GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

Date: 2/12/81

<table>
<thead>
<tr>
<th>Project Title:</th>
<th>Design Guidelines to Make Crossing Structures Accessible to the Physically Handicapped</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project No:</td>
<td>D-48-647</td>
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<tr>
<td>Project Director:</td>
<td>John Templer</td>
</tr>
<tr>
<td>Sponsor:</td>
<td>U.S. DOT Federal Highway Administration</td>
</tr>
<tr>
<td>Agreement Period:</td>
<td>From 9/29/80 Until 12/29/81</td>
</tr>
<tr>
<td>Type Agreement:</td>
<td>Contract No. DTFH61-80-C-00131</td>
</tr>
<tr>
<td>Amount:</td>
<td>$148,900</td>
</tr>
<tr>
<td>Reports Required:</td>
<td>Monthly; Task; Executive; Implementation Outline; Final</td>
</tr>
<tr>
<td>Sponsor Contact Person(s):</td>
<td>Mr. John Fegan</td>
</tr>
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<td></td>
<td>Technical Matters: Mr. Richard Richter</td>
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<td>Contractual Matters: Mr. Luther D. McCollum</td>
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<td>U.S. Dept. of Transportation</td>
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<td>Federal Highway Administration</td>
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<td>Office of Contracts and Procurement</td>
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<td>Washington, D.C. 20590</td>
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<td>Phone: 202-426-9710</td>
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<td>Defense Priority Rating:</td>
<td>N/A</td>
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<td>Assigned to:</td>
<td>Architecture</td>
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GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date March 30, 1984

Project No. D-48-647
School/Arch. 

Includes Subproject No.(s)

Project Director(s) Dr. John Templer

Sponsor U.S. DOT Federal Highway Administration

Title Design Guidelines to Make Crossing Structures Accessible to the Physically Handicapped

Effective Completion Date: 1/31/83 (Performance) (Reports)

Grant/Contract Closeout Actions Remaining:

☐ None
☒ Final Invoice or Final Fiscal Report
☒ Closing Documents
☒ Final Report of Inventions
☒ Govt. Property Inventory & Related Certificate
☐ Classified Material Certificate
☐ Other ____________________________

Continues Project No. ____________ Continued by Project No. ____________

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Form OCA 60:1028
19 November 1980

Mr. John Fegan
Federal Highway Administration
HRS-41
Washington, DC 20590

RE: Design guideline to make crossing structures accessible to the physically handicapped.

Contract #DTFH61-80-C-00131
First monthly progress report

Dear Mr. Fegan:

Phase I

Two difficulties have been encountered with respect to the schedule for Phase I. First, due to the delayed start date, it is anticipated that the cold and rainy weather conditions to be encountered during the end of November and December will delay and at some point during early December preclude further ramps testing until some time in March. Second, the importance of a review by a qualified physician of medical history forms for each participant, and the delays which this would create in scheduling participants, were not anticipated. However, it is expected that, since the majority of Phase I data will be collected prior to mid-December, these delays in testing will not significantly change the initiation of Phase II. During the next reporting period, testing will continue for as long as this is possible. Phase I is 13% complete.

Task A

RAMP GRADIENTS

During the month of October, four major activities were undertaken:

1) selection of the ramps for Phase I testing;
2) selection of test subjects for Phase I testing;
3) review of research procedures with the Advisory Panel; and
4) identification and training of research assistants for Phase I testing.
Selection of the Ramps for Phase I Testing

General Procedure. Ramps for Phase I testing were selected through a systematic survey of one mile radius segments of the city of Atlanta, radiating from a central point, selected for convenience to the Georgia Tech campus. This process was followed for two reasons:

1) to insure that all the ramps would be in close proximity with one another, and

2) to insure a systematic methodology to prevent any backtracking while surveying. A reasonable sampling of ramps was achieved within a three mile radius of the campus.

Identification of Candidate Ramps. The initial criteria for the identification of candidate ramps were the following:

1) there should be at least four ramps for each of the designated slopes;

2) each candidate ramp should be at least 400 feet in length;

3) if a ramp of the proper length could not be located, then it was required that the ramp achieve at least a 20 foot vertical height from one end to the other;

4) the slope of the ramp should be as consistent as possible.

Candidate ramps were surveyed in a two-stage process: the first stage, the general survey stage, was performed on all potential candidate ramps. The second stage, the detailed analysis stage, was performed on only the most promising of the ramps identified in the general survey.

The procedure used in the general Survey was to check the slope of the sidewalk or street in five places to determine whether the slope complied with the variance criteria defined above. The instruments used in calculating the slope were a two foot long carpenters level and a ruler. If the ramp met the criteria for selection, a general description was written about the physical condition of the surface and the context, and a rough sketch was drawn denoting the points along the route where the slope was taken, location of rough areas or obstructions, and the context.

The detailed analysis was performed using a transit and a 15 foot surveyors rod. The procedure used was to shoot the height at five foot intervals for the entire length of the ramp. At the same time, the cross slope was measured but at 10 foot intervals. Lastly, accurate measurements were taken of the location of any obstruction such as large cracks, grass growing in expansion joints or bushes protruding into the ramp area. After the slopes had been collected, detailed descriptions of the selection criteria were written.

Once the data had been collected, the slopes for the five foot intervals were calculated, as well as the mean and standard deviation of the slopes (to assess consistency of slope).
Criteria for Selection of Final Ramps. Once the selection of candidate ramps had been completed, the following criteria was used to select the final ramp in each category. The criteria are listed in the order of their importance, from most to least:

1) physical condition (e.g., a surface free of obstructions or debris and in good condition);
2) consistency of slope;
3) linearity of run;
4) proximity to other ramps;
5) provision of user amenities, such as, shade from the sun, location in a non-hazardous neighborhood or away from potentially dangerous situations.

Selection of Test Subjects for Phase I Testing. In order to identify a representative sample of test subjects for Phase I testing, a call for participation was developed as a public service announcement, for local radio and television stations, and was distributed to local newspapers (see Public Service Announcements). Thirty-one local service agencies were contacted. These agencies either arranged meetings in which we described the study and solicited participants, sent informational mailings to their clients, or provided us with client lists which were used to make personal phone solicitations (see Agencies Contacted). Personal phone contacts were also made using the Pedestrian Research Laboratory's file of participants from previous studies.

In addition to the above efforts, participants were solicited at the Atlanta Job Fair. During this Job Fair for the handicapped, an information booth was set up and literature distributed describing the study and calling for participants.

An initial telephone screening was conducted of all respondents to determine their disability type, general travel experience, and other background data pertinent to selection of the sample of test subjects (see Information to be Obtained from Participants). To date, 98 handicapped persons who are potential candidates for the study have been identified. The background characteristics of these people are described in the table, Handicapped Participants Identified to Date.

Concurrently with this effort, national and regional data is being collected on the background characteristics of the handicapped population as a whole and of wheelchair users. This data will be used to identify any biases present in our sample of participants, and if our pool of volunteers is large enough, to balance the sample by random selection from the available pool.

Potential participants have been sent Personal Medical History forms and Georgia Tech consent forms. Arrangements have been made with a local medical doctor, Dr. David Apple, to review all medical history forms to determine if a doctor's permission would be advisable for participation in the study.
Review of research procedure with the Advisory Panel.

On October 3, a meeting was held with members of the Advisory Panel to review procedures for selection of ramps, selection of test subjects, and proposed test procedures. Panel participants included:

Dr. Bruce Blasch, University of Wisconsin (Consultant)
Jim Bostrom, Georgia Institute of Technology (Mobility Researcher and himself handicapped)
Francis Curtiss, Emory Rehabilitation Center (Consultant)
Dr. Gary Evans, University of California (Consultant)
Gary Kelly, Georgia Institute of Technology (Consultant)
Pascal Malassigne, Georgia Institute of Technology (Mobility Researcher)
Richard Martin, Georgia Institute of Technology (Mobility Researcher)
Alan Winslow, Virginia Polytechnic Institute (Consultant)

Recommendations were made by panel members concerning the importance of selection criteria for the ramps. Consideration was given to the impacts of cross slope, surface condition (expansion joints, broken pavements, roughness, etc.), and other potential obstructions.

With respect to sample selection, the panel provided input as to potential sources for participants, and potential sources for information on national and regional background data on the handicapped population.

Finally, panel members reviewed the proposed test procedures. Among the recommendations, it was suggested that participants be photographed using the ramps to identify characteristics of the wheelchair (diameter of wheel, height of back rest, placement of wheels, etc.), and characteristic methods of negotiating the ramp (frontwards or backwards, hand position, whether participant wears gloves, etc.). The panel also discussed the advisability of constructing a moveable landing which could be rolled into position when participants desired to rest. This landing would simulate an actual ramp rest area, and would provide a flat surface to relieve the participant from maneuvering the wheelchair (or balancing if the person uses crutches, a walker, etc.). The landing would also provide a surface from which a participant can begin a further ascent (rather than starting on a slope).

Identification and Training of Research Assistants for Phase I Testing.

Research assistants for Phase I testing were identified and instructed in test procedures and operation of the data collection instruments. Intensive training sessions were scheduled over a period of several weeks, including several training sessions involving wheelchair participants.

A methodology was developed to test the reliability of research assistants to assure the accuracy of the data collected.
PUBLIC SERVICE ANNOUNCEMENTS

RADIO

WABE  
WPCH  
WTCZ  
WGST  
WRNG  
WREK  
WSB  
WPLO  
WAOK  
WIGO  
WQXI

TELEVISION

Channel 30  
Channel 36  
Channel 46  
Channel 17  
Cable News  
Channel 11  
Channel 5  
Channel 2

NEWSPAPERS

Dekalb News - Sunday  
Dunwoody Crier  
Fayette-Southside Sunday  
Fulton County Daily Report  
Gwinette Daily News  
Henry-Clayton Sunday  
Marietta Daily Journal  
Neighbor Newspapers  
Atlanta Constitution  
Atlanta Daily World  
Atlanta Inquirer  
Atlanta Journal  
The Atlanta Voice  
Creative Loafing  
Cycle News, Inc.  
Decatur-Dekalb News
AGENCIES CONTACTED

Atlanta Area Services for the Blind
Scottish Rite Hospital for Crippled Children
Shepherd Spinal Center
Cerebral Palsy Center of Atlanta
Cerebral Palsy United of Greater Atlanta
Atlanta Rehabilitation Center
Department of Human Resources
Handicapped Mobility Systems
Georgia Paraplegic Association
Dekalb Training Center
Easter Seals
Vocational Rehabilitation Center
MARTA
Columbia Place (Housing for the Handicapped)
Bureau of Human Services
MS Society
MD Society
Spina Bifida
National Center for Handicapped Rights
Gwinette County Parks and Recreation
Fulton County Health Department
MDIS
Catholic Social Services
High View Nursing Home
Council for Exceptional Children
Georgia Rehabilitation Center
Veterans Administration
Visiting Nurse Association of Metropolitan Atlanta
Elaine Clark Center
Cerebral Palsy Training Center
Senior Citizens Services

Atlanta Job Fair
Walking Aids

Crutches: 11 (5 Male, 6 Female)
Cane: 4 (1 Male, 3 Female)

No Walking Aids: 6 (3 Male, 3 Female) - 3 with CP

1 nervous condition: no physical handicap.
**HANDICAPPED PARTICIPANTS IDENTIFIED TO DATE**

(11/10/80)

**Wheelchair Users:**

- Manual: 65
- Electric: 21

**Manual Wheelchair Users:**

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**Sex:**

- Male: 39
- Female: 26

**Race:**

- White: 50
- Black: 15

**Income:**

- SS/Disability: 15
- Welfare: 1
- Under 5,000/yr: 8
- 5,000 - 9,999/yr: 10
- 10,000 - 14,999: 6
- 15,000 - 19,999: 5
- 20,000 - 24,999: 4
- 25,000 - 29,999: 3
- Unknown: 5
- Student: 1 (family income unknown)
- Alimony: 1
- VA: 1
Electric Wheelchair Users:

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</table>

Sex:

- Male: 12
- Female: 9

Race:

- White: 14
- Black: 6
- Unknown: 1

Income:

- SS/Disability: 12
- Under 5,000: 1
- 5,000-10,000: 1
- 10,000 - 14,999: 1
- 15,000 - 19,999: 2
- 20,000 - 29,999: 1
- 30,000 +: 1
- Unknown: 1
- Student: 1

Walking Aids

- Crutches: 11 (5 Male, 6 Female)
- Cane: 4 (1 Male, 3 Female)
- No Walking Aids: 6 (3 Male, 3 Female) - 3 with CP

1 nervous condition: no physical handicap.
PERSONAL MEDICAL HISTORY

Name: ________________________________________________

Age: ______

What is your medical diagnosis (Handicapping Condition)? _________________________________

When was your last medical checkup? _________________________________

What operations have you had? _________________________________

________________________________________________________________________

Have you been in a hospital for any other reason? Yes _____ No _____

What? __________________________________________________________________________

What drug allergies do you have? _________________________________

What medicines are you presently taking? _________________________________

Have you had: High Blood pressure _____
Heart Trouble _____
Irregular Heart Beat _____
Pneumonia _____
Asthma _____
Diabetes _____

Has anyone in your family had:

Heart attacks _____
High Blood Pressure _____
Stroke _____
Early death _____
Cancer _____
Diabetes _____
Epilepsy _____
Obesity _____
I hereby consent to act as an experimental subject in the architectural research program of the Georgia Institute of Technology. I am a physically handicapped person. My participation is on a voluntary basis and is in consideration of the contributions of this program to the advancement of knowledge in the area of improved accessibility for handicapped persons.

1. I understand that I may be asked to go along a sidewalk up hills that are approximately 400 feet long, and then back down, several times, at several different sites in Atlanta, and that some of these sites may be wet and slippery.

2. I understand that during my trips along the sidewalk, researchers will be gathering data about the distances I travel and any problem or difficulties I experience.

3. I understand that I am to exercise at all times the same degree of caution that I would in normal travel around the city, and that I should not attempt any test which I feel is hazardous to myself or to my equipment, or which will be too physically demanding on me. I understand that this will require considerable physical effort but that I may rest at any time upon request.

4. In connection with this study, I agree that photographs may be taken of me.

5. I agree that the data that I provide may be used for analysis and publication, but that no information will reveal the identity of the participants.

6. I understand that this study is being done to benefit science and research education, and agree that any photographs or research findings may be used for that purpose including publication in scientific journals.

7. I understand that I may make any inquiries concerning the procedure and that I am free to withdraw my consent and to discontinue participation in the project at any time. If I do not choose to participate now or if I withdraw from the study later, this will have no effect on any services or benefits that I am entitled to from the Dept. of Vocational Rehabilitation or any other agency. However, I understand that I will be paid a fee for participating only if I participate in all tasks.

8. I understand that proper safety precautions have been taken, but in the event of an accidental injury, I understand that no financial or other compensation is available from the Georgia Institute of Technology, the Board of Regents, or the Dept. of Human Resources.

Subject's Signature

Investigator

Informed Consent Form
Visually Impaired People

How severe is your visual impairment?

- totally blind
- light perception
- low partial vision
- high partial vision

For instance:
  - Can you read large type? (high)
  - Can you see TV? (high)
  - Can you read your own writing? (high)
  - Can you see color? (low)
  - Can you see form? (low)

Is your vision helpful when you travel?

In what ways?
  - Can you see when the sidewalk turns? (high)
  - Can you see a building entrance? (high)
  - Can you read bus numbers? (high)
  - Can you see crosswalks? (low, probably not light perception)

*If it were nearby, would you go to the store by yourself?

*Have you received formal orientation and mobility training. Where, when and for how long?

*What travel aid or aids do you use?
  - long cane
  - guide dog
  - electronic travel aid (what?)
  - other (specify)

*How old were you when you lost your vision?
Is your vision:
  - stable
  - deteriorating
  - increasing

Do you have vision in one eye or both eyes?

Thank you for your time. We will contact you as soon as we decide who will participate.
Information to be Obtained from Participants

We are conducting a study of the ability of handicapped people to move around the city and particularly their ability to go up and down hills. As a participant in this study you would be assisting in developing guidelines to make the environment accessible to disabled people.

We need some preliminary information to decide if you are eligible for the study.

Name:
   Age:
   Sex:
   Race:
   Income:

Address: (home)
   (work)

Phone: (home)
   (work)

Disability Type:
   visual impairment (white cane)
   (dog)
   wheelchair user (manual)
   (electric)
   walker
   crutches
   leg braces
   Cerebral Palsy
   other

Are you in generally good health?

Will you be in the Atlanta area during the months of October and November?

If you participate in this study, it would involve traveling along several selected short routes within the city with the researchers. To participate in the study we would need approximately six hours of your time. What days and times are you most likely to be available (days of the week, morning/afternoon)?

Do you have transportation or could you get to a test site in the Atlanta area?

Wheelchairs:

Assuming that a neighborhood was accessible to wheelchairs, would you travel two blocks and go up a short hill to a store?

Would this be with or without an attendant?
Phase II

Slip Resistance

We have located approximately 30 different materials or configurations of the same materials on the Georgia Tech Campus and immediate surrounding area. Each material was recorded with respect to its slope; condition (the state of disrepair); the approximate size, the width and length; and for the different configurations, a brief written description of the respective configuration along with a sketch of the pattern. In the next reporting period, the selection of materials will continue. Dr. Brungraber, the consultant, has approved the test procedures.

Phase II is 7% complete.

Detectability of Materials

The study of detectability of materials has been broken down into five smaller studies. These studies are of the five primary qualities of detection. They are Acoustical, the unique sounds that are produced by the material when tapped by the long cane or shoe; the Configuration, the linear, nonlinear and asymmetrical configurations of materials; Contrast, for the partially sighted, to determine the most visible cues by comparing the material with the control material and intramaterial testing; Rebound, the "bounceability" of the material; and the Texture, the relative slip resistance of the material.

It was determined, at the recommendation of an acoustical expert, that the testing for the acoustical characteristic be conducted by simply having a pretest where subjects walk through the test track with earplugs and a second run without earplugs. The testing for Configuration is being done by building a series of testing material areas, each with a different configuration (e.g., one with brick paving, or one with painted strips where the width of the strips may be equal to the width of the exposed concrete separating the painted strips). The Contrast testing has not been determined at present. We are conducting a literature search of the appropriate material. The Rebound testing also has not been determined but we are consulting with Dr. Brungraber to acquire the proper instrument. The testing for Texture will be conducted with a slip resistance instrument.

The design of a new test track is under progress. At the present, we are considering using a track with interchangeable testing material modules, believing that this will allow the testing of a large number of materials and configurations without having to construct a large test track. These modules also may be used in the slip resistance testing.

In the next reporting phase work on the appropriate measuring instruments will continue, and on the design of the test tracks.
Analysis of issues. The consultant panel and the research team established that crossing a structure can be broken down into eleven activities. These are presented in Table 1, along with specific potential problems and potential countermeasures.

Potential Countermeasures

Seven classes of countermeasures were identified in the original research proposal. Consultation with the panel suggests that these may be collapsed into three major categories. These are listed in Table 2.
Phase III

Orientation Cues for the Blind

To date, this task has focused on identifying and assessing existing countermeasures. Although useful progress has been made, advancement has been slowed by diverting some resources to Phase I. Because Phase I is now underway, and because countermeasures are identified, progress will be more rapid. Task A may not be completed until February 1, but Task B will be started on time. There are many preparatory tasks that can be achieved during the overlap.

Progress in October falls into several areas: consultant meeting, analysis of problem, identification of countermeasures.

Consultant Meeting

A panel of experts was convened to verify that the problems of the visually impaired were being adequately covered in the present project, to verify that the list of potential countermeasures was exhaustive and to provide input on design of the research. Those present at the panel focusing on Phase III included, in alphabetical order: Bruce Blasch, an expert in orientation and mobility from the University of Wisconsin at Madison; Lynne Davis, Director of the Low-Vision Clinic at the Atlanta Area Services for the blind; Gary Evans, an expert in field research methods and in environmental cognition from the University of California at Irvine; Gary Kelly, a rehabilitation engineer from Georgia Tech who is himself severely visually impaired; Scott McCall, an orientation and mobility specialist from the Atlanta Area Services for the Blind who is congenitally, totally blind. The meeting was also attended by the research staff: John Templer, Jean Wineman, Craig Zimring, Aline Smith, and David Lewis.

The consultants met for a half-day session and provided a number of valuable comments, some of which will be discussed below in the section entitled "Definition of the Problem." In general, it was agreed that the difficulties faced by the visually impaired were adequately covered in the research. Also, it was suggested that various difficulties could be simulated, but that the simulations need to be accurate if the results are to have application for the design and construction of crossing structures.

Definition of the Problem

Overall issues. The consultant meeting helped clarify that the visually impaired have three sets of problems on crossing structures that can be defined in terms of decreasing spatial scales: (a) general orientation, including maintaining Cardinal directions and understanding the relationship of the crossing structure to the adjoining streets, bus stops and overall pedestrian network; (b) local orientation, including maintaining an understanding of the form of the crossing structure; (c) minute-to-minute orientation, including the tasks of staying on the path, avoiding hazards and so on.

These problems may be further broken down as: (a) orientation problems, which include becoming lost or confused at the three spatial scales described above; (b) safety problems, such as falling down stairs, veering into traffic, etc.
PHASE III: Orientation Cues for the Blind

Table 1: Activities involved with crossing a crossing structure, potential problems, potential countermeasures and comments.

