confused by a driveway just prior to the intersection and believed that may be where they needed to cross, but was advised by the study administrator that this was not a safe crossing location. He then continued to the appropriate intersection and remarked that this was the intersection where he should cross to avoid the closed sidewalk.

Five of the participants successfully completed the wayfinding trip by traveling a path that would avoid the "closed" sidewalk. Three of the pedestrians completed the entire route as instructed in the message while the other two individuals continued one extra block (which was the remainder of the distance to their destination) before crossing back to the original side of the street. Of the two participants who did not successfully avoid the "closed" area, one pedestrian was confused by the multiple driveways along the route and counted two blocks when it was just one, crossing to the original side of the street one block early. This error would have put the pedestrian in the middle of the two blocks of the closed sidewalk. The remaining pedestrian indicated that the work area was in the street area of the upcoming cross street. This participant crossed over at the first intersection as instructed, crossed the side street on the opposite side and then immediately crossed back to the original side. She then continued her trip to her original destination. This participant also was confused by the driveways and counted one as an intersection, thereby ending her trip in the middle of the "closed" sidewalk area.

Based on the routes taken by participants in this exercise, researchers believe that all of the pedestrians understood that the sidewalk was closed ahead and they needed to use the opposite side of the street to avoid the closure. Additionally, all but one of the participants

understood that they needed to continue on the opposite side for at least two blocks to avoid the closed area.

While the researcher indicated to the pedestrians that they would be going westbound at the beginning of the study, several participants indicated it was hard for them to determine the correct cardinal direction. However, it should be noted that all of the participants did believe that the information included in the message was intended for their direction of travel. One individual suggested having beepers on all signals with different sounds to indicate the different cardinal directions that they are applicable to. This would allow the visually impaired pedestrian to more easily identify which direction is currently able to cross the street. Other problems indicated by the visually impaired pedestrians were as follows:

- The audio was too hard to hear with the adjacent traffic.
- Driveways made it hard to distinguish when they were encountering a cross street.

After reaching the pedestrian's destination, researchers asked questions regarding their reactions to the message and their recall of specific elements. Based on the responses to these questions, all of the pedestrians understood that they needed to cross the street at the next intersection. Six specifically stated that they needed to go on the opposite side of the street and that the sidewalk was closed. Also, five of these participants indicated that they should continue two blocks. Most of the responses corresponded to the pedestrians actions taken. However, as mentioned above some of the pedestrians had a hard time determining a block and would count one of the multiple driveways as an intersection.

The three pedestrians that heard the message with a combination of both street names and distance identifiers did not understand the message any more or less than the four that only heard the distance identifiers. None of the three stated the street names in any of their responses to the follow-up questions. Based on the actions they took, along with their responses, the combination of both the street names and distance identifiers did not improve the ability of the visually impaired pedestrians to follow the information in the message. Therefore, it is recommended that messages should use only blocks to have less message loading for the pedestrian.

Warning Messages

The warning messages portion of the study was conducted while the participant was stationary at their previous end location. The information gathered was done through questions following the participant listening to the message twice through as the participants did not travel the path for this portion of the study.

Three alternatives of descriptive information were evaluated for the warning message in this study. The initial information in all of these messages was identical, that the path ahead was open but that there was construction at a specific location; however the warning was rotated to determine if different features had a greater or lesser effect upon a pedestrian's actions. The descriptive elements that were used in the message were: loud noises, uneven path, and step down information.

For this group of warning messages all of the participants understood that they could continue on the path ahead and that the message was providing them with additional information regarding the area. The analysis from the previous messages evaluated in Phase 1 of this study indicated a need to be more concise in providing the information that the path was clear or available for use. The addition of the phrase "sidewalk is open" to the message in this phase seems to have addressed this concern and greatly increased the ease with which participants could correctly determine that it was a warning message and not intended to provide them with an alternate route but to provide information about the area even though the sidewalk was accessible.

When analysis was conducted to determine what types of information were recalled from the messages, it was the additional descriptors (e.g., "loud noises in area") that were remembered by all of the participants in addition to the fact that the sidewalk was open. As with the previous analysis, researchers believe these were elements that visually impaired pedestrians found critical to making route decisions as they would directly impact their travel ability. Of the different elements used in this study, the addition of "uneven path" had the greatest affect on the travel decisions of the participants. With this addition several of the participants (three of seven) indicated that they would choose to use a different path to avoid the uneven area. Also, for the indication of loud noises, two of the participants indicated that they would take an alternate route because the sound would impact their ability to hear what traffic was doing in the area. Finally, the addition of information regarding a step down did not influence any of the participants to

take a different path around the area. Researchers believe that because this was a more defined and isolated concern (only a single step versus an uneven area) that the participants felt more confident in their ability to identify and manage the change in expected conditions.

The least commonly remembered elements within these warning messages were the street names. Researchers believe that although the participants indicated that they would continue into the area of work activity, that they were not as concerned with the specific street points given, but with the need to use care as they continued ahead to identify changes in their environment.

Finally, researchers asked participants what changes they would make to the warning message to improve the information provided. For this question there were no suggestions other than the need for the audio used to be clear and loud enough to be easily heard by pedestrians.

Alternate Route in Roadway

In this situation, the evaluated message informed the pedestrian that they would need to travel on a temporary path which had been established in a closed vehicle traffic lane. When this type of message was included in the first phase of this study, there was very low understanding as to the fact that pedestrians would need to move into the road. To address this, researchers changed the message text to "protected path in street" to determine if this would be more clear than the previous message.

In this case, the majority of the participants (six of seven) understood that they would be leaving their original sidewalk to walk on an alternate path. However, only four of those participants (57 percent) clearly responded that the path they needed to use would be in the street. The other three participants did not understand "protected path" and were confused as to what was occurring ahead. One believed that they needed to use the other side of the street, one thought the surface was changing, and the last believed that this implied a narrowing of the available path. Other suggestions offered for use in this type of event were "temporary sidewalk" or "fenced path." The participants stated that images that are easier to visualize (such as fenced) would be more effective in communicating the intended meaning. When asked if they would follow the path that was given, six of the participants indicated that they would attempt to use the given alternate route. Those who did not clearly understand the message, but still wanted to follow the path, indicated that they would still need to try and follow the given directions or

that it would be safer. The participant who did not want to follow the alternate path in the road indicated that they did not want to walk closer to traffic as it would be dangerous.

With regard to other elements of the message, all of the participants were able to identify that the reason for needing to follow the given path was because of sidewalk construction. However, the location for the start of the path and the distance they would need to travel were not recalled by the majority of the participants. To this end, one participant suggested including a distance (i.e., in feet) to the start of the alternate path.

RECOMMENDATIONS

The recommendations for this section are based on both Phase 1 and 2 of the study described above. The objective of these studies was to establish preliminary message design guidelines for the development of audio speech messages intended to assist with navigation for visually impaired pedestrians. The messages used were divided into three categories.

- Directions to negotiate an alternate route on opposite sidewalk.
- Directions to negotiate an alternate route in the roadway.
- Warning only of events (the pedestrian can continue on route).

Through these studies, researchers are able to offer the following design points to be used when creating audio messages.

- It is critical that an alternate route message clearly state that the path will lead them to the sidewalk on the opposite side of the street or that it will take them to a different roadway when appropriate.
- The use of blocks or landmarks as identifiers of distance was much better received and understood by the participants. The inclusion of street names with the number of blocks did not improve pedestrian ability to follow a path and is therefore not recommended.
- The existence of a high number of driveways can impact the ability of pedestrians to count the number of blocks they have traveled and should be considered when establishing alternate routes.

- Although participants were not always able to understand the messages, most of the responses indicated that they would try and follow a suggested route.
- In relation to alternate pathways, critical message elements for navigation were the initial turning or crossing instruction and the distance that they would need to continue on that path.
- There is information that points to the idea that the standard unit of information analysis may not be the key factor in understanding for this application. Overload of information is still a concern; however, there are specific message elements or terms (e.g., the use of feet distances) that appeared to have a greater adverse impact upon recall than simply the typical message loading considerations.
- When it is important to provide warning messages about features for pedestrians traveling through or near a work area, it is critical to clearly state that the path is available (i.e., "sidewalk is open"). There is also evidence that providing additional path details (e.g., step down ahead) can further reassure pedestrians that they can continue along that path or help them in deciding if they would like to take an alternate route around the work area.
- When providing a path that takes the pedestrian into a roadway that has been temporarily closed for pedestrian use, the inclusion of "in street" for the descriptor did improve a pedestrian's ability to identify the appropriate area to travel. One suggestion for this phrase was "temporary sidewalk in street"; however, this was not specifically tested in this study.

Overall, researchers noted that the visually impaired pedestrians strongly desire accurate and credible guidance information when they will be experiencing unexpected path conditions. Much was learned through this effort, and the above guidance is a starting point for selecting information to include in this type of message and to determining how to better design a message that will assist pedestrians in navigation. As the researchers concluded their efforts for this project, they identified several areas within this topic where further work is desirable. For example, the following questions are in need of further investigation:

- Is there a definitive number of units of information to use as related to different message elements?
- What information should be considered within a message when an alternate path takes a pedestrian away from their current roadway (e.g., around a block)?

Researchers believe that these and other questions still unanswered within the field of audio messages for visually impaired pedestrians would considerably improve the pedestrians' ability to travel comfortably near or through temporary traffic control areas.

10. SUMMARY

Through the use of temporary traffic control planning, transportation agencies are able to provide a continuity of movement through an area that is affected by a work zone. This continuity is necessary for all public users including pedestrians and those persons with disabilities. However, the MUTCD and TMUTCD have very few typical applications that relate to pedestrian treatments in temporary traffic control situations. For this reason, Project 0-5237 was funded to identify strategies for handling pedestrians, and more specifically pedestrians with disabilities, in temporary traffic control situations.

Through this project, researchers gained a better understanding of the information currently available to practitioners and a clearer perspective of how the general public and persons with disabilities view temporary traffic control situations when they are pedestrians. The following paragraphs summarize the critical information gathered for this project.