<table>
<thead>
<tr>
<th>ACTIVITIES</th>
<th>POTENTIAL PROBLEMS</th>
<th>POTENTIAL COUNTERMEASURES</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Finding general area of crossing structure; know crossing is approaching.</td>
<td>a. becoming lost and disoriented</td>
<td>a. logical relationship of site to pedestrian network</td>
<td>a. logical relationship of site to pedestrian network may imply:</td>
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<td></td>
<td>b. walking into traffic flow</td>
<td>b. signage:</td>
<td>1. placing the structure where expected such as at major crossing, or at corners rather than mid-block;</td>
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<td>c. disrupting pedestrian flow (CANE)</td>
<td>c. tactual landmarks</td>
<td>2. not having long approach from sidewalk to structure (or at least having this geometrically simple and well marked)</td>
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<td>d. minor injuries due to overhanging tree branches, etc. (CANE)</td>
<td>d. auditory cues:</td>
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<tr>
<td></td>
<td></td>
<td>1. sound emitting, i.e., fountains</td>
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<td>2. acoustic changes, i.e., open area</td>
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Phase III: Orientation Cues for the Blind

1. some travelers may lack necessary experience or spatial concepts;
2. symbols have not been standardized and there is considerable debate on scale and other issues.
3. some travelers lack tactile sensitivity.

f. Auditory maps do not require the same conceptual and tactual maps, however:
1. permanently-mounted maps may cause maintenance problems in some settings.
2. different descriptions may be necessary for travelers with different abilities (e.g., those who orient to cardinal directions or not, those who have residual vision or not, etc.)

g. Both tactual and visual maps have been developed as teaching tools; they have been less used as site orientation devices.
Phase III: Orientation Cues for the Blind

**ACTIVITIES**

2. Find exact crossing structure entrance
   - a. missing entrance
   - b. disorientation
   - c. wander into traffic flow
   - d. minor injuries due to overhanging branches

3. Determine direction/destination of crossing structure
   - a. disorientation/lack of confidence

**POTENTIAL PROBLEMS**

- a. missing entrance
- b. disorientation
- c. wander into traffic flow
- d. minor injuries due to overhanging branches

**POTENTIAL COUNTERMEASURES**

- a. simple route to entrance (direct with landmarks)
- b. shorelines (CANE)
- c. visual signage (HP)
- d. color contrast on paving (HP)
- e. auditory cues at entrance:
  1. reverberation
  2. sound emitting
- f. clear slope change at entrance (CANE)

**COMMENTS**

- a. the route to entrance must include both:
  1. mobility cues such as shorelines that maintain a route (these have been studied in previous Handiped research)
  2. cognitive mapping and orientation aids that maintain overall orientation to the site and the pedestrian network (these have received little or no research)
- b. detectability of landmarks and shorelines has been studied; memorability has not.
- c. large open areas at crossing structures are particularly problematic.
- d. resilient plastic shorelines have been studied in previous Handiped research; pea gravel pressed into epoxy has also been found effective/although may be more easily confused with other cues.
- e. overall orientation aids seem most useful here.
### Phase III: Orientation Cues for the Blind

**POTENTIAL ACTIVITIES**

<table>
<thead>
<tr>
<th>ACTIVITIES</th>
<th>POTENTIAL PROBLEMS</th>
<th>POTENTIAL COUNTERMEASURES</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Moving from entrance to top of crossing structure</td>
<td>a. veering</td>
<td>a. tactual strip (CANE)</td>
<td>a. handrail placement and design for effective travel (e.g., handrail that signals slope change and that channels travelers to the proper area)</td>
</tr>
<tr>
<td></td>
<td>b. disorientation</td>
<td>b. simplicity of form</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. tripping on stairs</td>
<td>c. tactual/visual/auditory warning of hazards</td>
<td></td>
</tr>
<tr>
<td>5. Find top of crossing structure</td>
<td>a. disorientation (and possible confusion of rest area with crossing)</td>
<td>a. paving changes (CANE)</td>
<td>a. environmental conditions may be distracting (e.g., sway, wind, noise, etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b. slope changes (CANE)</td>
<td>b. some ramp or stair configurations may make this especially difficult (e.g., dog-leg, switch-back, etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c. initial model or signage showing ramp configuration</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>d. auditory landmarks</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>e. auditory maps</td>
<td></td>
</tr>
<tr>
<td>6. Cross structure</td>
<td>a. fright or disorientation</td>
<td>a. tactual strip</td>
<td>a. this may also be affected by environmental conditions</td>
</tr>
<tr>
<td></td>
<td>b. edging at cane-height</td>
<td>b. edging at cane-height</td>
<td>b. problems in this task are similar to navigation of walkway</td>
</tr>
<tr>
<td>7. Finding down-ramp/stairs/elevator</td>
<td>a. safety hazard of falling down stairs</td>
<td>a. paving changes</td>
<td>a. falling down stairs is a particular problem</td>
</tr>
<tr>
<td></td>
<td>b. disorientation</td>
<td>b. slope changes</td>
<td>b. it has been suggested that visual signage should be on pavement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c. tactual/visual/auditory warnings</td>
<td>c. obviously this cue must be coordinated with cue from opposite direction that indicates top of stair or ramp</td>
</tr>
</tbody>
</table>
### Phase III: Orientation Cues for the Blind

<table>
<thead>
<tr>
<th>ACTIVITIES</th>
<th>POTENTIAL PROBLEMS</th>
<th>POTENTIAL COUNTERMEASURES</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Traverse to bottom of ramp/stairs/elevator</td>
<td>a. disorientation</td>
<td>a. paving changes (CANE)</td>
<td>a. similar issues apply as in moving up stairs</td>
</tr>
<tr>
<td></td>
<td>b. safety hazard or falling down stairs</td>
<td>b. slope (CANE)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>c. visual/tactual/auditory</td>
<td>b. a rest area may be confused with the bottom of the ramp</td>
</tr>
<tr>
<td></td>
<td></td>
<td>warnings</td>
<td>b. the same contextual issues apply as in 1 and 2 (e.g., environmental conditions may affect use)</td>
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<tr>
<td>9. Find bottom of stairs or ramp</td>
<td>a. disorientation</td>
<td>a. visual/tactual/auditory</td>
<td>a. a ramp or stair configuration may affect orientation</td>
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<tr>
<td></td>
<td>b. confusion of rest area with bottom</td>
<td>warnings</td>
<td>b. distractions such as noise or pedestrian traffic may affect orientation here.</td>
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<tr>
<td>10. Become oriented at bottom of ramp or stairs</td>
<td>a. walking into traffic</td>
<td>a. logical siting and</td>
<td>a. issues similar to 1 apply here.</td>
</tr>
<tr>
<td></td>
<td>b. disorientation</td>
<td>relationship to sidewalk</td>
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<td></td>
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<td>signage:</td>
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<tr>
<td></td>
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<td>1. visual</td>
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<td></td>
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<td>2. tactual</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>3. auditory maps</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>c. well-defined path</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(shorelines, paving color)</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>d. auditory cues: sound</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>emitting, reflective</td>
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<tr>
<td>11. Find sidewalk</td>
<td>a. walking into traffic</td>
<td>a. logical siting and</td>
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<td></td>
<td>b. disorientation</td>
<td>relationship to sidewalk</td>
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<td>emitting, reflective</td>
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</table>
### TABLE 2: Classes of Potential Countermeasures

**Landmarks**

A. **Sound**
   1. **Acoustics - live/dead areas**
      - a. walls
      - b. passages
      - c. size, shape, materials of space
   2. **Sounds**
      - a. wood
      - b. metal
      - c. rubber
   3. **Sound emitting**
      - a. buzzers
      - b. bells
      - c. voices
      - d. recorded sounds
      - e. chirpers
      - f. clickers
      - g. fountains
      - h. horns
      - i. mechanical noises
      - j. other white noise

B. **Tactual/Haptic**
   1. 4 characteristics of texture (Templer and Lewis)
   2. **Mechanical vibrations**
      - a. vibrating mats
      - b. air movement
      - c. surface movement
   3. **Heat/Cold**
      - a. heat lamps
      - b. other heating elements
      - c. use sunlight

C. **Olfactory--smell emitting source**

D. **Light/Shadow/Color**
   1. Strong light
   2. Patterned light
   3. Color contrast
Shorelines

A. Tactual/Haptic

1. Natural edge of sidewalk
   - depends on material and level differences, i.e.,
     concrete/grass; asphalt/grass

2. Raised or lowered edging
   - bricks, cobblestone, concrete, etc.

3. Resilient strip
   - thermoplastic, rubber, etc.

4. Textured strip
   - textured concrete, gravel in epoxy, brick, etc.

B. Auditory

1. Sound emitting
   - street

2. Sound reflecting
   - echoes
     - metal strip flush with concrete

C. Olfactory

Orientation

1. Relating to initial use:
   a. Tactual/Haptic Maps
   b. Auditory Maps (directions)

2. Relating to repeated use:
   a. Siting issues (simple overall form)
   b. Relationship of site to Pedestrian network
   c. Distinctive landmarks, pattis, and nodes (memorable)

Phase III is 5% complete.
PROFESSIONAL STAFF:
Time Expended October 1980

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COST BY PHASE:
October 1980

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**TASK TIME CHART**

- Estimated
- Completed
Fiscal Information

We enclose:

- The bar chart shown; work performed this month by phase compared to the scheduled work.
- The money expended by phase and the cumulative totals for the month compared to the total scheduled costs.
- The time expended by the professional staff during the month and the cumulative totals.

Sincerely,

John A. Templer, Ph.D.
Principal Investigator

/nlp

Enclosures
12 December 1980

Mr. John Fegan
Federal Highway Administration
HRS-41
Washington, D.C. 20590

RE: Design guideline to make crossing structures accessible to the physically handicapped.

Contract #DTHF61-80-C-00131
Second Monthly Progress Report

Dear Mr. Fegan:

PHASE I

Task A

RAMP GRADIENTS

During the month of November, three major activities were undertaken:

1. detailed documentation of selected ramps;
2. pretest and test procedure revisions; and
3. initiation of ramp testing.

Detailed Documentation of Selected Ramps. To supplement the detailed measurements and written description of the physical condition and context (described in the October report), drawings were produced of each of the six ramps finally selected for the study (see attached drawings).

Pretest and Test Procedure Revisions. On November 4th a pretest was conducted with five handicapped participants. As a result of this test, several changes were made in procedure, and research assistants were involved in additional training sessions.
Two major procedural changes involved the activities to be conducted at each ramp. The original procedure (as defined in the proposal) identified three activities to be conducted during testing with the full (100) sample of participants:

**Activity 1: Free choice.** All the (100) participants will be asked to travel from the bottom to the top (and back) of each of the ramps. They will be asked to move at their own pace, and to stop and rest whenever they need to. They will use the ramps in the way that they would normally if they encountered them in their daily lives.

This will indicate to us how high each member of the group can go on each ramp. And it will show how far they chose to go before stopping to rest; in other words, they will self-select landing positions, both for ascents and descents. Finally, the test will indicate how long the subjects take and how long they rest.

**Activity 2: Maximum ramp landing position, single landing.** Again all the (100) participants will be used. They will be asked to travel up each of the six ramps and not to stop until this becomes necessary because of fatigue. No subject will be allowed to go further than 150 ft. This will limit their energy demand and reduce the time needed before the next tests can be run.

**Activity 3: Maximum ramp landing positions, and maximum height.** In the previous activity, the maximum distance to a single landing was established. In Activity 3 we plan to establish maximum distances between landings while attempting to travel 50 feet vertically.

All of the participants will be used. They will be asked to try to travel the whole length of the ramp and not to stop for each rest (landing) until this becomes necessary because of fatigue.

Pretest results suggest that there was no significant difference between the results of Activity 1 and Activity 3. In fact, participants suggested that they normally travel up gradients as far as they can each time before resting, because of the difficulties involved in getting moving again from a stopped position. In addition, the procedure was organized on the assumption that a team of two participants would complete the activities at one ramp in one hour. Pretest results demonstrated that in some cases this amount of time was inadequate to complete all three activities. On the basis of the above results the test procedure was modified to include only two activities at each ramp, a revised Activity 1 (to stress "normal pace" rather than either "free choice" or maximum distance between rest stops) and Activity 2. Activity 2 was revised to allow participants to complete the entire distance of the ramp (up to 400 feet) before resting rather than concluding the test at 150 feet.

A second major procedural change involved the trip down the ramp specified in Activity 1. Pretest results indicate that the trip down the ramp was a less critical aspect of the project (all participants returned to the bottom of the ramp without stopping to rest) than the trip up the ramp. The original procedure required that, for safety reasons, a researcher accompany the participant down the ramp. During the pretest it was found that if participants returned to the bottom of the ramp at their own pace, many times the researcher could not keep up with the participant. Because of the importance of insuring participant safety, and because this task appeared to be less critical than other tasks, testing of participants returning to the bottom of the ramp will be conducted with only a sub-sample of participants.
24.44' vertical climb

concrete retaining wall

guard rail

curb

250' overall length

1/10 North Ave.
20' vertical climb

brick paving   trees   2nd telephone pole

S

1st street light rough spot at 210'

240' overall length

1/12 North Ave. & Penn Ave.
parking

vertical climb

rough spot
parking
driveway at 270'
parking

parking
driveway at 200'
parking
rough spot at 360'

410'
overall length

1/13 6th St.
driveway at 0' parking Plum St. at 260' rough spot at 260' driveway at 360'

rough spot parking

manhole parking Atlantic Dr.

overall length

27'-1/2'' vertical climb

400'

1/15 5th St.
vertical climb

water meter at 225'

345'
overall length

1/17 North Ave. Presbyterian Center
Sub-sample testing will be conducted at a later date when additional research assistants will be available to insure participant safety.

Initiation of Ramp Testing. On November 13th ramp testing was initiated. An attempt was made to run six subjects a day, three days per week. However, delays were encountered due to the weather and in obtaining physician approvals (as described in the October report). In November, 19 participants were tested: 14 manual wheelchair users, 3 cane/crutch users; and 2 electric wheelchair users.

Phase I is 22% complete.

PHASE II

Task A

SLIP RESISTANCE

The search for materials and configurations of materials continued during the month of November. Written and sketched documentation was made for each material (see description in the October report). Test procedures were developed for slip resistance testing of both wet and dry surfaces. It is expected that this testing will be conducted in mid-December.

DETECTABILITY

The work accomplished during November is primarily a continuation of the work initiated in October. The literature search for data on visual contrast has resulted in several helpful sources which are currently being analyzed to establish guidelines for testing. In consultation with Dr. Brungraber an instrument to measure rebound, the Shore scleroscope, has been identified. We are in the process of locating such an instrument. The search continued for sources of materials for testing which range with respect to the qualities of detection described in the October report.

TEST TRACK

Work continued on the design of the test track and finalization of participant testing procedures. A range of materials has been identified for test track evaluation. Preliminary costing and construction procedures have been developed.

Phase II is 14% complete.

PHASE III

ORIENTATION CUES FOR THE BLIND

Work in November was devoted to identifying suppliers of existing countermeasures, evaluating novel potential countermeasures and developing test methodology -- some of the resources of Phase III were directed to Phase I, but genuine progress was seen in Phase III, nonetheless.
Identifying Suppliers of Existing Countermeasures. Whereas the needs of the visually impaired pedestrian have not been typically recognized in the U.S., considerable attention has been devoted to them in Japan and Scandinavia. Auditory cues have been particularly well-developed, although problems have been seen with buzzers and chirpers annoying neighbors and passersby. Attempts have been made to contact Japanese and Scandinavian suppliers, and a U.S.-made chirper has been ordered. The U.S. Park Service and other users of tape-loops have also been contacted. The American Foundation for the Blind has been particularly helpful in locating countermeasures.

In addition, information is being gathered about the "safety bridges" constructed by Nippon Industries. These are pedestrian crossing structures equipped with a full range of countermeasures: tactual cues, tape-loops, etc. These may provide useful insights for U.S. crossing structures. (There are, however, cultural differences. For example, the Japanese typically wear soft-soled shoes and detect textural cues with their feet.)

Evaluating Novel Potential Countermeasures. Countermeasures not already developed for use with the visually impaired are also being explored. For example, metal with a hollow cavity may be a distinctive landmark because of the noise produced by footsteps or a cane; an enclosed area may produce a unique echo. The various countermeasures listed in the previous report are currently being evaluated for durability, cost, distinctiveness, etc.

Developing Test Methodology. Progress has been made on developing the test methodology. Test routes and procedures have been tentatively established and subjects have been contacted. A table describing visually impaired potential subjects follows.

Phase III is 13% complete.
VISUALLY IMPAIRED PEOPLE INTERESTED IN PARTICIPATING

**Age Group:**
- 1-20: 2 Participants
- 21-25: 8 Participants
- 26-30: 10 Participants
- 31-35: 8 Participants
- 36-40: 7 Participants
- 41-45: 2 Participants
- 46-50: 6 Participants
- 51-55: 0 Participants
- 56-60: 4 Participants
- 61-65: 0 Participants
- Over 65: 4 Participants

**Sex:**
- Male: 17 Participants
- Female: 34 Participants

**Race:**
- White: 30 Participants
- Black: 21 Participants

**Annual Family Income:**
- SSI or Disability or Below 5,000: 27 Participants
- 5,000 -- 10,000: 6 Participants
- 10,000 -- 15,000: 3 Participants
- 15,000 -- 20,000: 2 Participants
- 25,000 -- 30,000: 0 Participants
- 30,000+: 3 Participants
- Unknown: 4 Participants
- VA Pension: 1 Participant
Degree of Impairment:

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Travel Aids Used:

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<td>Other</td>
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Fiscal Information

We enclose:

- The bar chart shown; work performed this month by phase compared to the scheduled work.
- The money expended by phase and the cumulative totals for the month compared to the total scheduled costs.
- The time expended by the professional staff during the month and the cumulative totals.

Sincerely,

Jean D. Wineman, Arch.D.
Principal Investigator

Enclosures
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COST BY PHASE:
November 1980

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3 February 1981

Mr. John Fegan
Federal Highway Administration
HRS - 41
Washington, D.C. 20590

RE: Design guidelines for making crossing structures accessible to the physically handicapped

Contract # DTFH 61-80-C-00131
Third Monthly Progress Report

Dear Mr. Fegan:

I am sorry this report has been delayed, but I was unwell for the first two weeks of January.

PHASE I

Task A

RAMP GRADIENTS

During the month of December, two major activities were accomplished:

(1) ramp testing was continued;

(2) procedures were developed for the creation of a computer data file.

Ramp Testing

Ramp testing was conducted through December 12th, at which time it was discontinued due to weather conditions. An attempt was made to test six subjects per day, three days per week. However, delays were encountered due to the weather, and due to poor participant turnout. As the weather became worse, the participant turnout rate dropped from its normal rate of about 80% to 50%. Although we scheduled additional participants to overcome this difficulty, we rarely obtained a full test group. In total, 39 participants completed the full day of
testing, 6 participants completed a half day of testing (see attached summary of test participants). Thus we have completed 42 percent (42 out of 100) of the total tests and 40 percent (32 out of 80) of the manual wheelchair tests. It is expected that ramp testing can be resumed sometime in the month of March as the weather improves.

Creation of a Computer Data File

Procedures were developed and tested for transferring the data collected on data recorders to a computer data file, in a form compatible with data analysis routines. It is expected that data will be transferred to the computer data file and prepared for data analysis in the month of January.

Phase I is 39% complete.

**SUMMARY OF TEST PARTICIPANTS**

**RAMP TESTING**

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PHASE II

DETECTABILITY

The testing procedures for four of the five measures of detectability have been finalized.

(1) A rebound test instrument has been designed and is presently being fabricated.

(2) The contrast testing will utilize the Munsell Color System (which we have ordered).

(3) The slip resistance testing utilizes the Brungraber Tester which we possess.

(4) The configuration testing will utilize a matrix of possible arrangements to systematically select potential configurations. This matrix consists of linear, orthogonal, non-orthogonal, non-linear and vertical variations that will be approached by the subjects from various angles.

An appropriate means of qualifying the fifth measure, the acoustic properties of the surface materials, has not yet been identified.

A preliminary list of approximately thirty surface materials has been developed. Each surface material was selected based upon the following criteria:

(1) whether the material exemplified a very strong characteristic in one of the five detectability measures and very low in the remaining four;

(2) conversely, exemplified very strong characteristics in several of the five measures; and

(3) a series of non quality related characteristics, such as cost, ease of construction, number of components, and maintenance.

Proposed for the month of January, we are planning to finalize all testing procedures, purchase or complete fabrication of the necessary testing instruments, and construct the testing panels for the test track.

SLIP RESISTANCE

The testing of twenty different paving materials was completed. The tests were conducted on level, dry surfaces only. The results were translated from the Brungraber figures into comparable coefficients of friction to determine whether the surfaces comply with present standards as stated in An Overview of Floor Slip Resistance by Dr. Robert Brungraber. Enclosed are the summary sheets for the slip resistance testing. Each has the listing of materials tested, their respective slip resistance and the coefficient of friction.

Because it was determined that the slip resistance is directly dependent upon the slope, a formula, provided by Dr. Brungraber, was derived allowing the results
from a level surface to be used to determine the respective necessary coefficient of friction for a sloped surface. The formula is:

\[
\frac{S_r \text{ (level)}}{\cos \theta} + \tan \theta = S_r \text{ (slope)}
\]

Where: \( S_r \) = slip resistance

\( \theta \) = angle of the slope

During the month of January, we plan to continue locating and testing paving surfaces.

Phase II is 22% complete.
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PHASE III

TASK A

Work in December was directed at three objectives:

1. further analysis of existing countermeasures;
2. exploration of novel countermeasures; and
3. refinement of test procedures.

ANALYSIS OF EXISTING COUNTERMEASURES

An auditory cuing device, produced by Traconex, was received on a trial basis. This device was designed to be mounted on pedestrian street crossing signals and makes a distinctive noise ("peep-peep") when the walk signal is activated. Although the advanced state of development of this device makes it worthy of evaluation, auditory cues have several limitations. First, in some cases they have been shown to interfere with other auditory cues relied on by the visually impaired, such as the surge of traffic that may indicate signal change. Second, the relatively high noise volume (90 - 110 dB's in some devices at 1 meter) has annoyed neighbors in the residential areas. These objections would suggest that auditory devices may be most suited to some situations where other auditory cues are not important and where there are no near neighbors. Other cues in addition to the Traconex device are presently being sought.

EXPLORATION OF NOVEL COUNTERMEASURES

The investigation continued of as-yet-unbuilt countermeasures. The practical consideration of olfactory, auditory and other cues suggested that cues need to be closely matched to the situation. For example, a fountain may be an effective auditory landmark, but because of relatively high initial costs and maintenance costs, may only be useful in a limited number of cases. Moreover, placement of landmarks is also important. It appears that when landmarks are placed at decision points they have much greater value. This observation will be tested empirically in the present study.

REFINEMENT OF TEST PROCEDURES

Procedures for spring testing are being established. Simulations of various crossing structure situations are being devised, and these will be used to test the various countermeasures.
### TABLE 1: Classes of Potential Countermeasures

#### Landmarks

**A. Sound**

1. **Acoustics - live/dead areas**
   - a. walls
   - b. passages
   - c. size, shape, materials of space

2. **Sounds**
   - a. wood
   - b. metal
   - c. rubber

3. **Sound emitting**
   - a. buzzers
   - b. bells
   - c. voices
   - d. recorded sounds
   - e. chirpers
   - f. clickers
   - g. fountains
   - h. horns
   - i. mechanical noises
   - j. other white noise

**B. Tactual/Haptic**

1. 4 characteristics of texture (Templer and Lewis)

2. **Mechanical vibrations**
   - a. vibrating mats
   - b. air movement
   - c. surface movement

3. **Heat/Cold**
   - a. heat lamps
   - b. other heating elements
   - c. use sunlight

**C. Olfactory--smell emitting source**

**D. Light/Shadow/Color**

1. Strong light
2. Patterned light
3. Color contrast
Shorelines

A. Tactual/Haptic

1. Natural edge of sidewalk
   - depends on material and level differences, i.e.,
     concrete/grass; asphalt/grass

2. Raised or lowered edging
   - bricks, cobblestone, concrete, etc.

3. Resilient strip
   - thermoplastic, rubber, etc.

4. Textured strip
   - textured concrete, gravel in epoxy, brick, etc.

B. Auditory

1. Sound emitting
   - street

2. Sound reflecting
   - echoes
   - metal strip flush with concrete

C. Olfactory

Orientation

1. Relating to initial use:
   a. Tactual/Haptic Maps
   b. Auditory Maps (directions)

2. Relating to repeated use:
   a. Siting issues (simple overall form)
   b. Relationship of site to Pedestrian network
   c. Distinctive landmarks, pattis, and nodes (memorable)

Phase III is 23% complete.
Fiscal Information

We enclose:

- The bar chart shown; work performed this month by phase compared to the scheduled work.
- The money expended by phase and the cumulative totals for the month compared to the total scheduled costs.
- The time expended by the professional staff during the month and the cumulative totals.