STATE-OF-THE-PRACTICE

To begin to define the current state-of-the-practice with regard to the accommodation of pedestrians in road work environments, researchers accomplished several tasks including a review of current polices and phone interviews with representatives from TxDOT, other state DOTs, and several Texas cities. From the interviews, researchers were able to identify the following general points regarding the current state-of-the-practice.

- Pedestrian accommodation in temporary traffic control at a state level is not a common occurrence. However, pedestrian accommodation becomes more of an issue in states with highly populous regions.
- The MUTCD, states' supplements to the MUTCD (if applicable), and ADA Accessibility Guidelines are the most common documents referenced by practitioners in regard to how to accommodate pedestrians in temporary traffic control situations.
- None of the state agencies interviewed had any other formalized policy for how to accommodate pedestrians in temporary traffic control situations. One Texas city did

report that they have standard traffic control plans that showed pedestrian traffic control treatments.

- Most states experience no problems in implementing work zones due to pedestrian concerns.
- All of the cities and all but one state indicated that work zone duration is not used to determine when pedestrian accommodations or pedestrian-specific traffic control needs to be included.

A few more specific points with relation to the TxDOT responses regarding current accommodation issues and practices are listed below:

- Most road work affecting pedestrians takes place when TxDOT performs road work in or near urbanized areas, often when TxDOT is performing work for a small city.
- Work by others (local jurisdictions, utilities, etc.) on or near TxDOT facilities is fairly common, but it is not generally perceived to affect pedestrian traffic.
- Only a few districts have historically had projects requiring special measures to accommodate pedestrians, but more districts expect to have them in the future.

The next task that was undertaken with regard to establishing the state-of-the-practice was to conduct field evaluations of work zone sites in Texas that had pedestrian accommodation elements. This task was useful in gaining an appreciation for the necessity of positive guidance for pedestrians and the tendency of pedestrians to walk wherever they are physically able to reach their destination. Not unexpectedly, researchers found that in lieu of clear instructions on the appropriate path to take, reinforced by positive guidance, pedestrians will take whatever path is easiest at the point where they make their decision. Moreover, without physical barricades to impede travel, pedestrians felt free to walk around signs and through the work zone to make their way to their chosen destination.

The knowledge gained through these state-of-the-practice investigation efforts was utilized in developing the foundation for the activities of creating the guidelines checklist and the pedestrian signing evaluation.

GUIDELINES CHECKLIST

Based on the results of the state-of-the-practice investigation, it became apparent that there was a need for specific guidance for practitioners to use in all facets of preparing and implementing the pedestrian component of temporary traffic control. With this in mind, researchers developed a checklist to provide advice regarding the handling of pedestrians within the public rights-of-way. This checklist consists of four stages. Each of the stages is described briefly below.

- Stage 1: Feasibility: This stage identifies the type of background information that may be necessary to assess pedestrian needs within a project area.
- Stage 2: Project Assessment: This stage provides an assessment of pedestrian concerns within a finished project.
- Stage 3: Temporary Traffic Control Plan Development: This is a focus on items to consider when developing the traffic control plans that will be used during construction.
- State 4: Construction In-Field Review: The final element of this document is to provide items that should be checked in the field during construction.

For each stage, researchers included applicable references to relevant manuals, plan sheets, and guidance documents, so that practitioners could read the supporting information and/or obtain more details if desired. The complete checklist has been developed as a stand-alone document:

- Fitzpatrick, K., M. Brewer, B. Ullman, and G. Ullman. *Checklist for Accommodating Pedestrians in Temporary Traffic Control Areas.* Report No. FHWA/TX-07/0-5237-P1. http://tti.tamu.edu/documents/0-5237-P1.pdf.

HUMAN FACTORS STUDIES

The final branch of the research that was performed was to conduct several human factors studies that would allow researchers to better understand the general public's perception of

temporary traffic control areas that are near or in their path as pedestrians. The studies conducted were:

- focus groups (including emphasis on mobility and visually impaired pedestrians),
- pedestrian signing evaluation, and
- visually impaired audio message study.

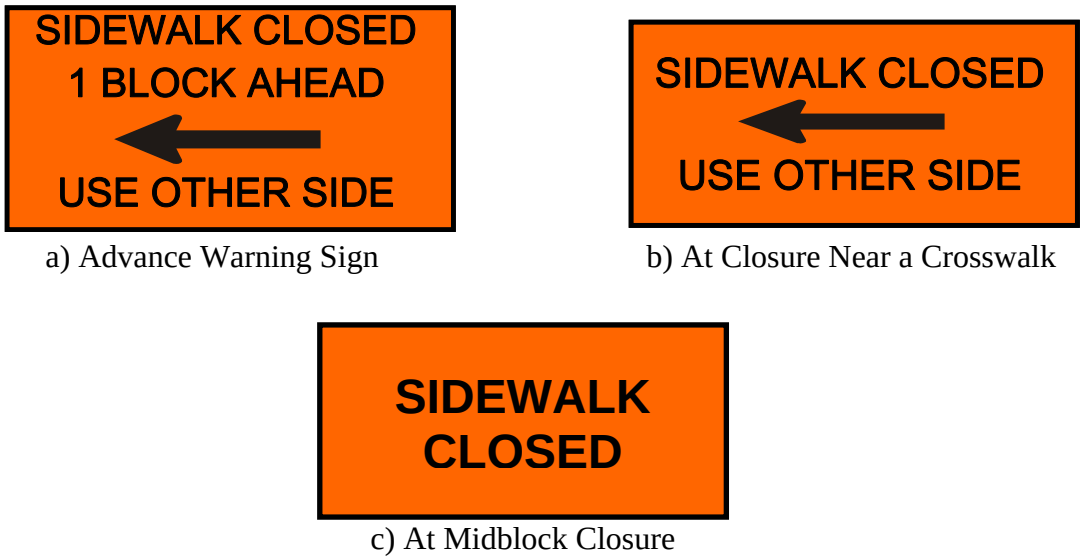
The first of these tasks was to conduct focus groups to gain a better understanding of the issues and concerns of the public when they are a pedestrian in a temporary traffic control area. Researchers specifically targeted the inclusion of pedestrians with disabilities (i.e., mobility and visually impaired pedestrians) in these groups.