Sincerely,

John A. Templer, Ph.D.
Principal Investigator

Enclosures
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**TASK TIME CHART**

--- Estimated ---
--- Completed ---
# PROFESSIONAL STAFF:
Time Expended December 1980

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## COST BY PHASE:
December 1980

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5 March 1981

Mr. John Fegan
Federal Highway Administration
HRS - 41
Washington, D.C. 20590

RE: Design guidelines for making crossing structures accessible to the physically handicapped

Contract # DTFH 61-80-C-00131

Fourth Monthly Progress Report

Dear Mr. Fegan:

PHASE I

Task A

RAMP GRADIENTS

During the month of January, work progressed in two areas:

(1) preparation of the data for analysis;

(2) preparation for the continuation of ramp testing in Atlanta.

Preparation of the data for analysis.

A number of unanticipated problems were encountered in the process of transferring data from the MORE data recorders to computer files. These were largely technical problems related to the compatibility of the MORE recorder with the Georgia Tech computer terminals.

Although these difficulties have resulted in time delay, they have now been resolved. Data preparation should be complete within the next two weeks.

Preparation for the continuation of ramp testing in Atlanta.

It is anticipated that the continuation of testing of handicapped participants on ramps in Atlanta will be initiated at the beginning of March, weather permitting. In preparation for testing, we have begun to schedule participants.
and make arrangements for the use of accessible vans.

We are attempting to select participants who provide the required range of characteristics to reasonably represent the handicapped population within the critical group, manual wheelchair users (80% of sample), and the non-critical groups (20% of sample). With those participants previously tested, and those we are currently scheduling, we anticipate little difficulty representing a range in type of aid used, race, sex, and income.

We have encountered considerable difficulty in determining the percentage of the sample appropriate to represent persons over the age of 65. Statistics available from the National Center for Health Statistics indicate that 56% of males in wheelchairs are over age 65 and 75% of females in wheelchairs are over age 65. These figures, however, do not differentiate between dependent and independent travelers.

We have been attempting to obtain more accurate data on percentages of independent travelers over the age of 65 with little success. Organizations we have contacted include: the Association of Retired Citizens, the Gerontological Society, Senior Citizens Services, the Center for Independent living, State Agencies on Aging, the Administration on Aging, the National Center for Health Statistics, and the National Center for Barrier-free Environments. We are continuing to contact other organizations and experts in the field.

An additional difficulty which needs to be resolved in order to initiate testing in March is reimbursement for participant lunches. Due to the tight schedule during testing it is important that we be able to serve lunch to those who are able to participate in both the morning and afternoon test sessions. We have requested that this be an allowable item within our budget.

Phase I is 49% complete.

Phase II

Task A

SLIP RESISTANCE

The work accomplished in January was on the most part a continuation of the same type of work done in December; that of locating and testing of paving material. This work centered around finding additional examples of materials already tested. The reason being to insure accurate results. The slip resistance of a paving surface may change because of usage; therefore, it is necessary to test a particular paving material in several locations.

Task B

DETECTABILITY

The work relating to detectability focused on the finalization of testing and analysis procedures. The efforts pertaining to the Acoustics Testing were to locate a transient noise recorder. The instrument (according to Dr. Patronis, an
acoustician) capable of permanently recording the transient, almost instantaneous single sound of the tip of the long cane tapping the respective paving surface. The actual testing will be done using the Rebound Tester (see attached page) except the walls of the tester will be insulated and the grid removed and replaced with an insulated panel. The Rebound Tester has been designed. The critical dimensions will be determined by conducting a pretest consisting of videotaping blind persons at the Atlanta Area Services for the Blind. The videotaping will allow us to find out the width of the cane sweep, length of the person's stride, height of the cane tip (this figure would correspond to the dropping height), the average height of the hand (this figure would tell us the height of the pivot point for the cane), length of the cane, and what distance the cane tip is in front of the forward foot. See attached drawings of AASB pretest.

The testing procedure for configurations is quite complex because of the 510 possible configurations for linear and nonlinear arrangements. With consultation by Dr. Douglas Montgomery, we are formulating a factorial selection process based upon the primary variables of direction, width of test strip, spacing between test strips, and the thickness or depression of test strip.

**Test Track.**

Because the design of the test track is dependent upon a number of variables, we established a list of criteria.

The work to be accomplished in February will be the final design of the test track and the instruments for testing.

Phase II is 33% complete.
REBOUND TESTER

- plywood, glue, etc.
-.sources may not be needed.

VDO

CHORDED ATTITUDE

PLAN VIEW

TEST CASIPIE
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<th>A cof</th>
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ANTHROPOMORPHIC DATA COLLECTION OF VISUALLY IMPAIRED

- Participant No.
- Weather Cond.
- Sidewalk Surface
- Length of Run
- Width of Run

Observation of Participants During Testing

1) Width of cane sweep
2) No. of steps per Run (2) Runs in a Test
   1st Run
   2nd Run
3) Veering Problems: Great walks off more than 3 times
   Little walks off 1 to 3 times
   None stays on track

Observation of Participants from Video Tapes

1) Height of cane tip (at highest point)
2) Avg. height of hand (where hand holds cane)
3) Length of cane
4) Length of step
5) Distance cane tip is in front of forward foot
I hereby consent to act as an experimental subject in the architectural research program of the Georgia Institute of Technology. I am a physically handicapped person. My participation is on a voluntary basis and is in consideration of the contributions of this program to the advancement of knowledge in the area of improved accessibility for handicapped persons.

1. I understand that I may be asked to walk a designated path until told to stop.

2. I understand that while walking this path researchers will be gathering data.

3. In connection with this study, I agree that photographs may be taken of me.

4. I agree that the data that I provide may be used for analysis and publication, but that no information will reveal the identity of the participants.

5. I understand that this study is being done to benefit science and research education, and agree that any photographs or research findings may be used for that purpose including publication in scientific journals.

6. I understand that I may make any inquiries concerning the procedure and that I am free to withdraw my consent and to discontinue participation in the project at any time. If I do not choose to participate now or if I withdraw from the study later, this will have no effect on any services or benefits that I am entitled to from the Dept. of Vocational Rehabilitation or any other agency.

7. I understand that proper safety precautions have been taken, but in the event of an accidental injury, I understand that no financial or other compensation is available from the Georgia Institute of Technology, the Board of Regents, or the Dept. of Human Resources.

Subject's Signature

Investigator

Informed Consent Form
Criteria for Design of Test Tracks

Design Criteria:

1. The track should be large enough to be able to incorporate a sufficient number of test panels to test the five qualities of detectability.

2. The track should be large enough to allow the participant sufficient distance between test panels to reach a normal walking speed.

3. The individual test panels should be large enough to allow a long cane sweep without the possibility of the tip touching another test panel at either side.

4. The test panels should be large enough (width and length) to allow some veering by the participant without detecting an adjacent panel.

5. The construction of the test track should simulate the ambient condition of the test panel.

Physical Criteria:

From the literature search (Syracuse and Georgia Tech), the maximum stopping distance after detection was 48", but of the more detectable paving surface was a distance of 42".
PHASE III

Orientation Cues for the Blind

Work in January was focused on several tasks:

1. creating a typology of crossing-structure end conditions that affect the blind;
2. creating a typology of crossings;
3. further developing test methodology;
4. developing a list of classes of problems encountered by the visually impaired;
5. completing a list of countermeasures.

Typology of End Conditions

Based on the sample of 124 crossing structures documented in previous research by the Pedestrian Research Laboratory, a typology was created of five end condition situations. These included: continuation of main pedestrian path (62 examples), continuation of path across roadway (50 examples), 90-degree-turn toward or away from structure (52 toward, 20 away), end condition at parking lot, plaza or beach (17 examples), veer toward or away from crossing structure (24 toward, 20 away). Identification of these end condition types helps highlight the situations for which orientation cues must be developed.

Typology of Crossings

A similar procedure was followed to create a typology of crossings. Fourteen types were identified ranging in complexity from simple straight approach to a double-switchback-double-or-triple-stair. These are represented in the attached drawings.

Development of Test Methodology

Test methods were further refined for expected start of testing in April.

Developing Problem Classes

Based on panel discussions in the previous Handeped research and on the panels in present research, a number of orientation problems were identified. These are presented in Table 1.

Completing a List of Countermeasures

A fuller list of countermeasures was prepared, and preliminary evaluation was started. A sample evaluation sheet is attached.

Phase III is 32% complete.
ORIENTATION CUES FOR THE BLIND

Table 1: Travel Problems

I. Orientation
   A. Main pedestrian grid
      1. not knowing location of crossing
      2. not finding approach path
   B. Approach Path
      1. losing orientation to cardinal directions
      2. losing orientation to crossing structure
      3. not knowing which is correct approach path
      4. not finding access to crossing structure
   C. Access
      1. not knowing which stair/ramp leads to crossing
      2. not knowing which crossing is reached
      3. losing overall cardinal directions
      4. losing orientation to direction of crossing
   D. Crossing
      1. not knowing appropriate down-access
      2. not knowing when to expect down-access
   E. Down-Access (parallel problems to access)
   F. Approach to pedestrian network (parallel problems to crossing structure approach)
Orientation Cues for the Blind
Continued

II. Mobility and hazard-avoidance

A. Pedestrian network approach
   1. not finding approach
   2. not maintaining appropriate line/not staying on path
   3. not anticipating stairs or ramp
   4. not being able to avoid pedestrian/cyclists
   5. not anticipating obstacles

B. Access
   1. not detecting obstacles in path
   2. not detecting stairs/ramp
   3. not detecting overhanging hazards
   4. not following most efficient path

C. Crossing
   1. not detecting obstacles in path
   2. not detecting overhanging hazards
   3. not detecting down-access
END CONDITION TYPOLOGY

CONTINUATION OF MAIN PEDESTRIAN PATH
62 EXAMPLES

CONTINUATION OF PATH ACROSS ROADWAY
50 EXAMPLES
90° turn towards or away from structure

52 examples "towards"
20 examples "away"

End condition at parking lot, plaza, or beach

17 examples

Veer towards or away from crossing structure

24 examples "towards"
20 examples "away"
TYPE ① STRAIGHT APPROACH -38

SIDEWALK

STREET

SIDEWALK

TYPE ② ONGRADE CHANGE OF DIRECTION -28
TYPE 3 SPIRAL RAMP 1 OR 2 SIDES - 15

TYPE 4 90° DOUBLE STRAIGHT RAMP/STAIR - 10

TYPE 5 90° DOUBLE SWITCHBACK RAMP/STAIR - 8

TYPE 6 1 SWITCHBACK/ION GRADE - 5
TYPE 7 DOUBLE SWITCHBACK
DOUBLE OR TRIPLE STAIR -4

TYPE 8 FIVE PLUS APPROACHES -3

TYPE 9 APPROACH AWAY FROM BRIDGE -2

TYPE 10 -2
TYPE 1 STRAIGHT RUN / ON GRADE - 2

TYPE 2

TYPE TRIPLE ACCESS - 2

TYPE 4 - 1
**Fiscal Information**

We enclose:

- the bar chart shown; work performed this month by phase compared to the scheduled work;
- the money expended by phase and the cumulative totals for the month compared to the total scheduled costs;
- the time expended by the professional staff during the month and the cumulative totals.

Sincerely,

John A. Templer, Ph.D.
Principal Investigator

JAT:nlp

Enclosures
### PROFESSIONAL STAFF:
Time Expended January 1981

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### COST BY PHASE:
January 1981

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**TASK TIME CHART**

*Estimated*

*Completed*
3 April 1981

Mr. John Fegan
Federal Highway Administration
HRS — 41
Washington, D.C. 20590

RE: Design guidelines for making crossing structures accessible to the physically handicapped

Contract #DTFH 61-80-C-00131

Fifth Monthly Progress Report

Dear Mr. Fegan:

PHASE I

Task A

RAMP GRADIENTS

During the month of February, work continued in two areas:

   (1) preparation of the data for analysis;

   (2) preparation for the continuation of ramp testing in Atlanta.

Preparation of the data for analysis. Further difficulties were encountered in the process of transferring data from the MORE data recorders to computer files. Again these were technical problems which are largely resolved at this time. It was discovered that the memory of one of the data recorders was faulty. We have been in contact with the manufacturer who has made modifications to the data recording machines to improve the memory system. The manufacturer has agreed to send out three new machines with improved memory to replace the machines we currently have. As a result of this problem, some of the recorded data has been lost. We estimate that this is at most one-sixth of the data which has been collected to date. Data transfer has begun.

Data analysis routines are being prepared. It is expected that initial results will be available in April.
Preparation for the continuation of ramp testing in Atlanta. Preparation is underway for continuing the ramps testing in Atlanta beginning the last week in March. Arrangements have been made for the use of accessible vans, and participants are being scheduled. We are attempting to increase our current percentage of participants in the over 65 age group in order to obtain a more representative sample of persons in wheelchairs.

It is expected that the testing of participants on ramps in Atlanta will take approximately six to eight weeks (from the date we begin testing) to complete.

PHASE II

Task A

SLIP RESISTANCE

No further work has been carried out on this task.

Task B

DETECTABILITY

The work accomplished in February focused upon the finalization of the design of the test track, the respective paths each participant should take during the testing period, the design of the test panels and the data collection procedure. Also during this month, the necessary coordination of ordering materials and scheduling participants was organized but not finalized.

The work involved with the test track pertained to fulfilling the design criteria, respecting the need to design a closed loop path, and the acquisition of the space for the test track. Because the criteria stated that the blank panels must be at least two panel widths long from the test panels (the premise being a participant should be at normal walking speed when he/she encounters a panel), and there must be a minimum of 32 panels to allow for a statistical analysis based upon a six-factor base, the difficulty in the design was arriving at a configuration which satisfied these criteria and provided for a closed loop path by each participant with as few overlaps as possible (see attached sheet of test track). The reason for the closed loop path system is that it allows for: (1) a controlled path which permits us to have a permanent and predesignated path for each participant which also aids in the actual testing; and (2) allows for a randomization of order without the need to design "n" number of test runs. To insure against any discrimination by the testers and to prevent a repetition of test runs, we randomized the starting panel for each participant; therefore when a participant is about to be tested all that is necessary is to check the sheet for their respective starting panel (see attached sheet with random starting panel list).

The design of the test panels involved (1) statistical configuration of the six factors; (2) the delineation of the construction details; and (3) the selection of probable materials. Utilizing Dr. Montgomery's assistance again we redesigned the test panels so that the total number of panels necessary was only 32 rather than the 64 originally needed. The reason was not to simplify the statistical analysis; in fact, it may complicate the analysis, but rather to simplify the
testing procedure and to insure against an accidental detection because a panel (which if 64 were necessary would have to be a drop-in panel) did not fit properly. Because we have only a total of 32 panels, the test panels can be cast directly in place, therefore, insuring a perfect connection. The delineation of the construction details of test panels requiring a cavity was done (see attached sheet). The purpose being to expedite construction and to guarantee uniformity. The solution of applicable paving surfaces was completed. The process utilized the following criteria: (1) the material should be one that may be normally found on an over/under crossing (i.e., concrete, but may be specially textured); (2) the material should have low maintenance characteristics; (3) the test panel and specifically the paving surface should not endanger the pedestrian (e.g., the paving surface can not cause a person to trip or slip); (4) the test panel should not be so complicated that a maintenance crew for a local transportation department would be unable to fabricate or maintain (to satisfy this last criteria, we are only constructing panels that members of the Pedestrian Research Lab are capable of making); and (5) in conjunction with the first criteria, the materials selected will not be so unique that they can not be acquired or replaced if vandalized.

The collection of data is a critical issue because of (1) the complexity of the path; (2) the number of questions both personal and detectability-related that must be collected; and (3) the number of participants versus the number of research personnel. The finalization of the process involved designing a method to allow the researcher to collect the respective quantitative and qualitative data from each participant each time he/she encounters a test panel. The method devised was to place an "X" in each square and in each quadrant write a code number to represent the actual stopping distance along with a second number to represent the participant's evaluation of the level of detectability. For example, with a person approaching from the left, the numbers would be placed in the left quadrant; if they required 24" to detect the material, a 4 is written and then either a 1, 2, 3, 4, or 5, is used to represent the qualitative measure. Because the path the participants walk is quite complex, to simplify the testing procedure for the researchers we are dividing the path into three sections; therefore, the researcher needs only to follow along for one third the length (see Data Collection Sheets).

We are in the process of finalizing the list of possible participants. The selection was restricted to persons totally blind and those people capable only of light perception. So far we have been able to obtain a list of approximately 30 interested individuals. We have also prepared but have not mailed the release forms. Presently all that remains to be done is the scheduling for the actual testing.
Experimental design for detectability studies. The experimental framework consists of seven basic factors. They are groove type (3 characteristics: depth, width, spacing), an acoustical factor (2 characteristics), slip resistance, rebound, color (4 characteristics), direction of approach and background noise. The initial experiment will concentrate on groove type, acoustics, and the rebound factor. This gives 3 groove types, 2 acoustic characteristics and rebound, or a total of 6 factors.

It is initially proposed to investigate each of these factors at two levels (a low and high value, say). This will allow statistical detection of a significant factor effect, and linear interpolation over the range of the factor studied. Additional experimentation using more levels of those factors found to be important will permit the development of threshold values and possibly more refined interpolation equations.

The test track contains at most 37 test squares. Since a complete replicate of the $2^6$ design (6 factors at two levels each) would require 64 squares, we propose using a one-half fraction of a $2^6$ or a $2^{6-1}$ design) having 32 test squares. The runs that are to be made are shown in Table 1. In this table "+" represents the high level of a factor and "-" represents the low level. Each row of the table represents one test square that must be constructed, and the pattern of + and - signs in that row denote the combination of factor levels present in that square.

While only 32 runs have been performed for each subject, this design is adequate to allow all main effects and low-order interactions of these effects to be studied. Specifically, each main effect (groove depth, groove width, etc.) is aliased with a five-factor interaction, and each two-factor interaction is aliased with a four-factor interaction. The complete alias relationship is shown in Table 2.

The statistical analysis of this design can be performed using the methods described in Montgomery (1976). Since the design will be replicated n times (once for each subject) we will be able to obtain an independent estimate of experimental error against which to compare the statistical significance of effects.

Further experimentation will be based on the results discovered at this stage. For example, if the acoustical factors emerge as influential, an additional experiment can be designed with more levels of the factors so that threshold detection levels and an interpolation equation may be obtained.
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PARTICIPANT NO. | DISTANCE KEY
--- | ---
Test Run 1 or 2 | 1 6”  5 30”
| 2 12”  6 36”
Time of Day | 3 18”  7 42”
| 4 24”

PERSONAL DATA (From Photograph)

1. Level of Acuity   TB LP HP
2. Adventitiously or Congenitally
3. Hand Height
4. Sweep Width
5. Stride Length

QUESTIONS:
1. Please describe the five most detectable paving surfaces.
   a)  
   b)  
   c)  
   d)  
   e)  
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PHASE III

ORIENTATION CUES FOR THE BLIND

Activity in February was devoted to several tasks: (a) refining the list of countermeasures; (b) prioritizing important problems; (c) further developing test methodology.

Refining the list of countermeasures. At least three sets of countermeasures are emerging from the present research: informational countermeasures, design-and-planning countermeasures, and training countermeasures. Most effort has been devoted toward developing the first two sets. Informational countermeasures are shown in the attached table, and are categorized by the general type of information each provides: point, path, direction, area or spatial relationship. This list represents countermeasures that have been shown in initial investigation to be at least moderately effective and practical (a much larger list was edited to produce the present list). The order of countermeasures in each category reflects the expected order of desirability of countermeasures. This order may change, of course, when the results of the Atlanta lab test are analyzed.

Design-and-planning countermeasures are issues of form, spatial relationship and structure that should be considered in the initial construction of crossing structures. These are also shown in an attached table.

Prioritizing important problems. Problems have been prioritized in several different ways: (a) by analyzing the 124 crossing structures previously documented by the PRL; (b) through discussions with various mobility experts and visually impaired people. The attached matrix shows the relationship between problems and design features for the 124 crossing structures. Similarly, the attached table shows the refined list of problems developed through discussion with visually-impaired people and mobility instructors. In general, these tables show that three kinds of problems affect the visually impaired crossing structure user: overall orientation problems (e.g., becoming disoriented with respect to cardinal directions), immediate orientation problems (e.g., not knowing where to expect the end condition), mobility problems (e.g., not detecting a hazard, or up-access).
PROBLEMS ENCOUNTERED BY THE VISUALLY IMPAIRED IN USING CROSSING STRUCTURES

* Problems shown to be especially serious

I. Not Knowing Where To Expect Intersections/Hazards

*A. Approach end condition
B. Return to main path end condition
C. Up access
D. Down access
E. Top of crossing
F. Bottom of crossing
G. Obstacles (e.g., overhanging branches, cantelevered phonebooths, etc.)

II. Not Detecting Intersections/Hazards

A. Approach end condition
B. Return to main path end condition
C. Stairs/curbs
D. Up access
F. Down access
F. Top of structure
G. Bottom of structure
H. Obstacles

III. Not Knowing Where To Expect Shorelines/Edges

A. Of path
B. Of access-ramp, stair
C. Of crossing

IV. Not Detecting Shorelines/Edges

A. Veering on path
*B. Veering off path

V. Losing Cardinal Directions

VI. Losing Site Orientation (e.g., not knowing where to find crossing, end condition, etc.)

VII. Not Knowing Appropriate shoreline/Edge (e.g., where more than 1 path)

VIII. Not Knowing Appropriate Intersection

A. Which path
B. Which end condition
C. Which down access
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50
COUNTERMEASURES FOR TRAVELLERS WITHOUT FUNCTIONAL VISION*

(Order within categories reflects approximate expected order of practicality of countermeasures)

I. Point Information
   A. Rubber/resilient mats
      1. Patterned
      2. No pattern
   B. Contrasting textures
   C. Metal grates
   D. Textured metal plates
   E. Rubber strip pattern
   F. Wood planks over air space
   G. Bulges and depressions in rail
   H. Braille in rail
   I. Braille blocks

II. Path Information
   A. Continuous shorelines
      1. Rubber strip
      2. Recessed aluminum channel
      3. Bolt-through metal plate
      4. Bolt-on metal or wood plate
      5. Railroad ties
      6. Metal or wood plate staked into ground
      7. Concrete curb
      8. Brick
      9. Braille blocks
   B. Discontinuous shorelines
      1. Bollard checkpoints
      2. Low relief markers
   C. Paving types
      1. Brick
      2. Cobblestones
      3. Asphalt
      4. Patterned concrete
      5. Inverse crown path
      6. Resilient tennis court covering
   D. Handrails
III. Area Information
   A. Traffic noise
   B. Chirpers

IV. Spatial Information
   A. Tactual/haptic maps
   B. Tape loops

V. Directional Information
   A. Fixed north arrow
   B. Chirpers

*Persons with functional vision would benefit from graphics, high contrast colors, and signage in all categories.*
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<tr>
<td>NOT KNOWING APPROPRIATE INTERSECTIONS</td>
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<td>A - I A, B A, B</td>
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</table>
I. End Conditions
A. End condition across parking lot
B. Veer away from structure
C. Veer towards structure
D. 90° turn towards or away from structure
E. Continuation of path
F. Cross street in path

II. Access Types
A. Spiral ramp greater than 360°
B. Stair and ramp intersect
C. Spiral ramp less than 360° and not in increments of 90°
D. Spiral ramp of 360°
E. Two or more 180° switchback stairs or ramps
F. Single switchback stair or ramp

III. Path/Crossing Types
A. Slight curve or dogleg
B. Multiple intersecting paths or access points
C. Crossing over 400 feet
D. Path/crossing between 100-400 feet

IV. Shoreline Situations
A. Dirt Path
B. Down curb edging paved walk
C. Open rail along paved walk
D. Vegetation or dirt edging paved walk
E. Chain link fence edging paved walk

V. Hazards
A. Parked cars
B. Sewer grates
PLANNING CONSIDERATIONS FOR PEDESTRIAN CROSSINGS

I. End Condition
   A. Turn 90° towards crossing
   B. One end condition per side
   C. Same type of end condition on both sides
   D. Consistent markings at both end conditions
   E. Place marker (material change, bollard, texture, etc.) at intersection of end condition and main path

II. Path
   A. Short path before access
   B. Straight path
   C. Paved w/curb or other shoreline
   D. At least 48" wide
   E. Lead directly to access
   F. No intersecting paths
   G. All turns in increments of 90°
   H. Channelize path
   I. Consistent markings on all paths

III. Access
   A. No more than 360° total turn
   B. Don't intersect 2 types of access
   C. Material change to mark top & bottom of access
   D. Same mode(s) of access at both ends
   E. Consistent markings at both access points
   F. All turns in increments of 90°

IV. Crossing
   A. At least 48" wide
   B. As short as possible
   C. Cross perpendicular to street or river
   D. Straight crossing
   E. Access points at extreme ends of crossing
   F. No intersecting paths
   G. Any turns at 90° angle

V. Hazards
   A. Physical barriers between pedestrians and cars or bikes
   B. All points visible to others
   C. Physical barriers to guard from all hazards
   D. No objects protrude into path below 7’ unless cane detectable on shoreline side of path
   E. Smooth paving w/small expansion joints
   F. Avoid sewer grates etc. in path
Further developing test methodology. Further refinement of test methods was accomplished, including development of procedures and instruments.

Fiscal Information

We enclose:

- the bar chart shown; work performed this month by phase compared to the scheduled work;
- the money expended by phase and the cumulative totals for the month compared to the total scheduled costs;
- the time expended by the professional staff during the month and the cumulative totals.

Sincerely,

John A. Templer, Ph.D.
Principal Investigator

JAT:nlp

Enclosures
**PROFESSIONAL STAFF:**
Time Expended February 1981

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**COST BY PHASE:**
February 1981

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**TASK TIME CHART**

---------- Estimated
---------- Completed
15 May 1981

Mr. John Fegan
Federal Highway Administration
HRS -- 41
Washington, D.C. 20590

RE: Design guidelines for making crossing structures accessible to the physically handicapped

Contract #DTFH 61-80-C-00131

Sixth Monthly Progress Report
(March, 1981)

Dear Mr. Fegan:

PHASE I

Task A

During the month of March, work progressed on:

(1) preparation of data for analysis;

(2) the continuation of ramp testing in Atlanta.

Preparation of data for analysis.

About one-half of the data now collected has been transferred to computer files. The process of transferring data from the MORE data recorders to computer files is considerably more time consuming than we had expected. Because of the difficulties with the MORE memory (as mentioned in the previous monthly report) some of the data files will require manual input to salvage useable portions of the files. This process and more routine "cleaning" of the data in preparation for analysis has begun.

Continuation of Ramp Testing.

Ramp testing in Atlanta was initiated the last week of this month. We are testing subjects approximately three days per week.

A change has been made in the ramp testing procedure. As a part of the procedure for test one on each ramp, participants were asked to roll back onto
the portable landing which was placed behind their wheelchair. During ramp testing in the Fall it was found that participants resisted using the landing. They preferred to stop and rest against the landing, without rolling onto it. Even when asked repeatedly, participants would not use it. They felt that rolling back onto the landing deterred their progress up the ramp. For this reason, during the continuation of ramp testing the portable landing was not used. Instead, a research assistant was instructed to hold the wheelchair in place whenever a participant desired to rest. This procedure was much more acceptable to participants.

We expect to complete ramp testing in May.

PHASE II
Task B
DETECTABILITY

Work accomplished in March focused on the fabrication of the test track, including ordering materials, panel re-design, and slight modification of test paths that each participant will follow during testing. Selection and scheduling of participants was nearly completed and a preliminary test protocol was developed and modified.

This month's primary effort involved the test track. Various materials appropriate to simulate textural differentiation were chosen based on appropriate physical character, availability for acquisition, economy of cost and suitability for eventual mass production, casting and installation on site. Textural panels were designed using steel, vinyl, neoprene, concrete and wood in combination with rubber, sandpaper, steel discs, and rubber.

Fabrication of the basic test track without textural panels was complete in late March. A four-inch concrete slab, 64' x 32' was poured in the Research Laboratory in mid-March. Thirty-two 4'x 4' areas were contained within the slab for the fabrication of test panels. These areas were located according to the test sequencing developed in February. All surface concrete not part of the 32 panels was leveled and brushed to a consistent texture during finishing.

Initial fabrication of the test panels occurred in late March. This activity focused on initial sizing of the base panels to form the base for textural surfaces. Panel fabrication will continue in April.

We have completed the selection of test participants. A draft of the test protocol has been prepared and is being studied for appropriateness. We expect further improvements to this protocol in April.
PHASE III

Orientation Cues for the Blind

Activity in March was devoted to several tasks:

1. establishing an Atlanta test route;
2. developing construction methods for countermeasures.

Establishing an Atlanta Test Route. A nine-segment test route was established. The route simulated important problems identified in the analysis of 124 crossing structures (see monthly report for February). For example, the test route provides a long, undifferentiated sidewalk, a dirt path, up-stairs and down-stairs and so on. Visually-impaired participants will be instructed by tape recording to traverse the route segment by segment. Their performance on each segment will be analyzed by recording the time necessary to complete the segment, by recording their performance on a five-point scale, and by other methods. The refined methodology will be discussed in the next monthly report.

Developing construction methods for countermeasures. Construction methods were developed for the countermeasures to be used in the field testing, including: several bolt-on shorelines, mats of various textures, handrails of several designs.

Fiscal Information

We enclose:

- the bar chart shown; work performed this month by phase compared to the scheduled work;
- the money expended by phase and the cumulative totals for the month compared to the total scheduled costs;
- the time expended by the professional staff during the month and the cumulative totals.

Sincerely,

Jean D. Wineman, Arch. D.
Investigator
**PROFESSIONAL STAFF:**
*Time Expended March 1981*

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**TASK TIME CHART**

- `ESTIMATED`
- `COMPLETED`
5 June 1981

Mr. Bill Wheeler
Federal Highway Administration
HRS — 41
Washington, D.C. 20590

RE: Design guidelines for making crossing structures accessible to the physically handicapped

Contract #DTFH 61-80-C-00131

Seventh Monthly Progress Report
(April, 1981)

Dear Mr. Wheeler:

PHASE I

Task A

During the month of April, work progressed on:

1. data analysis;
2. ramp testing in Atlanta.

Data Analysis. About two-thirds of the data collected to date has been transferred to computer files. We are in the process of "cleaning" this data in preparation for analysis. Some preliminary analysis routines have been tested on a small portion of the data.

Ramp Testing in Atlanta. Testing of participants on the ramps in Atlanta continued this month. We are experiencing a high rate of absenteeism. Approximately 50 percent of the participants scheduled for any particular day do not attend, even with a reminder phone call the previous day. These participants are rescheduled, but it appears that testing will have to extend through the month of May.

We have been attempting to increase the number of participants in the over 65 age group in order to obtain a more representative sample of persons in wheelchairs. Telephone calls to nursing homes, elderly housing projects, and associations of older persons have not been too successful; most of the older persons who have been identified as wheelchair users are not independent
travellers. We are, however, continuing these efforts.

PHASE II

Detectability

Research in April focussed on three activities:

1. The fabrication of the test track;
2. The first pre-test of the partially completed track by four blind subjects; and
3. The revision of the test protocol.

Test Track. During the finalization of test track design and selection of materials for the 32 test panels three construction variables had to be dealt with: availability of material, acquisition cost and ease of installation. To a large extent fabrication of the test track is being done with materials that are commonly available at reasonable cost.

Economy of fabrication is a concern addressed in the track design. The physical shape of each panel suggests the future potential for volume production. However, for this track, each panel is a prototype and thus requires an abnormally high fabrication time. This is averaging nearly twenty man hours per panel for completion.

The panels are constructed of four base materials, steel plate, concrete, neoprene and wood with texture either scored or added to the surface. A complete description of each panel will be included in the May Report.

Fabrication of the Test Track is approximately 50% complete as of April 30.

Pre-Test. Four subjects participated in a pre-test study of the track in late April. The intent of this activity was to test the protocol and the basic design of several test panels. Following the pre-test, the protocol was modified and one type of panel with 1/8" textured squares was eliminated. The 1/8" size was enlarged to 1/2".

Modified Protocol. Following the pre-test, the protocol was modified. The revised version follows:
SCENARIO FOR DETECTABILITY STUDY

INTRODUCTION

This is a study to try to find out how easily visually impaired persons can detect changes in walkway surface materials.

(a) We have constructed a special test track in which panels of various materials have been set into a walkway made of concrete, similar in texture to that of a sidewalk. We will be observing whether you can detect these different materials as you walk over them.

(b) You will be asked to walk a specific path on the test track, so that you will cross some of the test panels.

(c) You will continue to walk along the concrete walkway until you detect a change in the floor surface material.

(d) There may or may not actually be a change in surface material in the route you take.

SPECIFIC INSTRUCTIONS FOR EACH RUN

(a) I will tell you when to start walking.

(b) Please stop immediately when you are quite sure that you have detected a surface that is different from the concrete walkway from which you started your walk.

(c) If you are not sure that you have detected a different surface please keep walking.

(d) I may ask you to stop at any time, even though you may not have perceived a change. Please stop immediately when I ask you to.
Any questions?

When you detect a change in surface material, the researcher will ask you to say how difficult it was to detect the material. You will rate the material as either:

1. "Very difficult to detect"
2. "Fairly hard to detect"
3. "Some trouble in detecting"
4. "Fairly easy to detect"
5. "Very easy to detect"

We are interested also in how you detected the difference. For example, some materials may sound different to you; others are rougher; and some others may have more bounce to them, like rubber. The observer will ask you to decide whether you detected the difference primarily because of its:

S = Sound
B = Bounce
R = Roughness

or some combination of these (SB, SR, BR, SBR).

(e) After you have completed these ratings, we will ask you to proceed to the next test, and to turn either to the right or left, or proceed straight ahead. Then you will walk until you detect another change in surface material. Please do not start to walk until we ask you to.

(f) These runs will continue until you have completed the whole path, unless you need to stop for any reason.

Do you understand the instructions?
MAJOR POINTS IN THE INSTRUCTIONS

(1) Walk on the concrete until you believe you have detected a change in surface material.
(2) When you have detected a change, stop immediately.
(3) Please rate the surface.
(4) Wait for further instructions.
PROCEDURE FOR DETECTABILITY TESTING

PRELIMINARY

1. Read Scenario to all the participants at the same time.
2. Ask if there are any questions.
3. Question participants to ensure that they understand.

TEST

1. Take the subject to a test location in order to practice the procedure once.
2. Determine the correct starting panel from the list of starting panels.
3. Write on the test track sheet all the proper information:
   (a) participant number.
   (b) starting panel number
   (c) researcher name
   (e) the respective test number (1 or 2)
4. Guide the person to the panel via a route which does not touch a test panel.
5. Orient the person in the proper direction with respect to their path. Stand in front of them but beyond where they will walk to.
6.* At this time, you just repeat the major points of the scenario to the subjects, specifically the evaluation scale (this is on the data collection page).
7. Once you both are ready, ask the subject to proceed at a normal walking pace (please emphasize this, because some people may walk too slowly).

ITEMS OF IMPORTANCE WHILE THEY ARE ON THE CONCRETE

False Stop. "FS"—The participant has stopped on the concrete and not on a panel. Write a FS on the test track sheet. Please obtain rating nevertheless.
Veering. "V"— The participant may veer either to the left or right from the path. If they appear to be heading off course, write a V on the test tract sheet, at the point of correction (where you have asked them to stop).

To correct the veering problem, just ask them to take one or two steps to the left or right which will center them on the path (something to watch: a right-handed person, with the cane in the right hand, has a tendency to veer to the right).

Detecting the Panel. Persons using a long cane may use both their cane and their feet to detect the change in surface material. Be aware of both when you are walking with them.

Stopping the Subject. If a subject's feet have left the test panel, ask him then to stop for the next test.

Stopping distance.

(1) When a person has detected a panel, immediately, if not sooner, look down at their feet.

(2) Record the location of the toe of the front foot at its farthest forward position (Some people may detect the panel in a short distance, but because of their reaction time to stop, they may take additional steps. Record the position of that additional step).

(3) Someone may stop, then take a step backward to check themselves; record the farthest forward position.

Participant Rating

(1) When the participant detects a panel (or stops because he thinks he has detected a panel) you must obtain both of the ratings as to how detectable the change was for him. The rating should be always with respect to concrete, and not another panel.

(2) Write this number and letter along with the stopping distance number in the respective triangle of the panel.

Turning Instructions

Only after the numbers have been written in the triangle, give them the proper turning instructions, either left, right, or straight forward.

** As you know, the path is complex, so be sure you are making the correct turn.

These instructions should be followed for each run, from panel to panel, until the path has been completed.
INSTRUCTIONS FOR RECORDING STOPPING DISTANCE AND PARTICIPANT RATING

STOPPING DISTANCE. The first number is the stopping distance (see Key).

PARTICIPANT RATING. The second number is the participant rating.

DETECTION METHOD. Participants statement of how he detected surface.

DUPPLICATION. Write a 2, 3, or 4 in front of the two-digit number to designate the second, third, or fourth time a participant has contacted a panel.

EXAMPLE: The "41" means the person stopped at the fourth circle and rated it very difficult, and he first detected it because it felt rougher.

DIRECTION. Record the number in the triangle adjacent to the direction the subject has come from — if he comes from the left, write the numbers in the left triangle...

### STOPPING DISTANCE KEY

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<thead>
<tr>
<th>Number</th>
<th>Description</th>
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<tbody>
<tr>
<td>0</td>
<td>Detected with cane</td>
</tr>
<tr>
<td>1</td>
<td>6&quot; First Circle</td>
</tr>
<tr>
<td>2</td>
<td>12&quot; Second Circle</td>
</tr>
<tr>
<td>3</td>
<td>18&quot; Third Circle</td>
</tr>
<tr>
<td>4</td>
<td>24&quot; Fourth Circle</td>
</tr>
<tr>
<td>5</td>
<td>30&quot; Fifth Circle</td>
</tr>
<tr>
<td>6</td>
<td>36&quot; Sixth Circle</td>
</tr>
<tr>
<td>7</td>
<td>42&quot; Seventh Circle</td>
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### DETECTION METHOD KEY

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<td>S</td>
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<tr>
<td>B</td>
<td>Bounce</td>
</tr>
<tr>
<td>R</td>
<td>Roughness</td>
</tr>
<tr>
<td>SB</td>
<td>Sound/Bounce</td>
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<tr>
<td>SR</td>
<td>Sound/Roughness</td>
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### PARTICIPANT RATING KEY

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<td>Very Difficult</td>
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<td>Hard</td>
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PHASE III

Orientation Cues for the Blind.

Activity in April was primarily devoted to two tasks:

1. further refining the research design;
2. pre-testing research procedures.

Refining the Research Design. Designing the research in Phase III presents a challenge: answering the high-priority research questions without testing hundreds of subjects or taking years of study. This challenge is being at least partially addressed by taking a multi-method exploratory stance. Although the test involves relatively few subjects, careful efforts to reduce unwanted variability and attention to detail are expected to allow useful answers to emerge.

The current research design includes the following: Each subject will experience the test route four times, two times on Day 1, and two times on Day 2, about one week later. Subjects will be divided into four groups of 6-8 persons and each group will experience the test route and countermeasures in a somewhat different order: Groups 1 and 2 will first traverse the test route without countermeasures in place; Groups 3 and 4 will first traverse the route with countermeasures. In addition, Groups 1 and 3 will traverse the route on Day 2 without countermeasures; Groups 2 and 4 will traverse the route on Day 2 with countermeasures. The four groups are illustrated in Figure 1.

These combinations allow a number of useful comparisons: Group 1 allows a within-group before/after comparison; comparing Group 1 and 2 allows the effect of familiarity to be assessed; Groups 3 and 4 allow some understanding of the situation where the visually impaired person first experiences a crossing structure with the countermeasures in place; comparing Groups 1 and 2 with Groups 3 and 4 allows a between-group comparison of the countermeasures.

Pre-testing Research Procedures. After several pre-tests a seven segment test route has been developed. The total route which has been laid out on the Georgia Tech campus, is about 1/2 mile long. Each segment simulates one or more problems encountered by visually impaired people in using crossing structures: finding a dirt-path end condition; finding the top of a switch-back stair case; traversing a long (400') crossing; etc.

A multi-step procedure has been developed (see Figure 2). Each subject is initially explained the overall purpose of the study and the specific procedures. After this initial orientation, each subject is taken to a short practice route, and a tape recording is played of the instructions for the route. As with the instructions for the seven test segments, this tape recording gives simple instructions for finding the end of the route. Each set of instructions is designed to be similar to the instructions a routine or well-informed passerby might give a visually impaired traveller. The instructions are repeated twice and the subject is asked to repeat the instructions to the experimenter. Once the subject is familiar with the instructions, the subject begins to traverse the course. The practice segment generally takes about two minutes; the test segment takes 2-7 minutes depending on length.
Several aspects of the subject's performance are measured on the test segments: overall time; difficulty in negotiating turns or choice points on a 1-5 scale; problems such as veering, pausing or reversing direction. Recording sheets for segments 1-7 are attached. In addition, the subject reports his or her perceived difficulty in traversing the segment, is asked to point to several landmarks using a calibrated pointer and is asked to identify a tactual map representing the route. The latter two measures help to understand the cognitive maps of the participants: the mental image they have of their environment.

Fiscal Information

We enclose:

- the bar chart shown; work performed this month by phase compared to the scheduled work;
- the money expended by phase and the cumulative totals for the month compared to the total scheduled costs;
- the time expended by the professional staff during the month and the cumulative totals.

Sincerely,

John A. Templer, Ph.D.
Principal Investigator

JAT:mlp

Enclosures
PROFESSIONAL STAFF:
Time Expended April 1981

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COST BY PHASE:
April 1981

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**TASK TIME CHART**

- **ESTIMATED**
- **COMPLETED**

The chart indicates phases of a task timeline with months and estimated dates for completion.
### BLIND STUDY: RESEARCH DESIGN

#### CONDITION

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<td>b CM</td>
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<td>X</td>
</tr>
<tr>
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<td>4</td>
<td>X</td>
<td>X</td>
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#### PLANNED COMPARISONS:

- **Within group**: 3c - 3b
- **Between Group**: 3c - 3b vs. 4d-4b
  - Controls for experience: 1c - 1a vs. 2d - 2a
  - Verifies learning effects on CM's: 1a + 2a vs. 3b + 4b

**CM Types within Conditions**
- Design of shoreline
- Placement of mat

**Before/After** No CM → CM
No CM → CM vs. No CM → No CM
CM → CM vs. CM → CM

---

Figure 1.
TEST PROCEDURES

ATLANTA FIELD TEST

OVERVIEW OF PROCEDURES

1. Bring participants to New Building lobby and explain study.
2. Bring to starting point of practice route.
3. Play tape recording.
4. Have participants traverse test route.
5. Debrief at end of route:
   a. Have participants rate overall difficulty.
   b. Have participants describe how they got from origin to end.
   c. Have them point.
   d. Have them map.
6. Bring participants to origin of route (i.e., segment 2).
7. Play tape recording.
8. Have them traverse route.
9. Debrief at end. (Do mapping on segments 2, 6; pointer 2, 3, 5, 6)
10. Repeat until completed.
11. Repeat 3 times.

Figure 2
Subject No.  

Date 5.12

Coder C2

% Cloud Cover 0 50 100

Observation Coding Scheme
Add "A" if assistance is given

Record location:
Y = veers on path
S = stops experiment

Record lapsed time and location:
P = pause, no environmental reason
X = pause, exploring feature
T = turns off path
R = reverses direction

Circle at each node:
01 = missed entirely
02 = negotiated with great difficulty
03 = negotiated with some difficulty
04 = negotiated with little difficulty

Order: SR, Map, Pointer

SEGMENT 2
Length: 12'
SEGMENT 4
Length: 374'
Subject No. ____________
Date __________
Coder C2

Cloud Cover 0 50 100

Observation Coding Scheme
Add "A" if assistance is given

- Record location:
  V = veers on path
  S = stops experiment

- Record lapse time and location:
  P = pause, no environmental reason
  X = pause, exploring feature
  T = turns off path
  R = reverses direction

- Circle at each node
  D1 = missed entirely
  D2 = negotiated with great difficulty
  D3 = negotiated with some difficulty
  D4 = negotiated with little difficulty

Segment 5
Length: 200'

North

Start

Finish

Origin 5
Subject No. ______
Date 9/13________
Coder C2 ______

% Cloud Cover 0 50 100

Observation Coding Scheme

Add "A" if assistance is given

Record location:
V = veers on path
S = stops experiment

Record lapsed time and location:
P = pause, no environmental reason
X = pause, exploring feature
T = turns off path
R = reverses direction

Circle at each node:
D1 = missed entirely
D2 = negotiated with great difficulty
D3 = negotiated with some difficulty
D4 = negotiated with little difficulty

North ______
Origin 2 ______
Map No. ______

SEGMENT 6
Length: 415'

Start

Finish
SEGMENT 7
Length: 250'
August 17, 1981

Mr. Bill Wheeler  
Federal Highway Administration  
HRS - 41  
Washington, D.C. 20590

RE: Design guidelines for making crossing structures accessible to the physically handicapped

Contract #DTFH 61-80-C-00131  
Eighth, Ninth and Tenth Monthly Progress Reports  
(May, June and July)

Dear Mr. Wheeler:

As we are completing much of our Atlanta testing and as we wish to submit proposals for the remainder of the work, we are taking the opportunity to bring our monthly reports up to date.