During the focus group discussions, researchers introduced different scenarios and technologies to the participants and asked them for their reaction to each different situation. Through this process, several key issues were identified that need to be addressed with regard to the handling of pedestrians in temporary traffic control areas:

- advance warning signs for pedestrians near work areas, particularly for mobility impaired pedestrians, specific information preferred included distance to a closure and action to take;
- coloring of pedestrian signs related to temporary traffic control areas should be orange with black text to ensure that pedestrians recognize these signs as part of a work zone situation;
- visually impaired pedestrians' ability to detect and identify an area as being affected by temporary traffic control;
- noise generation drowning out audio cues for visually impaired pedestrians; and
- audio warning information for visually impaired pedestrians in advance of a crossing, specifically alternate route information.

Based on this information, researchers conducted two further human factors laboratory studies to gain the public's input regarding different pedestrian traffic control strategies. The first of these studies evaluated multiple options for signs to be used for pedestrians in temporary traffic control situations. In this effort, researchers administered a survey to the general public to

obtain interpretation and comprehension data for different sign alternatives. Based on this survey, researchers recommend the use of the signs shown in Figure 30 when there is a sidewalk closure due to work.



a) Advance Warning Sign

b) At Closure Near a Crosswalk

c) At Midblock Closure

Figure 30. Final Recommended Signs.

The key findings leading to the recommendation of these signs are listed below:

- It was found that none of the evaluated changes affected driver understanding that the signs were intended only for pedestrians and did not require them to take specific driving actions.
- From the pedestrian perspective, the use of an orange background with black text for signs was found to garner a higher level of compliance from the pedestrians with regard to the actions they would take upon encountering the sign without adversely affecting their comprehension of the sign meaning.
- Shape had little to no impact on the interpretation of the sign; therefore, researchers are recommending staying with a standard rectangular layout for the sidewalk closed signs.
- Action phrasing “Use Other Side” was found to be more intuitively understood by the participants and is therefore recommended for use as the better option when directing pedestrians to an alternate route across the street.

- The inclusion of a distance reference of the sign was found to be preferable to participants in the survey over the use of nearby landmarks. Therefore, researchers would recommend including "1 Block Ahead" on advance warning signs when there are regular blocks in the area as this would most likely garner the best results regarding comprehension of the distance. However, when blocks are not appropriate for the site, feet distances should be used to express the distance to the closure area.

The final task was to investigate what information should be included in audio messages if they are used as part of a temporary traffic control plan. Researchers focused exclusively on gaining information from the visually impaired community for this task. Overall, researchers noted that the visually impaired pedestrians strongly desire accurate and credible guidance information when they experiencing unexpected path conditions. To this end, researchers offer the following points to be applied in the design of audio messages based on the two laboratory studies that were conducted.

- It is critical that an alternate route message clearly state that the path will lead them to the sidewalk on the opposite side of the street or that it will take them to a different roadway when appropriate.
- The use of blocks or landmarks as identifiers of distance was much better received and understood by the participants. The inclusion of street names with the number of blocks did not improve pedestrian ability to follow a path and is therefore not recommended.
- The existence of a high number of driveways can impact the ability of pedestrians to count the number of blocks they have traveled and should be considered when establishing alternate routes.
- Although participants were not always able to understand the messages, most of the responses indicated that they would try and follow a suggested route.
- In relation to alternate pathways, critical message elements for navigation were the initial turning or crossing instruction and the distance that they would need to continue on that path.

- There is information that points to the idea that the standard unit of information analysis may not be the key factor in understanding for this application. Overload of information is still a concern; however, there are specific message elements or terms (e.g., the use of feet distances) that appeared to have a greater adverse impact upon recall than simply the typical message loading considerations.
- When it is important to provide warning messages about features for pedestrians traveling through or near a work area, it is critical to clearly state that the path is available (i.e., "sidewalk is open"). There is also evidence that providing additional path details (e.g., step down ahead) can further reassure pedestrians that they can continue along that path or help them in deciding if they would like to take an alternate route around the work area.
- When providing a path that takes the pedestrian into a roadway that has been temporarily closed for pedestrian use, the inclusion of "in street" for the descriptor did improve a pedestrians' ability to identify the appropriate area to travel. One suggestion for this phrase was "temporary sidewalk in street"; however, this was not specifically tested in this study.