PHASE I  
Task A  
Ramp testing in Atlanta.

Ramp testing on the six ramps in Atlanta was concluded the last week in May. Slightly over 100 subjects were tested, eighty percent of whom were users of manual wheelchairs.

Data on 67 participants has been prepared for data analysis. Preliminary analysis routines have been run on this data to show total distance achieved on each of the six ramps, and the location of rest stops. Results indicate that participants can travel significantly farther than 30 feet prior to their first rest. Thirty feet is the maximum distance to landings that is permitted by the ANSI standards. However, many participants could not complete the total ramp distance. The implications of this can be deduced from the vertical height (frequency) table.

There is a strong relationship (which we will test statistically later) between the subjects abilities to succeed in climbing a ramp to a certain height (the dependent variable) and ramp gradient. Once we are more confident of the results it suggests that we may recommend that pedestrian crossing ramps should not climb more than
# PER CENT OF SUBJECT WHO COULDN'T REACH A GIVEN VERTICAL HEIGHT (FREQUENCY)

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<td>2%(1)</td>
<td>4%(2)</td>
<td>8%(4)</td>
<td>16%</td>
</tr>
<tr>
<td>1:15</td>
<td>9%(6)</td>
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<td>18%(10)</td>
<td>22.8%</td>
</tr>
<tr>
<td>1:12</td>
<td>5%(2)</td>
<td>16%(7)</td>
<td>21%(9)</td>
<td>29.8%</td>
</tr>
<tr>
<td>1:10</td>
<td>7%(3)</td>
<td>17%(8)</td>
<td>26%(12)</td>
<td>42.0%</td>
</tr>
</tbody>
</table>
say 20 feet vertically, and that ramp gradient should be controlled by the total height to be climbed. For example, if 20 feet must be climbed then perhaps the ramps should not be steeper than 1:14. And if 15 feet is the goal then the gradient should not exceed 1:13; but that 1:10 would be adequate for ramps ascending ten feet or less. In each case this would eliminate about 17% of the wheelchair population. This is the type of recommendation that may be possible once all the data has been processed.

A portion of the data (approximately 35%) has not yet been analyzed because of discrepancies which required manual correction. These discrepancies were largely a result of either coder error or the faulty memory of the More Recorder (see previous monthly report). The data which could be salvaged from this data set has now been cleared and will be added to the data analysis. This will add the data from approximately 20 participants to the analysis. (Manual correction is being continued on the remaining data, and may result in the addition of a small number of cases at a later date.)

The preliminary data set (data on 67 participants, or approximately 75% of the anticipated data set) was analyzed in order to reach tentative conclusions about the location of optimal rest areas. For each ramp, a cumulative frequency distribution was obtained of the locations participants stopped to rest. These distributions were obtained for the location the first place participants stopped to rest, the location of the second rest stop, and so forth. The numbers of persons stopping to rest more than three times were small, and the location of any one rest stop had high impact on the results. Research results for rest stops beyond the third stop were, therefore, less reliable.

In reviewing the frequency distributions for the entire data set, it became clear that the location of rest stops was highly influenced by participants who initially rested quite often yet didn't travel very far in total distance. Since travel on a pedestrian crossing structure frequently requires that a person reach a height of approximately 20 feet in vertical distance, a decision was made to obtain frequency distributions for only those persons who reached 20 feet vertical or more.

Frequency distributions for this population were analyzed to determine critical rest area locations: locations beyond which significantly fewer participants could travel without a rest. Rest area locations were then selected which could be reached by at least 95% of the participants.

Preliminary results indicate that for the 1:12 through 1:15 ramps, the first rest stop might be located at approximately 80 feet. Results also suggests that the optimum configuration of rest stops for these ramps will be with stops increasingly close together as distance increases--stops at 80 feet, 150 feet, 210 feet, 260 feet, and 300 feet might be an optimum pattern over the first 300+ feet. Further data analysis with the full data set will be necessary to affirm these results, to extend them over the full length of the ramps, and to determine if variations in the patterns of rest stops are suggested for ramps of different slopes.

The preliminary research results were considered with respect to selecting crossing structures for the tests in Atlanta and two other cities as set out in the scope of work. The results suggest that the optimum configuration of rest stops for long ramps will be a configuration with the first stop a reasonably long distance such as 80 feet, with additional stops increasingly close together as distance increases. Crossing structures selected for the field tests should also represent a range in
structure types: over and undercrossings; helical, dogleg, and straight ramps; etc.

The data base of crossing structures from the 1980 survey (see The Feasibility of Accommodating Physically Handicapped Individuals on Pedestrian Over and Undercrossing Structures, Final Report, 1980) was reviewed to determine if crossing structures exist which match the above criteria. Structures located in several cities provide a range in structure types and several examples may fit the final determination of a reasonably long distance to the first rest stop. However, no structures contain rest stops that are located increasingly close together as distance increases. A potential solution to this problem is to select a small sample of structures which meet the criteria for variation in structure type and distance to first rest stop, and which continue ramping beyond the first rest stop. In this case we could follow a procedure similar to that used in the Atlanta tests where optimum rest stop locations beyond the first rest stop would be identified, participants would be requested to stop only at these locations, and the participants' wheelchairs would be held by the researchers at these stopping places.

A review of the data base of crossing structures suggests that it may no longer be necessary to conduct field tests in Atlanta and two other cities. Atlanta does not have structures which meet the criteria suggested above. However, it appears that a city with a wide variety of structures, such as Boston, might provide a sample of three or four structures which meet the criteria for field testing. In addition, several of the Boston crossing structures are complex and would be valuable test sites for the countermeasures for the blind. However, it will be necessary to carry out the data analysis of the full data set prior to reaching final conclusions concerning the optimal location of rest stops, and selection of crossing structures for the field tests. Data analysis of the full data set should be completed by the middle of August. Thus it is expected that the sub-testing of optimal rest area configurations in Atlanta and the field tests in another city will be conducted late in August and September.

Difficulties encountered in the Atlanta testing.

A number of difficulties have been encountered during the long-ramp tests in Atlanta which have resulted in unforseen time and cost overruns.

A fifty percent rate of absenteeism was encountered for persons scheduled to participate in the study. Even with reminder phone calls the previous day, and overbooking of sessions, many days of testing were conducted without a full set of participants. Difficulties were also encountered in obtaining a representative range of participants, particularly persons over the age of 65 who were independent travelers. Thus, the amount of time required for testing had to be extended, requiring the additional expense of researcher and research assistant time, van rental, and insurance.

Weather conditions were another cause of delay in completing the Atlanta tests, especially during the months of November and December and during the hot weather encountered in May. Weather conditions may have contributed to poor participant attendance during those months.

Technical difficulties were encountered with More Data Recorders. One problem occurred in transferring data from the More data recorders to computer files. The software developed by observational systems, Inc. (the manufacturers of the More data recorders) for transferring data from the recorder to computer file was not
totally compatible with the Georgia Tech system. Unscheduled time was expended in identifying technical difficulties and modifying the system to accept the data.

PHASE II
Detectability

The test track was completed by the end of May and approximately 30 subjects were tested during June and July; 7 of these subjects were partially sighted and are being used to evaluate the effect of color and contrast used in combination with the textures. In essence we are testing 5 colors - red, orange, yellow, yellow-green, and green. Each of these colors is painted onto the texture with a contrasting black or white background. For example, a panel that consists of two inch wide plastic strips stuck to a wooden base has been painted with the plastic strips orange and the two inch wide wooden base painted black.

To widen the scope of the tests we have also painted some of the non-textured panels so that we can evaluate the effect of the textures on those with partial sight. We have painted a 12" wide strip, on one or more sides of all of the textured or painted panels with a gray color to simulate tarmac in order to see whether this color contrast is significantly different from the gray of the brushed concrete sidewalks that are being used everywhere in the tests.

We expect to run the 7 partially sighted subjects over the test track for a second and final time by the time this letter is dispatched.

We have yet to complete the slip testing, rebound testing, and acoustic testing of the test track, but we expect to complete this by about the middle of August. By the end of August we hope to complete the analysis of all of the data gathered at the test track.

Two factors have tended to delay this phase of the work. Firstly, as discussed last month, the construction of calibrated panels has taken much longer than expected because we found that usually we could not purchase off-the-shelf materials. We had to manufacture most of the panels.

Secondly, as in the other phases, we have had a high proportion of no-show subjects. So staff have had to abort many scheduled tests, and reschedule.

PHASE III

Since the previous report, progress on this phase has occurred in two areas:

1. Testing participants in the Atlanta field test;
2. Designing countermeasures.

Atlanta Field Test. To date, 14 subjects have been tested in the Atlanta field test. Because of the need to use the same subjects at the same time as in Phase II, some changes have been made in the research design. All subjects have been tested without countermeasures; countermeasures will be added, then subjects will be re-tested. This will provide the most important comparison discussed in the previous report: before countermeasures, then after. Only a subsample will be tested in the other groups (before-before, after-after, after-before).
It has proven extraordinarily difficult to find appropriate subjects for this test. Every major agency for the usually impaired in the Atlanta area has been contacted, as well as the Radio Reading Service, Library for the Blind and other services. Many contracts have produced a pool of only 28 usable subjects, and many subjects cancel even when they are called on the day of testing. As a result, testing is taking much longer than was originally planned.

Designing Countermeasures

All countermeasures have been designed, and are under construction.

In a separate letter you will receive details of our financial needs to complete the work on the contract. That letter assures that the final field testing work will be conducted in Boston only. This proposal has been discussed with you by telephone and during a meeting in Washington on August 12, 1981. For us to complete our field test arrangements we would appreciate a response to the financial changes as soon as possible.

Fiscal Information

We enclose:

- the bar chart shown; work performed this month by phase compared to the scheduled work;
- the money expended by phase and the cumulative totals for the month compared to the total scheduled costs;
- the time expended by the professional staff during the month and the cumulative totals.

Sincerely,

John A. Templer, Ph.D.
Principal Investigator

Enclosures
### TASK TIME CHART

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<th>PHASE III</th>
<th>PHASE II</th>
<th>PHASE I</th>
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<td>NOV</td>
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<tr>
<td>DEC</td>
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<td>JAN</td>
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<tr>
<td>DEC</td>
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**LAB TESTING**

**DETECTABILITY**

**SLIP RESISTANCE**

**RAMP TESTING**

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**ESTIMATED**

**COMPLETED**
### PROFESSIONAL STAFF
Time Expended May, June, July

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<td>182</td>
<td>525</td>
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<td>628</td>
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### COST BY PHASE:
May, June, July

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<td>46,878</td>
<td>58,598</td>
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<td>Phase II</td>
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<td>47,365</td>
<td>49,858</td>
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<td>Phase III</td>
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<td>22,431</td>
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<td>Phase IV</td>
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<td>--</td>
<td>8,720</td>
<td>0%</td>
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August 17, 1981

Mr. L. D. McCollum
Federal Highway Administration
Contracts and Procurement
Washington, D. C. 20590

RE: Contract DTFH 61-80-C-00131
Design Guidelines to Make Crossing Structures Accessible to the Physically Handicapped.

Dear Mr. McCollum:

We are about to move into the last phases of this contract. As you will have noted from our monthly reports we have experienced certain difficulties and delays. We have managed to recapture most of the time lost because of bad weather and subject absenteeism and we still hope to finish on time, or very close to it. We expect to know within this month whether our field testing activities can be completed as scheduled. At the worst, this field testing may delay us by about one month.

Unfortunately, the problems that we have encountered have necessitated the use of more research staff time than we had anticipated in our proposal to FHWA, so regretfully, and for the first time in the seven years that we have been active in research contracts for FHWA, we will be unable to complete the scheduled work within the contract budget.

Several unforseeable circumstances caused us to devote extra time to the project. The More Data Recorders proved to have faults that were difficult to trace and required considerable interaction between ourselves and the manufacturers before we could put them into action for testing. Dr. Wineman had to devote an extra two weeks working with the instruments and returning faulty instruments to the manufacturer. Even then the memory in one instrument failed during the actual tests forcing us to use manual handling of some data.

Secondly, the contract was only negotiated finally in October leaving us very little time for testing before the cold weather made this impossible. One result of this was that subject absenteeism, presumably because of the cold, was unexpectedly high. On some days only two out of six subjects arrived for testing, and the average for the whole project has been about 50%. This has not happened to us before on previous projects. We can only assume that this is because this time we have been dealing with the most severely handicapped subjects who are particularly sensitive to cold and heat. On some occasions, of course, we ourselves had to cancel tests because of rain.
Unfortunately, when subjects fail to turn up, the researchers and assistants must still be present to work with those that do arrive. So many extra days of personnel time had to be scheduled, and the vans and buses that we had to rent to transport subjects from test site to test site, had to be kept for longer periods than anticipated. We had planned to test six subjects a day - 4 weeks to test subject on the ramps. It finally took us nine weeks to complete this work. Similarly for our outside and indoor test tracks, we expected to complete the tests of the 97 blind subjects in 3 weeks. In reality it took us two months. Cancellations and no-shows of course, also required personnel time for re-scheduling, or contacting and evaluating new subjects.

The extra time and costs that resulted are as follows:

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<th>Name</th>
<th>Rate</th>
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<td>1/3 person/month</td>
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<td>$1,347</td>
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<tr>
<td>Wineman</td>
<td>1½ person/month</td>
<td>@ $2,600</td>
<td>$3,900</td>
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<td>Zimring</td>
<td>1½ person/month</td>
<td>@ $2,700</td>
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<td>Graduate Asst.</td>
<td>1½ person/month</td>
<td>@ $1,250</td>
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Overhead 75% of $11,172 $ 8,379
Fringe benefits 11.11% of $9,297 $ 1,033

TOTAL $ 20,584

In my most recent monthly report to Mr. Bill Wheeler we have proposed a change in the field testing that will reduce the costs and scope of this activity. In this proposal we have suggested that it will not be possible to find useable sites for testing our findings. As an alternative, we have proposed to use overcrossing sites in Boston only and to omit the other cities. The effect of this will be to save $9,330 for the cost of conducting tests in these other cities.

If the Boston proposal is acceptable, then the extra funding that we need to complete the contract will be reduced to $11,254.

We would appreciate a quick response to this letter. If you have any questions, please do not hesitate to contact me.

Sincerely,

/ / 

John A. Templer, Ph.D.
Principal Investigator

cc: Bill Wheeler

JAT:ms
Dear Mr. Wheeler:

PHASE I
Task A
Ramp Testing in Atlanta

During much of the last month, data from earlier testing has been processed; data from the faulty MORE recorders has been manually salvaged where possible. In addition to the maximum vertical heights that should be permitted for various gradients, we now have developed a preliminary rationale for deciding where landings should be set. Our results indicate that a general rule can be developed. The steeper the ramp, the closer the first landing should be set. Secondly, the second and subsequent landings should be set at shorter distances than the first—if the first was set at the maximum distance.

The table reflects the best predicted values of distances for the first through fifth times that participants rested on the 6 ramps (slopes ranged from 1:17 to 1:15). It is important to realize that this data is for people who needed to rest; overall 66% of the people travelled the entire ramps without resting. Also, these results are preliminary and may change with further analysis.

The figures in parentheses represent reducing the distances to include 85-95% of the participants on each ramp. These were arrived at by using the same slope as the regression line, but lowering the Y-intercept. The variability of percentages (85-95%) is due to deviations from normal distributions on the ramps. Because of the low number of people who stopped 4 or more times, these figures are only provided on rests 1-3.
Tasks Remaining in the Contract

Final Tests in Atlanta

Now that the ramp data analysis is largely complete, and a rationale for landing places has emerged, the final test of this rationale can be tested in Atlanta before proceeding to field testing in Boston (if the proposals set out in the last monthly report are acceptable). This Atlanta testing will be completed by the end of September.

Boston Tests

If the proposed modification to the contract is accepted, we expect to set up test procedures in Boston during September, and to carry out the field tests in the second full week of October. We have made arrangements to employ a doctoral candidate at MIT as the organizer of the Boston tests. She will, in turn, hire graduate research assistants from the MIT campus to assist with the work. As discussed with Jan by telephone, I plan to attend the TRB pedestrian committee mid-year meeting in Washington and to proceed from there to Boston to set up the arrangements for the testing. Obviously the contract modification that we requested last month will have to be complete before we can carry out the Boston tests. This is urgent because after about the middle of October, Boston is likely to be too cold for the sort of outdoor testing that we envisage. If we cannot test in October, it may well be late March before the weather is sufficiently benign for testing to start again.

Completion date of contract

In my last monthly report I detailed the cause of the delays in our testing program. It is now certain that we will not be able to complete our out-of-town testing in Boston before the middle of October (assuming that the contract modification is accepted). Obviously, therefore, we cannot provide you with the draft of the final report by the end of September. Therefore, the completion date (12-29-81) for the contract cannot be met. We are confident that the project can be completed by 2-28-82 and we request that the contract be modified accordingly. I should mention that if FHWA exercises the option for us to prepare a manual and accepts our outline by mid-October, then we should be able to complete the manual by the proposed new completion date.

Fiscal Information

We enclose:

- the bar chart shown; work performed this month by phase compared to the scheduled work;
- the money expended by phase and the cumulative totals for the month compared to the total scheduled costs;
PHASE II

Detectability

Subject testing on the track was completed, and most of the data has been prepared for analysis. Data analysis should be completed by the end of September. Slip resistance, rebound, and acoustic testing has been completed and will be utilized for the analysis.

PHASE III

Orientation Cues for the Blind

Activity in August was devoted to:

1. Preliminary analysis of performance of subjects who have experienced the Atlanta test route without countermeasures;

2. Building of countermeasures.

Preliminary Analysis of Atlanta Test Route Data

Preliminary analysis suggests that subjects had serious difficulties negotiating certain areas in the test route. Of 16 people who completed the route (3 more were tested but did not finish), 13 had problems crossing the open paved plaza, even when given clear instructions. Fourteen subjects had difficulty detecting a dirt path that they were to follow and 7 had difficulty following that path. In addition, 14 subjects had difficulty finding the proper street crossing at a curved corner. Although these results may change somewhat with more detailed analysis, they strongly suggest that open areas, street crossing and unpaved approach paths, at least, require countermeasures.

Building of Countermeasures

Several countermeasures are in the process of construction, including: Tactual strips, mats of metal and rubber, and others. These will be described in detail in the next monthly report as they are more fully developed.

In addition, the results from the lab testing will be validated in the field. As the lab test results become available, materials will be tested that represent the most successful materials indoors. While it is likely that these will also be the most successful materials outdoors as well, this has yet to be determined.

It should be noted that the Atlanta Field Test represents what was proposed as Task A (Lab Test) and Task B (Field Test). Whereas two separate tests were originally contemplated, because of the extraordinary difficulty of getting subjects these phases have been combined into one task. The test route serves both to identify problems and to refine countermeasures; it also helps verify the results of Phase II (Detectability). To help make this combined task a valid replacement, the test route was chosen to simulate the significant problems encountered in the previous survey of 124 crossing structures.
the time expended by the professional staff during the month and the cumulative totals.

Sincerely,

John A. Templer, Ph.D.
Principal Investigator

Enclosures

JAT:ms
Best Fit Regression Line of Stop on Ramp Tests

Key: Predicted Values (Approx. 90% Point)

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<tr>
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<th>13</th>
<th>12</th>
<th>10</th>
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- **Phase IV**: Lab Testing
- **Phase III**: Detectability
- **Phase II**: Slip Resistance
- **Phase I**: Ramp Testing

**Estimated**

**Completed**
### PROFESSIONAL STAFF

**Time Expended August**

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<td>Wineman</td>
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<td>601</td>
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<tr>
<td>Zimring</td>
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<tr>
<td>Smith</td>
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<td>743</td>
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<td>Lewis</td>
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<td>896</td>
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### COST BY PHASE:

**August**

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<td>4,575</td>
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<td>3,800</td>
<td>26,231</td>
<td>31,724</td>
<td>80%</td>
</tr>
<tr>
<td>Phase IV</td>
<td>--</td>
<td>--</td>
<td>8,720</td>
<td>0%</td>
</tr>
</tbody>
</table>
Mr. Bill Wheeler  
Federal Highway Administration  
HRS-41  
Washington, D.C. 20590

RE: Design guidelines for making crossing structures accessible to the physically handicapped

Contract #DTFH 61-80-C-00131  
Twelfth Monthly Progress Report

Dear Mr. Wheeler:

PHASE I  
Task A  
Ramp Gradients

During the month of September, work progressed in two areas:

1.) data analysis continued, and focused on the identification of the optimum configuration for rest area locations;

2.) the procedures for the sub-sample tests were finalized and testing was initiated.

Identification of Proposed Optimum Rest Area Configuration

On the basis of the complete data set from the Atlanta ramps tests, a regression analysis was conducted to determine a proposed optimum configuration of rest area locations. The slope of the regression line was used as a decision rule to establish rest stop distances. The use of the slope of the regression line provides a way of interpolating rest stop locations for ramp slopes other than those tested in the Atlanta study. Although the regression model was developed from tests conducted on ramps of the following slopes: 1:10, 1:12, 1:13, 1:14, 1:15, 1:17, it can be used to predict rest stop locations on ramps of such slopes as 1:11 or 1:16.

The regression line indicating mean distances to rest stop locations was adjusted (the Y-intercept of the line was lowered) to identify distances such that - 85-95% of the participants would be able to reach that distance or greater (see Table 1). This variability in percent of participants reaching a designated distance is due to the distribution of rest stop distance on the six
TABLE 1. Best Fit Regression Line of Stop on Ramp Tests

Key: Predicted Values (Approx. 85-95% Point)

<table>
<thead>
<tr>
<th>RAMP</th>
<th>17</th>
<th>15</th>
<th>14</th>
<th>13</th>
<th>12</th>
<th>10</th>
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<tbody>
<tr>
<td>1</td>
<td>170(95)</td>
<td>160(85)</td>
<td>155(80)</td>
<td>145(75)</td>
<td>140(65)</td>
<td>115(45)</td>
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<tr>
<td>2</td>
<td>225(170)</td>
<td>215(155)</td>
<td>205(145)</td>
<td>190(130)</td>
<td>180(120)</td>
<td>155(90)</td>
</tr>
<tr>
<td>3</td>
<td>240(180)</td>
<td>225(165)</td>
<td>220(160)</td>
<td>200(140)</td>
<td>190(130)</td>
<td>160(100)</td>
</tr>
<tr>
<td>4</td>
<td>260</td>
<td>240</td>
<td>225</td>
<td>210</td>
<td>200</td>
<td>140</td>
</tr>
<tr>
<td>5</td>
<td>265</td>
<td>245</td>
<td>235</td>
<td>225</td>
<td>210</td>
<td>162</td>
</tr>
</tbody>
</table>
ramps. For example, when the regression line was lowered so that 95% of the Atlanta test subjects could reach a designated rest stop location on the 1:10 ramp: only 85% could reach the rest stop distance indicated by the slope of the regression line on the 1:12 ramp.

The regression model is appropriate for calculating the location of the first rest stop location for each ramp; however, beyond the first rest stop, changes in the base sample of participants confound results. As the number of rests increases, participants who rest only a few times in the total ramp distance are no longer included in the calculation of rest stop location. These participants are also those whose rest stops (since they only stop a few times in the total ramp distance) are likely to be at greater distances than participants who stop often to rest.

Thus, as the number of rest stops increases, the mean distance to rest stops increases less rapidly and the distance between rest stops decreases. For example, to accommodate 85 to 95 percent of the participants on the 1:14 ramp, the predicted distance for the first rest stop is 80 feet, the predicted distance for the second rest stop is 145 feet (a distance of 65 feet between the first and second stop), and the predicted distance for the third rest stop is 160 feet (a distance of 15 feet between the second and third stop).

To overcome the confounding effects of the change in the base sample of participants (for rest stops beyond the first rest), an analysis was conducted of distances between rest stops. For each ramp, the distance between the first and second, and the second and third, rest stops was calculated. Distances were then identified that would allow 85 percent of the participants or more to reach the next rest stop location (see Table 2). These distances were used to identify proposed optimum locations of the second and third rest stop.

Beyond the third rest stop, the sample size was not large enough to reach reliable conclusions. Therefore, for rest stops beyond the third rest stop, equal intervals of 30' (the current ANSI standard) were proposed.

In summary, the proposed optimum rest area locations were identified as follows:

1) For each ramp, the location of the first rest area was determined from the best fit regression line that would allow 85 to 95 percent of the participants to reach this rest location.

2) For each ramp, the distance to the second rest location and to the third rest location were calculated on the basis of the distance between rest stops that would allow 85 percent of the participants or more to reach these rest locations.

3) For the fourth rest and beyond, our sample size was insufficient to reach reliable conclusions. Therefore, these rest areas were located on the basis of current ANSI standards, at distances of thirty feet.
TABLE 2. Distance Between Rest Stops

(approx. 90% point)

<table>
<thead>
<tr>
<th>RAMP</th>
<th>1/17</th>
<th>1/15</th>
<th>1/14</th>
<th>1/13</th>
<th>1/12</th>
<th>1/10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance between Rest 1 and Rest 2</td>
<td>45'</td>
<td>60'</td>
<td>45'</td>
<td>55'</td>
<td>50'</td>
<td>30'</td>
</tr>
<tr>
<td>Distance between Rest 2 and Rest 3</td>
<td>50'</td>
<td>45'</td>
<td>50'</td>
<td>50'</td>
<td>25'</td>
<td>20'</td>
</tr>
<tr>
<td>Distance between Rest 3 and Rest 4</td>
<td>20'</td>
<td>30'</td>
<td>35'</td>
<td>40'</td>
<td>30'</td>
<td>20'</td>
</tr>
</tbody>
</table>
## TABLE 3. Proposed Optimum Locations for Rest Stops - Atlanta Testing

<table>
<thead>
<tr>
<th></th>
<th>5th Street 1/15</th>
<th>6th Street 1/13</th>
<th>North Avenue 1/12</th>
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<tbody>
<tr>
<td>1st</td>
<td>85</td>
<td>75</td>
<td>65</td>
</tr>
<tr>
<td>2nd</td>
<td>155</td>
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<td>3rd</td>
<td>200</td>
<td>175</td>
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</tr>
<tr>
<td>4th</td>
<td>230</td>
<td>205</td>
<td>195</td>
</tr>
<tr>
<td>5th</td>
<td>260</td>
<td>235</td>
<td>225</td>
</tr>
<tr>
<td>6th</td>
<td>290</td>
<td>265</td>
<td>240</td>
</tr>
<tr>
<td>7th</td>
<td>320</td>
<td>295</td>
<td></td>
</tr>
<tr>
<td>8th</td>
<td>350</td>
<td>325</td>
<td></td>
</tr>
<tr>
<td>9th</td>
<td>380</td>
<td>355</td>
<td></td>
</tr>
<tr>
<td>10th</td>
<td>400</td>
<td>385</td>
<td></td>
</tr>
<tr>
<td>11th</td>
<td></td>
<td>410</td>
<td></td>
</tr>
</tbody>
</table>
Sub-Sample Testing

A series of sub-sample tests were organized to assess the following:

1) the effectiveness of the proposed optimum configuration of rest areas,
2) the need for rest areas for travelling down a ramp, and
3) the impact of wet ramps on performance.

Three of the Atlanta ramps were selected for sub-sample tests: the 1:12, the 1:13, and the 1:15. These ramps were selected to provide a representative sample of slopes within the critical range (the 1:10 slope was not selected because of the large percentage of participants (42%) who could not achieve a distance of 20 vertical feet.)

A group of 20 persons using manual wheelchairs were identified for testing. This sample was matched as closely as possible to the characteristics of the initial sample of participants for the Atlanta testing. All persons identified for sub-sample testing had previously participated in the Atlanta tests. In addition, only persons who had rested two or more times on each ramp during the initial Atlanta testing were selected.

Optimum configuration of rest areas

To test the effectiveness of the proposed configuration of rest areas, we were interested in two questions:

1) could 85-95% of the participants reach the first rest area?
2) would the proposed optimum configuration of rest areas allow as many or more participants to reach a given vertical height as the configuration of rest areas mandated by the ANSI standards?

In order to respond to these questions the following methodology was developed:

It was determined that a straight comparison of performance on the proposed optimum configuration versus the ANSI recommendations might be biased by the very first large distance to the first rest area of the proposed optimum configuration (over twice the distance specified by the ANSI standards).

In order to separate the first research question (concerning the location of the first rest area) from the second research question (concerning the configuration of rest areas) a comparison was made between the proposed optimum configuration of rest areas, and a second test configuration that began with the first rest area at the same location as in the proposed optimum configuration, however, subsequent rest areas occurred at intervals of 30 feet (as specified by the ANSI standards).
Traffic safety cones were set up to designate rest area locations for each of the two test configurations. The order of ramps and test on each ramp was randomized by subject. For both tests, participants were requested to go to the top of the ramp or as far as they could reasonably go. If they needed to stop to rest, they were requested to stop only at one of the traffic safety cones if possible. As in the previous Atlanta test sessions, participants were cautioned to proceed at their normal pace, resting as they normally would in travel.

During each test, researchers recorded the number and location of rest stops taken by the participant, total elapsed time, and evaluated the case with which the participant travelled both at the beginning and end of the test.

**Traveling down the ramp**

Following each of the two previously mentioned tests, participants were asked to travel down the ramps. As in the previous tests, participants were requested to rest only at locations designated by traffic safety cones if possible. To ensure their safety, participants were asked to travel slow enough that a researcher could keep one hand on the back of the wheelchair. This required that many participants expend more energy than they normally would in holding back their wheelchair. However, this measure was deemed necessary to assure the safety of participants.

Researchers recorded the number and location of rest stops taken by the participants.

**Wet ramps**

In order to assess the impact of wet ramp surfaces on performance, tests were conducted to identify instances of wheel slips (or skids). Following the previous tests, the first 50 feet of the ramp was hosed down to create a wet ramp surface. Participants were requested to travel up the first 50 feet and back down. Researchers recorded instances of wheel slips.

Because of the need for water and the complexity of the procedure, these tests were only carried out on one of the ramps: the 1:13 ramp.

During the month of September, test procedures were developed and pretested. Researchers were trained. Testing commenced on September 29th. Four subjects were tested during this month.

**PHASE II**

**Test Track Analysis**

The data from the test track has been compiled and the analysis of variance has been run. The results of which indicate a significant level (\(a = .01\)) for all main effects as well as several of the two and three-factor interactions. However, the analysis was designed to analyze the binary polarized (eg. high/low) effect
of the main factors. Unfortunately, this analysis has proven to be unreliable as we have found after measurements were made that it is impossible to control loudness, frequency and rebound on a two-level (high/low) basis. They are rather continuous variables. In addition, the Analysis of Variance was based on the initial assumption that panel detection would be the result of either high or low level loading of specific factors. The data, to the contrary indicates that there may well be an effect due to either or both the high and low levels of any particular factor. For instance, the data suggests that detection and stopping distance are affected by the low level loudness as well as the high level. This too has rendered the ANOVA unreliable.

Consequently, we have begun further analysis of the data which will include a regression of the probability of detecting a panel vs. the main effects factors and a stepwise multiple regression of the stopping distances for all panels that were detected vs. the main effects. These regressions will compensate for the continuous nature of certain variables. These analysis have proved to be considerably more time consuming than we had originally anticipated, but we expect to complete the analysis within the next month.

PHASE III

Orientation Cues for the Blind

Activity in September concentrated on two areas: construction of countermeasures and further preliminary data analysis.

Construction of countermeasures

As was illustrated in previous monthly reports, the countermeasures have been developed to resolve the most common and serious orientation and mobility problems encountered by visually impaired crossing structure users. Specifically, these problems include: crossing a large open space such as a parking lot or plaza; finding the ramp, stairs or other access to the crossing-structure; crossing an undefined intersection between several walkways; finding an approach path (and especially a dirt approach path); finding the appropriate crossing in a street intersection; other problems. In addition several other criteria were considered in the development of countermeasures. Specifically, countermeasures were chosen that: were made of commonly-available materials; were of relatively low initial cost; required little maintenance; does not endanger other pedestrians; and for which there was reasonable expectation they would be effective based on the lab testing or other previous research. These criteria resulted in several countermeasures:

1. Wooden shorelines:
   a. A 6" tall box that can be placed on a plaza, sidewalk or other paved area. Although in the present test this is a portable triangle 3 feet on a side, in actual application this could be a planter or other object. This shoreline allows a visually impaired person to establish a line and project across an open space.
b. Wooden staked shorelines that are 3'-6' long and 6" high that can be staked into dirt. This shoreline helps the visually impaired traveller follow the edge of a path.

2. Cane-detectable mats and strips:
   a. sheet metal
   b. artificial-turf carpeting
   c. rubber mats of several thicknesses and textures
   d. epoxy strips with embedded rough materials (such as pea gravel)

3. "Tweeter" sound emitting device (by Traconix Inc.)

4. Tactual north arrow mounted on a wooden pedestal.

These countermeasures are currently being pre-tested in preparation for further Atlanta field testing as well as Boston field testing.

**Preliminary data analysis**

Preliminary analysis of the Atlanta field test is confirming the above problems. If all errors are combined (veers, turning off path, reversals, etc), the preliminary results are quite clear:

**TOTAL ERRORS BY APPROACH TYPE**

<table>
<thead>
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<th>Approach</th>
<th>Errors</th>
</tr>
</thead>
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<td>Curve Paved</td>
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<tr>
<td>Rough Paved</td>
<td>10</td>
</tr>
<tr>
<td>Following Unpaved Dirt</td>
<td>19</td>
</tr>
<tr>
<td>Finding Dirt path from paved</td>
<td>30</td>
</tr>
<tr>
<td>Crossing open plaza</td>
<td>34</td>
</tr>
</tbody>
</table>

The four highest priority problems are being addressed by countermeasures.
Computing Expenses

In terms of our contract we must let you know that our computer expenses have passed the $1000 budgeted. As of the end of September our computer account had reached $1350 and we expect it to reach approximately $1800. These additional costs have arisen because of the complexities of the analysis and the quantity of data being processed. We have included these expenses in our contract modification so no new monies will be requested.

Boston Tests

These tests are of course dependent on your acceptance of our proposed contract modification. We are however under some pressure to proceed with these tests because we believe that to postpone these tests any further would mean delaying the tests until about March 1982 when the weather in Boston is suitable for outdoor testing. It is our opinion that the first week in November is the latest that we can test outdoors and we are planning accordingly.

We have succeeded in identifying a series of ramps in Boston along the Charles river across Storrow Drive. These are in every way suitable for our testing except that we have been unable to find any helical pedestrian ramps in Boston.

Rather than go to the expense of carrying out further tests in some other city, we propose to use two helical (automobile) ramps in Atlanta. We propose to evaluate these ramps using the same subgroup of subjects used earlier. By this means we can at least calibrate helical ramps and see how they compare with the regression models described earlier.

Users Manual

With this letter we enclose a fairly detailed proposal for the manual which is the FHWA option. We believe that the description is reasonably complete, but we are quite willing to adjust the product to meet any suggestions that may be forthcoming. If we are to meet the proposed completion time modification (2-28-82), then we should start work a the manual immediately. Therefore we would appreciate a quick response to the proposal.

Fiscal Information

We enclose:

- the bar chart shown; work performed this month by phase compared to the scheduled work;
the money expended by phase and the cumulative totals for the month compared to the total scheduled costs;

the time expended by the professional staff during the month and the cumulative totals.

Sincerely,

John A. Templer, Ph.D.
Principal Investigator

Enclosures

JAT:mr
## PROFESSIONAL STAFF

**Time Expended September**

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<thead>
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<th>Person Hours</th>
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<td>Smith</td>
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## COST BY PHASE:

**September**

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<td>88%</td>
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<tr>
<td>Phase IV</td>
<td>--</td>
<td>--</td>
<td>8,720</td>
<td>0%</td>
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</table>
A Design Manual for Accessible Pedestrian Crossing Structures

Proposal and Outline

The Need for and Function of the Manual

Within the past two decades there has been increasing effort to eliminate environmental barriers that prevent or limit the mobility of elderly and handicapped persons. However, these efforts have largely centered on barrier free mobility through buildings while neglecting those barriers encountered within other components of the pedestrian system. One particular component, the crossing structure, has often failed to accommodate the handicapped user. (Templer, Wineman 1980, FHWA-RD-79-146).

As the crossing structure is a special building type and a vital link in the pedestrian network; it is unfortunate that existing knowledge, codes and standards have failed to be incorporated within the design of such structures. Recent research by the pedestrian laboratory has identified hazards and barriers to pedestrian mobility on crossing structures and developed solutions and strategies to counter such failures. Yet, as before, there is at this time no satisfactory vehicle for distributing this information among designers and planners. Consequently, it is proposed that these counter-measures be prepared in a self contained user manual to aid state and local planning/design engineers in making the crossing structure accessible to the handicapped pedestrian.
What follows is a detailed outline describing the proposed content, section headings and layout for such a manual. The manual is intended to make use of new as well as existing knowledge while performing as a needed supplement to the requirements of the A.N.S.I. and other federal, state and local standards.
GENERAL OUTLINE

I. INTRODUCTION
   A. Definition of the crossing component and its comprising elements
   B. Definition of Problem
   C. Description of the accessible network
   D. List of Handicap conditions accommodated by the user manual

II. DESIGN STRATEGIES FOR WHEELCHAIR USER AND THE VISUALLY IMPAIRED

III. DESIGN DETAILS
   A. Forward
   B. Section Headings
      1) Environmental components of the crossing structure
      2) Walkways
      3) Ramps
      4) Steps and stairs
      5) Handrails, railings, protective barriers
      6) Signage, media cues
      7) Lighting, illumination
      8) Street Furniture

IV. APPENDIX (If needed)

V. INDEX
FORMAT

The user manual shall be similar in format to our previous implementation manual entitled "Development of Priority Accessible Networks." (Templer 1980). Clear, concise graphics and layout will contribute to the easy location and comfortable reading of material in the manual. Each 'Design Detail' page shall first state a problem then on the opposite margin offer recommendations suitable to the specified condition. Along the bottom of each page shall be two "picture boxes" that are intended to visually communicate various solutions, problems or hazardous conditions. (see example, following pages). All dimensions will be metric as well as foot/inch.

EXPLANATION OF CONTENTS

I. INTRODUCTION

A. Definition of the crossing component and its subelements.

From previous research, a description of the most typical environmental circumstances will be provided as well as a general indication of the most typical over/under crossings that have been used. The text will further define the crossing structure and break down its vertical and horizontal elements. Specifically the elements involved in approaching the structure and in making the transition from ground level to the spanning structure (i.e. stairs, ramps, elevators and their subelements; rail, texture etc.). Combined with the horizontal element (i.e. the spanning structure itself and his subelements) shall be defined as comprising the crossing component.
B. DEFINITION OF THE PROBLEM

The text shall give an overview of accessibility barriers encountered within over and crossings as revealed by previous research.

C. DESCRIPTION OF THE ACCESSIBLE NETWORK

The text provides a brief summary of the planning procedures involved in the development of the 'priority accessible network' as outlined in "Development of Priority Accessible Networks - An Implementation Manual" (FHWA-IP-80-8). The thrust of this discussion is to emphasize that the crossing structure as a whole is still only a component of the pedestrian system. Therefore, the crossing is dependant on the accessibility of routes leading to and from its location. This section will direct the reader to the afore mentioned manual and other sources of information on accessibility in order to avoid overlap between the proposed manual and previous publications.

D. OUTLINE OF HANDICAPPING CONDITIONS TO WHICH THE USER MANUAL RESPONDS

1) Sensory Disorders (blindness, low vision, deafness, hearing loss, vestibular and kinesthetic disorders)
2) Circulatory disorders (artieriosclerosis, heart disease)
3) Orthopedic disorders (amputation, rheumatoid arthritis, degenerative joint disease)
4) Respiratory Disorders (emphysema, allergy, and asthma)
5) Disorders associated with age (decreased visual activity, poor valance, slow reflexes, decline in short-term memory)
6) Disorders of the central nervous system (neoplasms, epilepsy, cerebral palsy, multiple sclerosis, parkinsons disease, spinal cord disfunctions, stroke).
The manual will list the typical mobility problems of these groups of people and the sorts of design considerations that must be treated.

II. DESIGN STRATEGIES

This section will outline overall design and planning strategies that should be incorporated early in the design process, complimenting more specific recommendations that should be incorporated into the design detail phase of the design process.

Visually Impaired

Because of their lack of vision, the visually impaired rely heavily on the mental image of the setting they are traversing. If their mental image is accurate, they may be able to travel independently and without getting lost; if their image is confused or poorly developed, they may be stressed and uncertain. A number of design strategies aid the visually impaired in developing and using mental images. For example, all crossing structures in a given area should be as similar as possible, including similar overall form and consistent use of cues and signage; each crossing structure should be as simple as possible in circulation plan, including having a comprehensible geometric overall form, simple and condition and short, straightforward crossing.

Physically Disabled

Similarly, a design strategy is important to ensure accessibility for persons using manual wheelchairs. For example, site selection is
critical in minimizing the vertical distance that must be negotiated, in allowing enough space to accommodate a ramp of reasonable slope, and in providing an accessible route which is clear and direct.

III. DESIGN DETAILS
A. FORWARD

...A brief text discussing the derivation and development of the recommendations set out in the manual. Moreover, background and complimentary research reports are identified and suggestions on the most effective use of the proposed manual are discussed.

B. SECTION HEADINGS

Each section of the design details section is preceded by an introductory page. Contained on this page are: definitions of the specific elements discussed, an explanation of the scope of the section (i.e. issues addressed/not addressed), the objectives of the chaptered and a list of the contents within each section.

1). ENVIRONMENTAL COMPONENTS OF OVER AND UNDER CROSSINGS

...Recommendations deal with the general layout of a crossing structure and the conditions inherent within its design.

Contents of the section: Space available
  Crime
  Visibility
  Traffic
  Parking
  Planting
  Legibility/Comprehension of layout
  Weather
2). **WALKWAYS**

...Recommendations center on the provision of adequate pathways for the pedestrian. For example, walkway width is of particular importance to persons in wheelchairs, or, while paving surfaces can provide difficulty for wheelchairs other detectable surfaces may aid the orientation of the visually impaired. Within this section cross reference will be made to signage and media cues.

Contents of the section: Pedestrian walkways and sidewalks
- Dimensions
- Surfaces & Materials
- Gradients
- Expansion joints & covers
- Hazards

3). **RAMPS**

...Recommendations address several major concerns, steep ramps, ramps with cross slopes, long ramps and the need for types of rest areas within the ramping element. Emphasis is also placed on the need for alternate routes i.e. while persons using wheelchairs require ramps for vertical movement, persons with prosthetic walking devices find ramps difficult to travel and prefer stairs.

Contents of the section: Dimensions of ramps (gradient, maximum vertical height)
- Landings and Platforms/rest areas (frequency, location, type)
- Surfaces & Materials
- Handrails and protective barriers
- Auxiliary stairs
4) **STEPS & STAIRS**

Stairs constitute a hazard zone on the crossing site; yet, they may be required as a preferred route by certain handicapped groups (i.e. persons with prosthetic devices). To insure safety and minimize the extent of injury in the case of an accident, guidelines for stair design are included in the manual. Recommendations range from dimensions to slope and overall layout.

Contents of Section:  
- Stairs Generally  
- Hazardous layouts  
- Landings  
- Stair runs  
- Tread and riser dimensions & shapes  
- Types of steps  
- Surfaces & materials

5) **HANDRAILS, RAILINGS, PROTECTIVE BARRIERS AND CAGES**

The provision of handrails of proper design is of major importance to persons in wheelchairs, persons with balance problems, the elderly etc. Also of significance is the protection of pedestrian walkways from vehicular traffic edges etc. in addition to physical seperation, a need is expressed for a barrier which usually appears to substantially offset fear of heights.

Contents of the section:  
- Where required  
- Heights - physical and visual support  
- Handrail extensions  
- Handrail projections  
- Handrail continuity  
- Handrail slope  
- Handrail supports  
- Handrail materials  
- Protective cages, designs/material
6). SIGNAGE, MEDIA CUES

This section addresses the needs of the visually impaired as other users of crossing structures. Recommendations derive from accommodation of the users' basic goals: a) finding the structure and knowing where it is. b) crossing the structure safely and easily.

Counter-measures included in this section:

- Environmental landmarks
- Shore lines
- Auditory landmarks
- Tactual maps
- Signage and visual maps
- Tactual landmarks
- Auditory maps
- Interaction of cues
- Warning signs

7). LIGHTING AND ILLUMINATION

This section sets out guidelines for the adequate lighting of pedestrian areas. Security and the safe use of stairs and ramps in the evening hours are major concerns of this chapter.