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APPENDIX A:
SIGNING ALTERNATIVES SURVEYS

Pedestrian Perspective Survey

Demographics:

Gender: ❒ male ❒ female

Age: ❒ 16-25 ❒ 26-39 ❒ 40-54 ❒ 55-70 ❒ 71+

Education: ❒ some high school ❒ high school graduate
❒ some college ❒ college graduate

Before we begin, for all of the questions that I will ask, I want you to assume that you are a PEDESTRIAN when you see the signs.

When you press the space bar your first sign will appear on the laptop monitor. You will have control over how long you view the message. So, the instant you understand the situation and know what you would do, you will need to press the space bar again to turn the image off. Then you will be asked questions about the information displayed on the screen. Do you have any questions?

Part 1: Comprehension

Sign 5: Rectangular White Cross Here

Questions:

1. What information is this sign providing to you? _____

_____

2. Based on the information provided on the sign, what action would you take (if any)? _____

_____

Why? _____

_____

3. Would you change anything about the sign to improve it? ☐ Yes ☐ No

If yes, what? _____

_____

Press the space bar to see the next sign.

Sign 1: Use Other Side with Arrow

Questions:

1. What information is this sign providing to you? _____

_____

2. Based on the information provided on the sign, what action would you take (if any)? _____

_____

Why? _____

_____

3. Would you change anything about the sign to improve it? ☐ Yes ☐ No

If yes, what? _____

_____

Press the space bar to see the next sign.

Sign 6: Pedestrian Symbol White

Questions:

1. What information is this sign providing to you? _____

_____

2. Based on the information provided on the sign, what action would you take (if any)? _____

_____

Why? _____

_____

3. Would you change anything about the sign to improve it? ☐ Yes ☐ No

If yes, what? _____

_____

Part 2: Comparisons

The next time you press the space bar, you will see two signs shown side-by-side. As soon as the signs appear, I will ask you questions about the signs while they are still on the screen.

Group 1: Signs 1 & 2 – arrow vs. no arrow

Which sign is better to help you decide on an action to take? ☐ Sign 1 (left) ☐ Sign 2 (right)

Why? _____

_____

Press the space bar to see the next set of signs.

Group 2: Signs 2 & 4 – use other side vs. cross here

Which sign do you prefer? ☐ Sign 2 (left) ☐ Sign 4 (right)

Why? _____

_____

Press the space bar to see the next set of signs.

Group 3: Signs 3 & 5a – diamond vs. rectangular

Do these signs have different meanings? ☐ Yes ☐ No

If yes: What is the difference? *(Answer can not just be shape, how does the different shape change the meaning to them.)* _____

_____

Press the space bar to see the next set of signs.

Group 4: Signs 5 & 5a – white vs. orange

Would the color difference between the signs mean different things to you? ☐ Yes ☐ No

If yes, what? _____

_____

Which color of sign (if any) would be more likely to mean that you are breaking a law if you continue to walk on this sidewalk? ☐ White (left) ☐ Orange (right) ☐ no difference

Press the space bar to see the next set of signs.

Group 5: Sign 5 & 6 – words vs. symbol

Do these signs mean different things to you? ☐ Yes ☐ No

If yes, what is the difference? _____

_____

Which sign do you prefer? ☐ Sign 5 (left) ☐ Sign 6 (right)

Why? _____

_____

Part 3: Wording Questions

1. Which (if any) of these phrases requires you to select a different path to follow? **(select as many options as you would like, or is there a different phrase you think should be used)**

   ☐ *Detour* ☐ *Alternate Route* ☐ *Alternate Path* ☐ *Cross Here* ☐ *Use Other Side*

   ☐ *Other:* _____

2. Which of the phrases listed below is the **best** to use if a sidewalk is closed and pedestrians will need to use a different route? *(select only one option)*

☐ *Detour* ☐ *Alternate Route* ☐ *Alternate Path* ☐ *Other:* _____

3. If all of the phrases below represent the same walking distance, which phrase would be best to put where the "?" is to help you decide if the sidewalk is closed before or after your destination?

☐ *200 FEET AHEAD* ☐ *PAST MCDONALDS* ☐ *1 BLOCK AHEAD* ☐ *AFTER GREEN ST*

Why is that the best option? _____

_____

_____

We have two final questions about your walking experiences:

1. Approximately how often to you walk on a sidewalk near a road?

Once a Year Once a Month Once a week Several days a week Everyday

2. What percent of this walking time is in or near a road work area?

Never < 25% 25-50% 50-75% 75-100%

Driver Perspective Survey

Demographics:

Gender: ❒ male ❒ female

Age: ❒ 16-25 ❒ 26-39 ❒ 40-54 ❒ 55-70 ❒ 71+

Education: ❒ some high school ❒ high school graduate
❒ some college ❒ college graduate

Before we begin, for all of the questions that I will ask, I want you to assume that you are DRIVING when you see the signs.

When you press the space bar your first sign will appear on the laptop monitor. You will have control over how long you view the message. So, the instant you understand the situation and know what you would do, you will need to press the space bar again to turn the image off. Then you will be asked questions about the information displayed on the screen. Do you have any questions?

Part 1: Comprehension

Sign 5: Rectangular White Cross Here

1. What does this sign mean to you as a driver? _____

_____

2. Does this information affect you as a driver? ☐ Yes ☐ No
If yes, how? _____

If no, who do you think it affects? ☐ Pedestrians ☐ Other:_____

How are they affected? _____

_____

Press the space bar to see the next set of signs.

Sign 1: Use Other Side with Arrow

Questions:

1. What does this sign mean to you as a driver? _____

_____

_____

2. Does this information affect you as a driver? ☐ Yes ☐ No
If yes, how? _____

_____

If no, who do you think it affects? ☐ Pedestrians ☐ Other:_____

How are they affected? _____

_____

Press the space bar to see the next set of signs.

Sign 6: Pedestrian Symbol White

Questions:
1. What does this sign mean to you as a driver? _____

_____

_____

2. Does this information affect you as a driver? ☐ Yes ☐ No
If yes, how? _____

_____

If no, who do you think it affects? ☐ Pedestrians ☐ Other:_____

How are they affected? _____

_____

Part 2: Comparisons

The next time you press the space bar, you will see two signs shown side-by-side. As soon as the signs appear, I will ask you questions about the signs while they are still on the screen. So do not press the space bar again until we are finished with the questions.

Group 1: Signs 3 & 5a – diamond vs. rectangular

Do these signs have different meanings? ☐ Yes ☐ No

If yes: What is the difference? *(Answer can not just be shape, how does the different shape change the meaning to them.)* _____

_____

_____

Press the space bar to see the next set of signs.

Group 2: Signs 5 & 5a – white vs. orange

Would the color difference between the signs mean different things to you? ☐ Yes ☐ No

If yes, what? _____

_____

_____

Press the space bar to see the next set of signs.

Group 3: Sign 5 & 6 – words vs. symbol

Do these signs mean different things to you? ☐ Yes ☐ No

If yes, what is the difference? _____

_____

_____

Which sign do you prefer? ☐ Sign 5 (left) ☐ Sign 6 (right)

Why? _____

_____

APPENDIX B:
VISUALLY IMPAIRED AUDIO MESSAGES STUDY – PHASE 1

Audio Messages – Phase 1 Survey Instrument

Introduction:

Today we are evaluating different messages that could be used to provide information to pedestrians as they are walking on public sidewalks. For this study, I will play you a message that will repeat one time and following the message I will ask you questions about the information you heard. There will be a total of nine messages that you will hear. For this study, assume that the message you hear does apply to the road and direction you are traveling. Do you have any questions?

Test Message:

"Attention Eastbound Main Street pedestrians. Construction ahead on sidewalk. Thomas Ave. to Cardinal Dr. Use alternate route."

Questions:

1. Based on the message you just heard, what action would you take?_____

   _____

   Why?_____

   _____

   _____

2. What path was the message telling you to follow? _____

   _____

4. What type of situation was the message informing you about?_____

   _____

   _____

5. Using a scale of 1-5, how clear was the information provided in the message?

   (1 is very clear, 5 is not clear) 1 2 3 4 5

6. What would you change about the message to help people move through or around this area?

   _____

   _____

Message 1 (M4):

" Attention westbound College Dr. pedestrians. Sidewalk closed. Alternate path, cross College Dr. at Elm Rd. Turn right. Continue past 4 intersections to Terrace Dr. Turn right to cross College Dr. and return to north side of the road."

Questions:

1. Based on the message you just heard, what action would you take?_____

   _____

   Why?_____

   _____

   _____

2. What path was the message telling you to follow? _____

   _____

3. Would you use the suggested path? ☐ yes ☐ no

   Why or why not?_____

   _____

   _____

4. What type of situation was the message informing you about?_____

   _____

   _____

5. Using a scale of 1-5, how clear was the information provided in the message?

   (1 is very clear, 5 is not clear) 1 2 3 4 5

6. What would you change about the message to help people move through or around this area?

   _____

   _____

Message 2 (M7): *" Attention eastbound Military Rd. pedestrians. Construction area ahead. College Ave. to Texas Ave. Construction activity will be between walking path and traffic lanes. Use caution."*

Questions:

1. Based on the message you just heard, what action would you take?_____

   _____

   Why?_____

   _____

   _____

2. What type of situation was the message informing you about?_____

   _____

3. What information did the message provide to you about this situation?_____

_____

_____

4. Where was the situation located?_____

_____

5. Using a scale of 1-5, how clear was the information provided in the message?

   (1 is very clear, 5 is not clear) 1 2 3 4 5

6. What would you change about the message to help people move through or around this area?

_____

_____

Message 3 (M2):

"Attention eastbound Orchard Rd. pedestrians. Construction ahead. To avoid construction area, cross at Green Street. Turn left. Continue on opposite side of street for the next ½ mile."