Contents of the section: Security lighting

- IES lighting levels
- Illumination of ramps & stairs
- Crosswalk illumination

8). STREET FURNITURE

...Temporary or permanent equipment located within the crossing component with the purpose of facilitating pedestrian activity (e.g.
sign posts, telephones, light poles, seats, waste receptacles etc.). The objective of the recommendations is to eliminate hazards caused by the furniture, increase provision of necessary furniture and the opportunity for their use.

Contents of the section: Location of street furniture

- Overhead projections
- Public telephones, police telephones
- Manhole covers, drain gratings
- Seating Locations
- Seating
- Trash cans and receptacles

IV. APPENDIX

Supplementary information as required

V. LITERATURE SOURCES

VI. INDEX
November 23, 1981

Mr. Bill Wheeler
Federal Highway Administration
HRS-41
Washington, D.C. 20590

RE: Design guidelines for making crossing structures accessible to the physically handicapped

Contract #DTFH 61-80-C-00131
Thirteenth Monthly Progress Report

Dear Mr. Wheeler:

Phase I
Task A: Ramp Gradients, and
Task B: Field Testing Using Existing Over and Undercrossing Structures

During the month of October work progressed in three areas:

1) Sub-sample testing,
2) Data analysis,
3) Preparation for testing in Boston.

Sub-Sample Testing

In October, the performance of 8 manual wheelchair users was evaluated on three of the Atlanta Ramps. Participants were asked to travel up and down the ramps with rest area locations in the proposed optimum configuration of landings, and again with rest area locations in a second test configuration (see monthly report of September). Data was collected on the number and location of rest stops taken by participants travelling both up and down the ramps, and total elapsed time in each case. Participants were also tested on the 1:13 ramp under wet surface conditions. Incidents of loss of traction or increased travel time (if any) were recorded.

Data Analysis

Data analysis of the Fall and Spring data collected from the Atlanta ramp tests continued.

Preparation for Testing in Boston

Preparations were made to conduct evaluations of the use of crossing structures by manual wheelchair users in the Boston area.
Boston area ramps from the 1980 survey conducted by Templer and Wineman (see The Feasibility of Accommodating Physically Handicapped Individuals on Pedestrian Over and Undercrossing Structures, Final Report, 1980) were reviewed. A sample of four structures were identified which provided a representative range within what has been identified from previous tests as the critical range of slopes; 1:12 to 1:15, and which provided a range in ramp configurations: dogleg, straight ramp, switch-back, etc. No helical ramps could be located in the Boston area. For this reason, with your concurrence it was decided to conduct tests of helical ramps with a limited number of the participants in the Atlanta sub-sample tests.

A research protocol and instruction package was prepared for the study organizer in the Boston area (see enclosure). Since the performance capabilities of participants for the Boston tests would not be known prior to the tests, this population was somewhat different than the sample used in the Atlanta sub-sample tests. In the Atlanta tests, the participants selected were only persons who had rested two or more times on each ramp during the initial Atlanta testing, and who had achieved a vertical distance of at least ten feet. Because we expected a wider range in capabilities of the Boston participants, it was decided that the proposed optimum configuration of landing locations (proposed on the basis of the Atlanta tests) would be tested first, then this would be compared to a less demanding configuration of landing locations in a second set of tests.

To determine this less demanding configuration of landing locations, the regression line (indicating mean distances to rest stop locations) and the distances between rest stops were adjusted such that a greater percentage of participants would be able to reach those distances or greater.

The proposed optimum configuration of landing locations and the less demanding configuration for comparison for use in the Boston testing are shown in Tables 1 and 2 respectively.
### TABLE 1: PROPOSED OPTIMUM CONFIGURATION OF LANDINGS - BOSTON TESTING

<table>
<thead>
<tr>
<th>Location</th>
<th>Leverett Circle 1:12</th>
<th>Mass General 1:12</th>
<th>Fairfield Circle 1:13</th>
<th>Arthur Fiedler 1:14</th>
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<tr>
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<td>≈ 200'</td>
<td></td>
<td>≈ 165'</td>
<td>≈ 200'</td>
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</table>

### TABLE 2: ALTERNATIVE CONFIGURATION OF LANDINGS - BOSTON TESTING

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<th>Mass General 1:12</th>
<th>Fairfield Circle 1:13</th>
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<td>≈ 165'</td>
<td>≈ 200'</td>
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PHASE II

Test Track Analysis

The data for the totally blind subjects has been completely input into the computer and two independent SPSS analyses have been performed. The first test is an analysis of the probability of panel detection vs. the 5 measurable, main effects factors (frequency has been omitted because of an inability to isolate frequency levels in the test panels). This analysis involved several phases. First, a straight line regression was run, but this resulted in an extremely low R². To compensate, a second straight line was performed utilizing interactions of the 5 main effects as well as the individual factors as the independent variables. This increased the R² significantly, but it was felt that a better fit could be found. Finally, the independent variables were transformed by the square root of the arc sin of both the interactions and the individual variables (\( y = \sqrt{\sin^{-1}(x_1 \cdot x_2)} \)). This regression curve thus far most satisfactorily fits the data.

The second test is an analysis of the stopping distances vs. the physical and behavioral effects. Straight-line regressions have been performed which account for stopping distance vs. age, sex, severity of blindness, run number, panel number, direction of approach, subject rating, and method of detection.

Both tests 1 and 2 will be completely analyzed within the week, at this time suggestions for further analysis if necessary will be made.

PHASE III

Orientation Cues for the Blind

Progress in October was devoted to testing countermeasures. After testing 5 subjects, a portion of the course was razed for campus renovations, affecting 2 of the 8 test segments. This required some revamping of the test route. The forms and materials have been modified to allow comparability with the previous tests. Also, the data from the test route prior to the countermeasures are being entered in the computer to allow further analysis.
Fiscal Information

We enclose:

- the bar chart shown; work performed this month by phase compared to the scheduled work;

- the money expended by phase and the cumulative totals for the month compared to the total scheduled costs;

- the time expended by the professional staff during the month and the cumulative totals.

Sincerely,

John A. Templer, Ph.D.
Principal Investigator

Enclosures

JAT:mr
## PROFESSIONAL STAFF

**Time Expended September**

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## COST BY PHASE:

**October**

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<tr>
<td>Phase IV</td>
<td>4,360</td>
<td>4,360</td>
<td>8,720</td>
<td>50%</td>
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OVERVIEW OF STUDY

The purpose of this research program is to study how the needs of physically disabled pedestrians may be accommodated in the design of pedestrian highway crossing structures. The goal of the Boston research is to verify on 4 actual crossing structures the results of controlled Atlanta testing. Over a 5 day period, Oct. 12-16, 1981, we need to test 40 disabled people: 24 wheelchair users and 16 visually-impaired people. The wheelchair users will each participate in full day sessions on Oct. 14-Oct. 16 (Monday-Wednesday); the visually impaired will participate in half-day sessions in the afternoon of October 12 and in the morning and afternoon of October 13. A training session will be held at 9:00, Monday Oct. 13.

We need the Boston team to do a number of things: (1) Find and schedule the subjects. These subjects must be representative of the groups we tested in Atlanta; a further description is enclosed; (2) Locate crossing structures for testing that meet certain characteristics of ramp-slope and form; these criteria are enclosed; (3) Locate the necessary materials including 2 accessible vans and highway traffic cones; (4) Aid us during the actual testing, including picking up subjects, setting up test sites, and so on. This is a big task and we very much appreciate it!

SELECTION OF CROSSING STRUCTURES

We need to select 4 structures on which to conduct our tests. If you would identify 8 candidate structures, we will review these and select the final four.

Criteria for Selection:

1) All should be pedestrian or pedestrian/bicycle structures crossing over roadways.

2) Access on both sides must be by ramp or on grade.

3) Ramp slopes should be consistent as possible and represent a range of slopes between 1:10 and 1:17.

4) Ramp configuration should represent a range of types: dogleg (or switchback), helical, straight-on, or U-shaped.

5) At least one structure should have a broken pavement or dirt approach path to structure.
6) At least one structure should have a complex configuration of ramps, stairs, and/or intersecting walkways (the Leverett Circle Footbridge over Storrow Dr. at the Science Museum is a good example).

7) At least one structure should end in an open space, such as a parking lot or grassy area (i.e. without a clear pedestrian walkway).

8) The ramp on at least one side of each structure should have a rest area (landing—where the ramp flattens out for a short distance) located at one of the following distances:
   
   1:10 -- 45'
   1:12 -- 65'
   1:13 -- 75'
   1:14 -- 80'
   1:15 -- 85'
   1:17 -- 95'

Following this rest area, the ramp should continue on for a total ramp distance of between 250 and 400 feet (the location of all rest areas over this distance should be noted).

9) Geographically, the ramps should be as close to each other as possible to facilitate transportation for testing.

Each candidate ramp (one side of structure only) should be documented as follows:

1) measure total length of ramp;

2) identify slope and approximate consistency of slope over the entire ramp;

3) locate the distance of each rest area (flat portion of ramp) and dimensions; of flat portion.

4) describe condition (re: debris, broken pavement, presence of expansion; joints (their size and location, etc.)

5) describe environmental conditions (amount of traffic, availability of parking, etc.)

6) photographs or slides of the ramps, crossing structures and end conditions.

7) after the actual ramps are chosen, they should be surveyed at intervals.
Subject Selection

Subject selection is a very difficult but critically important task. Subjects chosen need to be representative of the general disabled population and of the subjects used in earlier Atlanta tests; the sample must not be skewed in favor of the extraordinarily active, competent, young, poor, or wealthy. We are very concerned that we do not merely attract socially-active participants.

In Atlanta we used a multiple strategy for attracting subjects: prepare ads for all radio and television stations (including, for the visually impaired, the Radio Reading Service) be careful, public service messages take time to get on the air; contact all relevant private and public agencies (including social service agencies, handicapped advocacy groups, schools for the visually impaired, etc. — where possible agencies should serve a range of incomes, ages, and disabilities). These agencies and groups often need to be visited in person following an initial phone contact. When subjects are contacted, background information should be solicited over the phone. The forms for the wheelchair participants must be screened by a physician to identify high risk participants. After an initial pool of subjects is identified, participants for the test should be randomly selected from within the characteristic groups identified in the following sections (e.g., 2-4 people should be randomly chosen from the sample of wheelchair subjects over 65). The older subjects are particularly hard to find; we were able to enlist people by calling homes and organizations for the elderly.

Each subject should be scheduled for a given day and called the night before to confirm the testing. Our experience suggests that even with these precautions, the no-show rate is more than 25%; if 40 subjects are scheduled in total we hope to get 30: 18 wheelchair users, 12 visually impaired people.

Subjects will be paid $20 for a full day of testing, and $10 for a half day. They will be paid by check from Atlanta: we will need their mailing address and social security number.

Subject Selection-Wheelchair Tests

Twenty-four subjects should be scheduled for the ramp tests. Ramp tests will be conducted from 9:00 a.m. to 4:00 p.m. on Oct. 14-16. Participants should be asked to bring their own lunch.

Our experience indicates that absenteeism among participants is high, even if they are reminded the day before the test. Therefore, eight participants should be scheduled for each day of testing, and we can expect a turn-out of about six each day. Tests will be run on three days: October 14-16, with Saturday October 17 as a rain date.

The sample of participants should be:

1) All manual wheelchair users
2) Reflecting as closely as possible the characteristics of our larger test sample--
   a) 50% male/female (12 of each)
   b) adults over the age of 18
   c) 8% over the age of 65 (2-4 participants)
   d) 33% on social security income, disability, welfare, or alimony (8 participants)
   e) 20% black and 80% white (about 5 black, 19 white)

Over the telephone, preliminary background information should be obtained (see attached sheet). Once the sample has been selected, each participant should be sent a consent form (attached) and a medical evaluation form (attached). The medical evaluation forms should be reviewed by a medical doctor to determine whether participants are at risk because of heart conditions or other problems. If a participant is at risk, a doctor's permission may be required prior to the subjects' involvement in test activities.

A gathering place should be arranged for meeting participants in the morning and for eating lunch. This gathering place should provide accessible shelter and accessible bathrooms, and be as close as possible to the test sites.

**Subject Selection - Visually Impaired Tests**

Sixteen visually impaired subjects should be scheduled for testing starting at 1:30 on October 12 and from 9:00-12:30 and 1:30-5:00 on October 13, with Saturday October 17 as a rain date. Testing will run from 9:00-12:30 and 1:30-5:00 in half-day sessions. Again absenteeism is expected to be high; we should schedule 16 with hopes of testing 12 subjects.

The sample of participants should be:

1) All long cane users;
2) All severely visually impaired with little or no useable vision (light perception is okay, but no more vision);
3) Adults over 18;
4) At least 4 subjects over 65.

Again over the telephone, preliminary background information should be obtained. Consent forms should be sent participants and should be returned before testing starts. These subjects need not be medically screened.

Professor Billie Bentson, at Boston College has agreed to help find visually impaired participants.
PERSONNEL AND EQUIPMENT NEEDED FOR RAMP TESTS

2 Research Assistants (to pick up participants who require transportation to the gathering place, to drive the vans, to assist in data collection, and to return participants who require transportation to their homes). A trained replacement needs to be available in case of illness.

For Wheelchair Testing

2 Vans equipped with wheelchair lift and some means of securing wheelchairs (each van should accommodate 3 wheelchairs).

60 Roadway safety cones. 15 cones will be used at each ramp to identify start finish, and rest area locations.

2 Water jugs + cups (one for each van).

Parking spots need to be identified at each site.

Chalk for marking distances

For Visually-Impaired Testing

2 Cars or vans to transport participant, and parking at each site.

PROCEDURE FOR TRAINING SESSION

At 9:00 on October 12 we will have a 3 hour training session. We will practice procedures for both the blind and visually-impaired testing. This will involve a "full dress" rehearsal including preparation of ramps. Please bring a wheelchair and we will have the research assistants serve as practice subjects. Everyone should participate, including the backup research assistant.

PROCEDURE PRIOR TO DAY OF TESTING

1. Permission should be obtained from the appropriate authorities governing the crossing structures to conduct the tests on the days specified. Normal crossing structure usage will not interfere with the tests. Parking places should be reserved.
2. At each ramp site, the closest available phone and accessible bathroom for use in emergency situations should be identified. The telephone number of an ambulance service should also be determined.

3. On the day before testing begins, distances every ten feet should be clearly marked in chalk on each of the ramps.

4. Prior to testing, the selected ramps should be surveyed every 5' using a surveyor's transie to record exact slope for each interval.

**PROCEDURE ON DAY OF TESTING**

1. Research assistants should pick up participants who need transportation to the gathering place.

2. At 9:00, 3 subject/participants, an Atlanta researcher, and a Boston research assistant will drive in each of the vans to one of the test sites.

3. Actual wheelchair testing will be conducted from 9:30 - 4:00 with a break for lunch at an appropriate time. Visually impaired testing will go on from 9:00 - 12:30 and 1:30 - 5:00.

4. Wheelchair testing will involve:
   a) setting up safety cones at specified distances
   b) setting up countermeasures.
   c) reading instructions to participants.
   d) recording data as participants travel up and down the crossing structure ramp(s).
   e) moving to additional ramp and repeating procedure.

5. Visually impaired testing will involve:
   a) setting up countermeasures
   b) having participants cross structures while observing
   c) debriefing participants
   d) moving to additional ramp and repeating procedure
December 4, 1981

Mr. Bill Wheeler  
Federal Highway Administration  
HRS-41  
Washington, D.C. 20590

RE: Design guidelines for making crossing structures accessible to the physically handicapped

Contract #DTFH 61-80-C-00131  
Fourteenth Monthly Progress Report

Dear Mr. Wheeler:

Phase I

Task A: Ramp Gradients

During the month of November work proceeded in three areas:

1) Sub-sample testing in Atlanta;
2) Data analysis of the fall and spring Atlanta tests;
3) Field testing in Boston.

The sub-sample testing on three of the Atlanta ramps continue. However, given the limited size of the participant pool (persons who had stopped to rest between 2 and 4 times on the previous ramp tests) it was becoming more difficult to find subjects willing to participate. We have also been delayed due to rainy weather. A total of twelve participants have been tested to date.

In addition, due to the absence of any helical ramps on crossing structures in the Boston area, it was decided that an evaluation of the impacts of helical ramps on performance should be conducted with a limited number of the sub-sample participants. In preparation for these tests, helical ramps (most commonly associated with parking garages) in close proximity to the Tech campus were identified and surveyed. It was determined that the tests would be conducted on a parking garage ramp. Two four foot wide paths would be delineated with chalk on this ramp: one on the outside edge of the ramp, with a slope of approximately 1:15; and one in the middle of the ramp, with a slope of approximately 1:12. Participant performance on straight ramps within the critical range of ramp slopes 1:10 to 1:17. The location of safety cones representing ramp landings and the
research procedures to be used in these helical ramp tests were the same as those used in the sub-sample tests on straight ramps. Preparations have been made to conduct these tests in the first two weeks in December.

Data analysis continued on the data from the fall and spring Atlanta tests.

Task B: Field Testing

We had hoped to conduct the field tests of crossing structures in the Boston area the week of October 12-16. However, the subject organizer, hired through the M.I.T. Architectural Research Laboratory, had great difficulty locating and scheduling subjects. Twice the scheduled research plans had to be postponed.

Even with these delays, only manual wheelchair users were scheduled for testing the first week in November. Due to the increasing chances of poor weather, a decision was made to proceed with the tests November 2 through 5 despite the small sample size. As we anticipated, the absenteeism rate on test days was high. A final total of 8 manual wheelchair users were evaluated on four crossing structures in Boston.

Data from these test is be prepared for analysis.

Phase II

Detectability

The two regression analyses which were performed last month have been reviewed by Dr. Montgomery. The first analysis, the regression performed on the probability of detecting a panel (rate of detection) vs. the 5 main effects, has been expanded to include the interaction of the main effects and the type of surface material. The addition of surface material, identified as either concrete or non-concrete (0/1), derived from the occurrence of extremely low(<.40) detection rates for concrete panels which resulted in unusable values greater than ±2 standard deviations. The inclusion of materials and the transformation of the equation from a straight-line regression to a curve $y = \sqrt{\sin^{-1}(\text{rate on each panel})}$ incorrectly written in last month's report as $y = \sqrt{\sin^{-1}(x_1 \cdot x_2)}$, eliminated the outliers at ±2SD and yielded an $R^2 = .85457$.

The final equation indicated by the analysis is:

\[
y = 50.614(M) - 20.315(BCF) + 19.303(ABC) + 1.372D - 110.232
\]

where
\[
y = \sqrt{\sin^{-1}(\text{rate})}
\]
M = Surface material (0 = concrete, 1 = non-concrete)
A = Groove width (in inches)
B = Groove spacing (in inches)
C = Groove depth (in inches)
D = Loudness (in dBs)
F = Rebound (in 0.1 inches)
The second test provided less useful information, and the decision was made to run a regression of the subjects stopping distances for each panel vs. the 5 main effects. The data for this analysis has been reformatted and a preliminary straight line regression has been performed.

**Phase III**

**Orientation Cues for the Blind**

Work in November was devoted to data entry, analysis of the Atlanta field test data and preparation of the final report. Twenty subjects have to date been tested; the remaining subjects are currently being tested. It has proven extraordinarily difficult to find a large subject population in the "critical group", people with little or no functional vision. This group constitutes a small proportion of the severely visually impaired -- one third at most -- and many of these people are multiply handicapped or have full time jobs that do not allow time for testing. As a result, a large amount of time has been spent finding and scheduling subjects. Much of the final report is written; the rest will be added as analyses become available.

The purpose of the testing in Boston was to confirm and extend the results from the Atlanta Field Testing. Subjects from the "critical population" were selected to experience actual pedestrian crossing structures both with and without countermeasures. Two structures along Storrar Drive were selected. The relevant design issues represented by these structures included: dirt-path approach, open-space approach, complex up-access, complex approach path. The countermeasures employed included: textured metal paving plate, carpet strips and mats, sound-emmiting tweeter, rubber strips, and others. A large number of individuals, schools and agencies were contacted to recruit subjects. These included: Perkins School for the Blind, Carroll School, State Office of Vocational Rehabilitation, and others.

Six subjects were tested on November 4-5. These subjects experienced the crossing structures before and after the countermeasures were added. A coding scheme similar to the Atlanta Field Testing was used.

**Phase IV**

**Development of Criteria for Crossing Structures**

**Task A: Development of Criteria**

Based upon the findings of phases I through III preliminary criteria for ramp gradient, orientation and detectability/slip resistance have been developed as reported earlier.

**Task B: Outline for Implemental Package**

The outline was submitted with the October report. If the outline is satisfactory we would appreciate an immediate written authorization from the contracting office so that we may proceed with the work.
Fiscal Information

We enclose:

- the bar chart shown; work performed this month by phase compared to the scheduled work;
- the money expended by phase and the cumulative totals for the month compared to the total scheduled costs; it should be noted that as Georgia Tech does not finalize its monthly budgets until the 15th of the month, the figures are estimates. Actual expenditures will be supplied with the next monthly report.
- the time expended by the professional staff during the month and the cumulative totals.

Sincerely,

John A. Templer, Ph.D.
Principal Investigator

Enclosures

JAT: mr
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**PHASE IV**

**PHASE III**

**PHASE II**

**PHASE I**

---

**TASK TIME CHART**

- ![Estimated](image)
- ![Completed](image)
### PROFESSIONAL STAFF

**Time Expended November**

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### COST BY PHASE:

**November**

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January 14, 1982

Mr. Bill Wheeler
Federal Highway Administration
HRS-41
Washington, D.C. 20590

RE: Design guidelines for making crossing structures accessible to the physically handicapped

Contract #DTFH 61-80-C-00131
Fifteenth Monthly Progress Report

Dear Mr. Wheeler:

During the month of December, we completed a draft of the final report and this was sent to you. This draft does not contain all of the results and conclusion because the late start of the Boston testing (awaiting the contract modification) delayed the acquisition and processing of data; also because we could not test helical ramps in Boston, we have had to do these tests in Atlanta. We expect to be able to supply you with the missing material later this month.

Phase I

Task A: Ramp Gradients

During the month of December the Atlanta sub-sample tests were completed, and data analysis continued on the Atlanta test and sub-sample test data.

A total of 13 wheelchair users completed the sub-sample tests on three of the Atlanta ramps. Six wheelchair users were tested on two helical ramps.

Task B: Field Testing

Data analyses were conducted on the data collected from the Boston field tests.

Phase II

All of the work on this phase has been completed. However, the regression equations relating stopping distance of subjects to the five main effects have not shown strong relationships. We intend to reexamine the data and attempt some transformations.
Phase III

Orientation Cues for the Blind

The Atlanta Field Testing has been completed and most of the data are coded and entered into the computer. Preliminary data analysis is currently underway.