Questions:

1. Based on the message you just heard, what action would you take?_____

_____

Why?_____

_____

_____

2. What path was the message telling you to follow? _____

_____

3. Would you use the suggested path? ☐ yes ☐ no

   Why or why not?_____

_____

_____

4. What type of situation was the message informing you about?_____

_____

_____

5. Using a scale of 1-5, how clear was the information provided in the message?

   (1 is very clear, 5 is not clear) 1 2 3 4 5

6. What would you change about the message to help people move through or around this area?

_____

_____

Message 4 (M5):

"Attention eastbound Brady Street pedestrians. Sidewalk closed. Detour turn left at 2nd Ave. Turn right and proceed past 3 cross streets to Quarter Street. If desired, turn right and cross Brady Street to original side."

Questions:

1. Based on the message you just heard, what action would you take?_____

   _____

   Why?_____

   _____

   _____

2. What path was the message telling you to follow? _____

   _____

3. Would you use the suggested path? ☐ yes ☐ no

   Why or why not?_____

   _____

   _____

4. What type of situation was the message informing you about?_____

   _____

   _____

5. Using a scale of 1-5, how clear was the information provided in the message?

   (1 is very clear, 5 is not clear) 1 2 3 4 5

6. What would you change about the message to help people move through or around this area?

   _____

   _____

Message 5 (M1):

"Attention northbound Clark Ave. pedestrians. Sidewalk Closed. To avoid closed area, cross Clark Ave. at next intersection. Turn right and continue 6 blocks on opposite side of street. Return to original side of street if desired."

Questions:

1. Based on the message you just heard, what action would you take?_____

   _____

   Why?_____

   _____

   _____

2. What path was the message telling you to follow? _____

   _____

3. Would you use the suggested path? ☐ yes ☐ no

   Why or why not?_____

   _____

   _____

4. What type of situation was the message informing you about?_____

   _____

   _____

5. Using a scale of 1-5, how clear was the information provided in the message?

   (1 is very clear, 5 is not clear) 1 2 3 4 5

6. What would you change about the message to help people move through or around this area?

   _____

   _____

Message 6 (M8):

"Attention northbound Turtle Ave. pedestrians. Road work ahead. Loud noises possible. Hollow St. to Georgia Dr. Work area is on your left and is separated by traffic barrels."

Questions:

1. Based on the message you just heard, what action would you take?_____

   _____

   Why?_____

   _____

   _____

2. What type of situation was the message informing you about?_____

   _____

3. What information did the message provide to you about this situation?_____

_____

_____

4. Where was the situation located?_____

_____

5. Using a scale of 1-5, how clear was the information provided in the message?

   (1 is very clear, 5 is not clear) 1 2 3 4 5

6. What would you change about the message to help people move through or around this area?

_____

_____

Message 7 (M3):

"Attention southbound Maple Ave. pedestrians. Work area ahead. Alternate path in roadway to left beings in 200 feet. Edge of pathway has construction barrels. Alternate path ends after 300 feet."

Questions:

1. Based on the message you just heard, what action would you take?_____

_____

Why?_____

_____

_____

2. What path was the message telling you to follow? _____

_____

3. Would you use the suggested path? ☐ yes ☐ no

   Why or why not?_____

_____

_____

4. What type of situation was the message informing you about?_____

_____

_____

5. Using a scale of 1-5, how clear was the information provided in the message?

   (1 is very clear, 5 is not clear) 1 2 3 4 5

6. What would you change about the message to help people move through or around this area?

_____

_____

Message 8 (M9):

"Attention southbound Main St. pedestrians. Approaching construction area. Uneven path ahead. Step down required in 100 feet. Walkway separated from work area by plastic fence on left. Paved surface begins again after Village Dr."

Questions:

1. Based on the message you just heard, what action would you take?_____

   _____

   Why?_____

   _____

   _____

2. What type of situation was the message informing you about?_____

   _____

3. What information did the message provide to you about this situation?_____

   _____

   _____

4. Where was the situation located?_____

   _____

5. Using a scale of 1-5, how clear was the information provided in the message?

   (1 is very clear, 5 is not clear) 1 2 3 4 5

6. What would you change about the message to help people move through or around this area?

   _____

   _____

Message 9 (M6):

"Attention northbound Carolina Ave. pedestrians. Construction area ahead. Alternate route turn left at Legend St. Turn right on opposite sidewalk. Proceed past 3 streets to Palm Dr. Return to original sidewalk."

Questions:

1. Based on the message you just heard, what action would you take?_____

   _____

   Why?_____

   _____

   _____

2. What path was the message telling you to follow? _____

   _____

3. Would you use the suggested path? ☐ yes ☐ no

   Why or why not?_____

   _____

   _____

4. What type of situation was the message informing you about?_____

   _____

   _____

5. Using a scale of 1-5, how clear was the information provided in the message?

   (1 is very clear, 5 is not clear) 1 2 3 4 5

6. What would you change about the message to help people move through or around this area?

   _____

   _____

General Questions:

We have now listened to all of the messages for this study and I am going to ask you some overall questions about the messages you just heard.

1. Based on the messages you just heard, what information did you feel was most important in helping you travel to your destination?_____

_____

_____

_____

Why?_____

_____

_____

2. Was there information in the messages that you did not need? ☐ yes ☐ no

If yes, what information and why? _____

_____

_____

_____

3. Was there other information that you would have included in these messages to help visually impaired pedestrians in work zone areas? _____

_____

_____

_____

_____

I would now like to ask you a couple of questions about specific parts of the messages.

1. Is there a difference to you between messages that tell you about a "detour" vs. an "alternate route"? ☐ yes ☐ no

If yes, what is the difference? _____

_____

_____

2. When trying to specify a distance ahead that you will need to travel what is the best or easiest description to use?

☐ street names ☐ street count ☐ miles ☐ feet ☐ walking steps or paces

☐ other _____

a) Does the best way to specify a distance vary depending on if it is a short distance (such as 50 feet) or a long distance (such as 1000 feet)? ☐ yes ☐ no

If yes, how does this difference change your answer? _____

_____

_____

3. Some of the message you heard instructed you to "Use Caution". Does this statement effect how you would move through the area? ☐ yes ☐ no

If yes, how? _____

_____

_____

a) Is it helpful to include this type of warning statement in the message? ☐ yes ☐ no

Why or why not?_____

_____

_____

b) Are there other warning statements that would be helpful to you? ☐ yes ☐ no

If yes, what statement(s) would you include?_____

_____

_____

4. In the messages you heard, affected pedestrians were identified by the direction they were traveling, for example it would say "northbound Wallace Ave. pedestrians." If you were actually traveling on a sidewalk, would this information be helpful in determining if the message applied to you? ☐ yes ☐ no

Why or why not? _____

_____

_____

If no, how could this part of the message be improved? _____

_____

APPENDIX C:
VISUALLY IMPAIRED AUDIO MESSAGES STUDY – PHASE 2

Audio Messages – Phase 2 Survey Instrument

Section 1: Field Navigation Exercise

Instructions:
Right now we are on University at South College. Once I have finished giving you instructions, I want you to start walking westbound and walk to Loupot's Bookstore, which is approximately four blocks on this side of the street. During this exercise, additional information will be provided to you about the path you are walking on. Please react as you normally would to any information provided to you. If you need assistance in crossing a signalized intersection, please let me know. A researcher will be with you at all times to assist you; however, please do not ask any questions on the route you are to take. When you believe you have reached your destination, please let me know. At that point, I will ask you a few questions. Do you have any questions?

Subject will begin trip, at appropriate location a message will be played regarding a road work situation ahead that has affected the pedestrian walkway. NOTE: record all their route decisions during the test trip on the wayfinding check list. Once the subject has reached the destination given to them by the study administrator, they will be asked the following questions.

Navigation Message 1A *Attention westbound University Drive pedestrians. Sidewalk closed. Alternate path on opposite side of road. Cross at next intersection, Spence Street and continue 2 blocks to Asbury Street.*

Questions:
1. Do you feel that you took the path that the message instructed you to? Yes No

   If no, do you know what you did that was different than what the message instructed? __
   _____
   _____

2. Tell me the path that the message instructed you to take?_____
_____
_____

If subject took a different path ask Question 3, if not go to Question 4.
3. Why did you decide to take a different path? _____
_____
_____

4. What information in the message helped you decide on the path you took? _____
_____
_____

5. What other information do you need to follow the path in the message? _____
_____
_____

6. Do you have any suggestions to improve this message? _____
_____
_____

7. Do you have any other comments about the message you just heard? _____
_____
_____

Section 2: Warning Message

Instructions:
Now, for the second half of the study, I will play you a message and following the message I will ask you questions about the information you heard. We will not actually travel the path for these messages. There will be two messages that you will hear. For this part of the study, assume that the message you hear applies to the road and direction you are walking. Do you have any questions?

Message 2A: *Attention eastbound University Drive pedestrians. Construction ahead from College Main to Nagle Street. Sidewalk is open. Loud noises expected in area.*

Questions:
1. Based on the message you just heard, what action would you take? _____
_____
Why?_____
_____

2. What type of situation was the message informing you about?_____
_____
_____

3. What information did the message provide to you about this situation?_____
_____
_____

4. Where was the situation stated in the message located?_____
_____
_____

5. Would the indication of an uneven sidewalk through this area effect your travel decisions?
Yes No If yes, how - If no, why?_____
_____
_____

6. Would the indication of a required step down 20 feet ahead effect your travel decisions?
Yes No If yes, how – If no, why? _____
_____

7. Do you have any other suggestions or comments about this particular message? _____
_____
_____

Section 3. Path in Roadway Message

Message 3: *Attention westbound University Drive pedestrians. Sidewalk construction ahead. Pedestrians use protected path in street beginning here are Loupot's Bookstore. Rejoin original sidewalk in 1 block before Boyett Street.*

Questions:
1. Based on the message you just heard, what action would you take? _____
_____
Why? _____
_____

2. What path was the message telling you to follow? _____
_____
_____

3. Would you use the suggested path? _____
_____
_____

Why or why not? _____
_____
_____

4. What type of situation was the message informing you about? _____
_____
_____

5. What does the phrase "protected path" mean to you? _____
_____
_____

6. Is there a better term or phase to use to explain that the pedestrian path will be in the road next to the sidewalk or curb area? _____
_____
_____

7. Do you have any other suggestions or comments about this particular message? _____
_____
_____