Fiscal Information

We enclose:

. the bar chart shown; work performed this month by phase compared to the scheduled work;

. the money expended by phase and the cumulative totals for the month compared to the total scheduled costs; it should be noted that as Georgia Tech does not finalize its monthly budgets until the 15th of the month, the figures are estimates. Actual expenditures will be supplied with the next monthly report.

. the time expended by the professional staff during the month and the cumulative totals.

Sincerely,

John A. Templer, Ph.D.
Principal Investigator

Enclosures

JAT:mr
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**TASK TIME CHART**

- ESTIMATED
- COMPLETED
PROFESSIONAL STAFF

Time Expended December

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COST BY PHASE:

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February 10, 1982

Mr. Bill Wheeler  
Federal Highway Administration  
HRS-41  
Washington, D.C. 20590

RE: Design guidelines for making crossing structures accessible to the physically handicapped  

Contract #DTFH 61-80-C-00131  
Sixteenth Monthly Progress Report

Dear Mr. Wheeler:

There is little to report this month. We are wrestling with the statistical analyses --trying to find data transformation that will indicate a higher level of significance than the variables that we have been using. As you will be well aware, this is simply a very time consuming process and this has been exacerbated by the difficulties encountered in accessing the Georgia Tech computer system. Our system has reached one of those cycles when it is very overloaded and a larger system is being installed. Changing the system means many aggravating delays while the system is 'down' and the frequent loss of data and programs.

I am well aware that without these data and conclusions, you cannot get much feedback on our draft report. However, I assure you that we are putting all our efforts into completing this project. Like many parts of the country we have been experiencing an unusually severe winter and in fact, Georgia Tech was completely closed from Tuesday 12th of January in the afternoon until Monday 18th because of heavy snow and icy roads.

We hope to be able to send you the missing findings and recommendations within a week or two.

Fiscal Information

We enclose:

- the bar chart shown; work performed this month by phase compared to the scheduled work;
- the money expended by phase and the cumulative totals for the month compared to the total scheduled costs.
the time expended by the professional staff during the month and the cumulative totals.

Sincerely,

John A. Templer, Ph.D.
Principal Investigator

Enclosures

JAT:mr
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**TASK TIME CHART**

- Estimated
- Completed
### PROFESSIONAL STAFF

**Time Expended January**

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<td>Phase IV</td>
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May 12, 1982

Mr. Mohan Pillay  
Federal Highway Administration  
HRS-21  
Washington, D.C. 20590

RE: Design guidelines for making crossing structures accessible to the physically handicapped

Contract # DTFH 61-80-C-00131  
Monthly Progress Report - Phase V.

Dear Mr. Pillay:

Contract modification #3 became effective on February 28, 1982 and work on the user manual was started.

The general graphic layout of the manual has been completed and work on each of the sections has commenced. Parts B4 and B7 of the design details are complete and these were presented to you on May 6 for approval of the layout. The graphics for these and all sections were developed from slide transparencies of actual disabled people in our view this will enhance the realism of the illustrations.

Fiscal Information

We enclose details of:

- The money expended during the phase and the cumulation total for the month compared to the scheduled cost.

- the time expended by the professional staff during the month and the cumulative totals.

Sincerely,

John A. Templer, Ph.D.  
Principal Investigator

Enclosures  
JAT:mr

AN EQUAL EDUCATION AND EMPLOYMENT OPPORTUNITY INSTITUTION
PROFESSIONAL STAFF

Time Expended April

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June 15, 1982

Mr. Mohan Pillay
Federal Highway Administration
HRS-21
Washington, D. C. 20590

Re: Design guidelines for making crossing structures accessible to the physically handicapped.

Contract #DTFH 61-80-C-00131
Monthly Progress Report - Phase V

Dear Mr. Pillay:

The work on the manual is progressing on schedule. We propose to send you approximately one half of the material on or about July 14, 1982.

Fiscal Information

We enclose details of:

   The money expended during the phase and cumulation total for the month compared to the scheduled cost.

   The time expended by the professional staff during the month and the cumulative totals.

Sincerely,

John A. Templer, Ph.D.
Principal Investigator
JAT:pb
Enclosure
### PROFESSIONAL STAFF

**Time Expended May**

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### COST BY PHASE

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16 July 1982

Mr. Mohan Pillay
Federal Highway Administration
HRS-21
Washington, D.C. 20590

RE: Design guidelines for making crossing structures accessible to the physically handicapped

Contract #DTFH 61-80-C-00131
Monthly Progress Report - Phase V

Dear Mr. Pillay:

The work on the manual is progressing as scheduled. Under separate cover we have sent you approximately one-half of the manual. We expect to be able to send you the remainder early in August.

Fiscal Information.

We enclose details of:

The money expended during the phase and cumulative total for the month compared to the scheduled cost.

The time expended by the professional staff during the month and the cumulative totals.

Sincerely,

John A. Templer, Ph.D.
Principal Investigator

JAT:nlc

Enclosure
PROFESSIONAL STAFF

Time Expended June

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COST OF PHASE V

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<td>Complete:</td>
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ACCOMODATING THE PHYSICALLY HANDICAPPED ON OVER AND UNDERCROSSING STRUCTURES

PEDESTRIAN RESEARCH LABORATORY
COLLEGE OF ARCHITECTURE
GEORGIA INSTITUTE OF TECHNOLOGY
PROJECT TEAM

For the Pedestrian Research Laboratory, Georgia Institute of Technology:

John Templer, Ph.D., Co-Principal Investigator
Jean Wineman, Arch.D., Co-Principal Investigator
Craig Zimring, Ph.D., Co-Principal Investigator

Research Associates

David Lewis
Jon Sanford
Aline Smith
Deborah Hayes-Sanford

Research Assistants

Robert Beck, George Bushey, David Marlatt, Howard Minsk, Robert Osgood
contents

1. introduction ...........................................

2. design strategy ........................................

3. schematic design ......................................

4. design details ..........................................  
   a. walkways ............................................
   b. ramps ...............................................  
   c. steps and stairs ..................................
   d. handrails, railings, barricades ..............
   e. signage and media cues .........................
   f. lighting and illumination .....................
   g. street furniture ...................................

5. appendix ............................................... 

6. index ..................................................
INTRODUCTION

Since the Second World War grade separation structures for pedestrians have become a standard part of our roadway systems in urban and rural locations. Most of these pedestrian crossing structures have been built over freeways; others span minor roads, rivers and railroad tracks; and some are underpasses.

The 1968 Architectural Barriers Act mandates that if these structures are financed with federal funds then they must be made accessible to the disabled. Most states also have laws requiring accessibility for all buildings and facilities that are to be used by the public. The advent of these statutes has made much of the environment accessible and enabled many more disabled people to move around our cities and buildings.

A recent survey (Templer and Wineman, 1980) showed that 86 percent of a sample of 124 crossing structures that were surveyed in 9 cities had at least one major access barrier; and not one of the structures was barrier free. In many cases, only stairs or only ramps were provided. Frequently ramps were too steep, or too long. Some of the crossing structures were accessible but the walkways leading to them and the surrounding environments were not. Frequently the structure had complex approach paths and layouts that would be incomprehensible and even hazardous to many blind people. In some cases accessibility had been considered conceptually but details of the designs were faulty. Forty percent of the structures had large deep expansion joints that would be impassible to some wheelchair users. About one third of the sample had ramps that exited directly into a street or a parking area in a way that would be hazardous for blind pedestrians. Many of the ramps and some of the stairs had no handrails or had discontinuous handrails. Forty-three percent of the sample had faulty illumination and vandalized light fittings. Some of the structures had access paths of gravel which were impassible to wheelchairs.

To remedy these barriers to access would require substantial modification of the crossing structure in the form of new construction or reconstruction; and modifying existing structures is inevitably costly. It is obviously important to ensure that new crossing structures are carefully designed for accessibility at the outset.

Pedestrian crossing structures represent a distinct engineering type, and designing these for accessibility requires specialized information at both the schematic planning level and in terms of design details. This manual is arranged to provide information for decision making at both these levels.

The scope of the manual includes most of the detailed information that will be useful for the design of the structure and its immediate environment. However for a more extensive treatment of detail design consideration for elderly and handicapped pedestrians a companion implementation manual is available entitled "Development of Priority Accessible Networks: Provisions for the Elderly and Handicapped Pedestrians", (Templer et al. 1980). The recommendations in that publication as well as those contained in this manual are based on a series of research studies carried out at the Pedestrian Research Laboratory of the Georgia Institute of Technology (Templer 1979, 1980 and Templer, Wineman and Zimring 1982).

It should be noted that the recommendations that follow in this manual may not agree with the codes and standards that are in force in various jurisdictions of the U.S. And in certain respects the recommendations differ from the re-
quirements of the ANSI standards (1961) and those of the ATBCB (1981). Obviously the designer must be governed by the dictates of the extant statutes where there is a conflict.

THE ACCESSIBLE NETWORK

A crossing structure that has been carefully designed for accessibility may still be inaccessible to elderly and disabled pedestrians if the sidewalks and walkways that lead to it are inaccessible. If, for example, pedestrians must cross a road to reach an overcrossing, and there are no curb cuts at the crosswalk, then wheelchair users may not be able to reach the structure. In other words the pedestrian walkway system is inaccessible even if individual components are accessible. The concept of the Priority Accessible Network (PAN) was developed (Templer et al. 1980) as a response to the problems arising from a nonsystematic approach to the development of accessible routes for the disabled.

The PAN consists of a number of fully accessible pedestrian routes which are gradually expanded according to a master plan. Each accessible route consists of a connected sequence of components (a street crossing is a component) which in turn are formed from a connected sequence of elements. (such as cross walks and streetlights) The over/under crossing as a component is a vital link in the pedestrian network.

The process for development of the PAN is fully described in Development of Priority Accessible Networks - An Implementation Manual (Templer et al. 1980). The general concept underlying the successful implementation of a PAN requires that as each route is made accessible, it is then added to the accessible system according to priorities set out in the plan. In practice, routes serve elderly and disabled pedestrians who reside and work within districts; routes connect the districts to each other.

Each district is added to the accessible system according to the priorities of the master plan, eventually leading to complete accessibility of the larger community.

Accessibility is achieved by the use of appropriate countermeasures that resolve problems encountered with in particular elements of the system. A typical countermeasure might be the addition of a curb ramp. Such a countermeasure would then lend itself to the accessibility of the over/under crossing component and thereby complementing the accessibility of that particular route of which the crossing structure is a part.

Before a final decision is made as to where to locate a pedestrian crossing structure, it is therefore necessary to consider whether the proposed site is accessible to the disabled population of the districts that are served. If the routes leading to the structure are not accessible, will some other location for the structure be better? Or, will accessible routes leading to the structure be developed?

The strategies for locating and planning pedestrian crossing structure will now be discussed. In this discussion these pedestrian facilities are considered in terms of the end conditions, the approaches and the structures. The end condition is where the over/under crossing meets the adjoining roads or walkways. The structure refers to the section of the crossing that spans over or tunnels under the road, river etc. And the approaches are the stairs, ramps, walkways, etc. that connect the structure to the end conditions.
over crossing

under crossing
THE DESIGN IMPLICATIONS OF DISABLING CONDITIONS

The general strategies for designing accessible crossings do not differ from those of good engineering practice; the purpose of this manual is to provide the necessary data on the special needs of disabled pedestrians. Many design guides discuss the needs of wheelchair users, but there are many other types of disabilities that must be considered. A familiarity with the nature of these disabling conditions enables the designer to avoid potential hazards or barriers to mobility. The table that follows sets out the most typical impairments and gives examples of the types of solution to the mobility problem or hazard. The table may also be used as check list when considering any portion of a pro-design. The question then is whether or not the proposed design element can be used by all people including those with the listed disabling conditions.

<table>
<thead>
<tr>
<th>EXAMPLES OF PROVISIONS REQUIRED</th>
<th>REASONS</th>
<th>DISABLING CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Stopping and resting places</td>
<td>• Cannot travel far without stopping and resting</td>
<td>LIMITED STAMINA</td>
</tr>
<tr>
<td>• Seating</td>
<td>• Cannot travel unless there are places to sit.</td>
<td>SLOW TRAVEL SPEED</td>
</tr>
<tr>
<td>• Additional pedestrian walk interval time at signalized intersections.</td>
<td>• Moves much slower than the average pedestrian</td>
<td>SLOW REACTION TIME</td>
</tr>
<tr>
<td>• Additional walk interval time</td>
<td>• Cannot physically react quickly</td>
<td></td>
</tr>
<tr>
<td>• Detectable warning cues</td>
<td>• Cannot see at all</td>
<td>IMPAIRED VISION</td>
</tr>
<tr>
<td>• Elimination of low projection</td>
<td>• Cannot see low overhanging projection</td>
<td></td>
</tr>
<tr>
<td>• Tactile and audible signage systems</td>
<td>• Cannot react to visual information and signs</td>
<td></td>
</tr>
<tr>
<td>• Signage with large letters</td>
<td>• Cannot react to small print</td>
<td></td>
</tr>
<tr>
<td>• Visual information systems</td>
<td>• Cannot hear sound warnings</td>
<td>IMPAIRED HEARING</td>
</tr>
<tr>
<td>EXAMPLES OF PROVISIONS REQUIRED</td>
<td>REASONS</td>
<td>DISABLING CONDITION</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>---------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Provide ramps; smooth hard surfaces; maneuvering space, etc.</td>
<td>Uses a wheelchair</td>
<td>LIMITED USE OF LOWER EXTREMITIES</td>
</tr>
<tr>
<td>Avoid the use of metal surfaces that may become very hot or cold</td>
<td>Cannot detect heat or cold sensation with certain parts of the body</td>
<td></td>
</tr>
<tr>
<td>Provide steps as an alternative to ramps</td>
<td>Cannot traverse steep ramps</td>
<td></td>
</tr>
<tr>
<td>Telephones, etc. must be places within reach</td>
<td>Cannot reach very high or low</td>
<td>LIMITED REACH</td>
</tr>
<tr>
<td>Walkways must be wide enough for the anticipated number of pedestrians</td>
<td>Cannot tolerate being bumped</td>
<td>IMPAIRED BALANCE</td>
</tr>
<tr>
<td>Provide handrails</td>
<td>Cannot traverse ramps and stairs without something to lean on</td>
<td></td>
</tr>
<tr>
<td>Ensure that surfaces are not slippery and will not cause trips</td>
<td>Increased likelihood of falls</td>
<td></td>
</tr>
<tr>
<td>Ensure that water fountains, etc. can be operated without precision movements</td>
<td>Cannot perform tasks requiring precise manual dexterity</td>
<td>LIMITED MANUAL DEXTERITY</td>
</tr>
<tr>
<td>Avoid heavy gates, etc.</td>
<td>Limited ability to push, pull, lift, carry</td>
<td>LIMITED STRENGTH</td>
</tr>
<tr>
<td>Ensure that signs, etc. are within range; and that people will not be hidden from vehicle drivers</td>
<td>Small stature</td>
<td>EXTREMES OF HEIGHT OR SIZE</td>
</tr>
<tr>
<td>Ensure that openings etc. are enough</td>
<td>Person (or wheelchair) is wider than most pedestrians</td>
<td></td>
</tr>
</tbody>
</table>

Obviously some types of disabilities limit mobility more than others, and likewise the mobility problems of some people are more severe than others. Some of the people may be able to traverse all parts of the pedestrian environment although perhaps with great difficulty. Others simply cannot use the pedestrian environment at all unless it is designed to accommodate them. We have chosen to call the latter population the critical groups; for crossing structure, people who use manual wheelchairs, and people who have little or no sight form the critical groups.

Manual wheelchair users, for example, cannot use steps or stairs and are
limited in their ability to ascend ramps; severely visually impaired people may have great difficulty in even locating the structure and understanding its layout. The needs of all mobility impaired groups must be considered in the design process, but the needs of these two critical groups are likely to affect the finished structures to a much greater extent. Therefore a fuller description of the nature of their disabilities and needs is provided in the following paragraphs.

A. MANUAL WHEELCHAIR USERS

Wheelchair users may be people with various disabilities they may have multiple disabilities, or they may be elderly with degenerative conditions. Each disability has its own physical consequences with respect to strength, stamina coordination etc.; and the physical conditions are affected by individual factors such as age, experience, training, attitude and general health. Clearly then manual wheelchair users vary greatly in their mobility abilities.

Some may be strong and athletic and quite capable of doing "wheelies" over a 6" curb. Others may have strength in one arm, or in their feet only. The former may have great difficulty in maintaining a straight course; the latter may travel backwards by pushing on the ground with their feet. Many wheelchair users experience spasticity, muscular spasms, engendered by a sudden jolt as a wheel meets an obstruction; this spasm may be severe enough to cause the user to fall from the chair.

The manual wheelchair is a light unprung vehicle with limited stability. The wheels are narrow in width and can become trapped in a grating; and the wheels can easily become bogged down in gravel, mud, or any soft surface. Rough hard surfaces such as cobblestones, uneven brick paving and materials with many joints will jolt wheelchair users and may even be painful to travel over. An expansion joint or a step as little as one half an inch may be too much for some users to ascend, and may be sufficient a barrier to jolt others from their seats.

Wheelchair users who travel independently can use ramps, but the effort required is substantial; the physical demands of this activity is dependent as the length and steepness of the ramp. As a group wheelchair users tend to have less energy and stamina than able bodied people, so the fewer hills and ramps they must ascend, and the shorter and less steep the ramps the better it is. The longer the ramp, the fewer the number of wheelchair users who can reach to top.

If a walkway has a slope across it, the wheelchair user must use much more effort to keep the wheelchair from veering towards the downhill side.

Some wheelchair users can propel their chairs with remarkable precision through an opening with no more than 1/4" clearance on either side. Others, by the nature of their disability, have much more strength on one side of their body than on the other, and swerve from side to side as they travel.

Like any wheeled vehicle, the wheelchair has critical dimensional needs for passage and for turning; and because the hands are used as brakes, usually, it needs space within which to decelerate and stop, and it is necessary to consider the (unusual) event of a runaway wheelchair where the user has lost control of the vehicle.

Having limited reserves of strength many wheelchair users must conserve their energies carefully, so travel distances must be reduced to a minimum.

Despite their disabilities wheelchair users can lead normal and productive lives and will expect to use the pedestrian environment to the same extent as anyone. They can do this if a few fairly simple design principles and solutions to generic problems are
considered during the design phase. The most typical impediments to wheelchair travel are summarized below, and the planning requirements shown.

<table>
<thead>
<tr>
<th>PLANNING REQUIREMENT</th>
<th>MOBILITY BARRIER</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Structure should be accessible and connected to an accessible part of the pedestrian network</td>
<td>• Lack of continuity with other accessible pathways</td>
</tr>
<tr>
<td>• Access routes and structure should be in convenient locations that do not unduly extend travel distances</td>
<td>• Long distances</td>
</tr>
<tr>
<td>• Select a location that is safe from crime and natural hazards</td>
<td>• Fear of crime and natural hazards</td>
</tr>
<tr>
<td>• Provide a smooth, slip resistant walkway surface that allows good traction</td>
<td>• Soft ground; broken uneven or slippery pavement</td>
</tr>
<tr>
<td>• Provide sufficient turning space at all walkway turns of junctions</td>
<td>• Insufficient turning space</td>
</tr>
<tr>
<td>• Provide walkways that are of sufficient width to allow two wheelchairs to pass each other</td>
<td>• Narrow spaces</td>
</tr>
<tr>
<td>• Provide a ramp as well as stairs</td>
<td>• Stairs</td>
</tr>
<tr>
<td>• Keep ramps short and shallow</td>
<td>• Long/steep ramps</td>
</tr>
</tbody>
</table>

B. THE VISUALLY IMPAIRED

According to the American Foundation for the Blind (AFB), there are about 1.7 million people in the United States who are severely visually impaired. About 400,000 of the severely visually impaired have no usable vision and can be classified "blind". According to the AFB, in the U.S., 65 percent of the severely visually impaired are 65 years of age or more; only 4 percent are under 25. Because many visually impaired people are older, they often experience multiple disabilities: visual impairment plus the problems with balance and agility that may come with aging. These diseases may have different impacts on vision: reduced color vision, reduced color vision, reduced central or peripheral vision, heightened susceptibility to glare, or even total loss of vision.

Two sets of skills are needed if visually impaired people are to successfully negotiate the environment. First, they must know where things are. They must comprehend their own relationship to furniture, streets, building entrances, and at a larger scale, the layout of buildings and towns. This set of skills has been labeled orientation. The second set of skills, which has been labeled mobility, requires the minute-to-minute use of environmental information that allows a visually impaired person to stay on the route and avoid hazards.
As visually impaired people get to know a place better their strategy for orientation may change. At first, they may travel from point-to-point, going from remembered landmark to remembered landmark. Later, they may develop an overall mental map of their setting that represents the spatial relationship of important features. For example, if a visually impaired person is using a crossing structure, he or she may at first merely memorize a string of landmarks: the location of a sign, a path, a wall, the entrance to the crossing, and so on. Later, he may develop an overall mental picture of the site and crossing structure. An overall mental map is desirable in that it allows flexibility and confidence in travel (missing a single landmark in a point-to-point strategy may lead to confusion), but a mental map may be almost impossible if a route is highly complex and hard to imagine. Travelers are generally taught to keep track of the cardinal points -- North, South, East, West -- and simple routes with right angles that support those directions aid mental mapping.

During mobility training visually impaired travelers are taught to use all possible environmental information to help them stay on a route and avoid danger: touch, sound, odors, and so on. Most severely visually impaired people rely on their residual (remaining) vision to find their way rather than on any additional aid. The second most common mobility aid is the long cane. This cane, which is usually made of thin aluminum tubing similar to the shaft of a golf club, is used to sweep the path in front of the traveler. The cane is held at waist level and is angled down; travelers are trained to sweep an area as wide as their shoulders (24 inches or so), although most actually sweep an area 42 inches wide or more. The angle and sensitivity of the cane allows an experienced traveler to be adept at detecting and evaluating various kinds of environmental cues: walls, up and down curbs, paving changes, posts etc. However the downward angle of the cane makes it difficult to detect overhanging objects, or anything that is more than about 27" above the ground. Cane users are taught to make use of shorelines, which are lines, such as the edge of a sidewalk, that help them to stay on a path, and landmarks, which are memorable points (lamp poles, mail boxes, curbs etc.) that help confirm that a traveler is on the remembered route.

Dog guides are much less frequently used as mobility aides. Because dog users need to be temperamentally suited to dog ownership, as well as able to maintain the dogs' rapid walking pace, dog users are limited to a small percent of the severely visually impaired population. Dog users have different needs and abilities than cane users. They are less vulnerable to overhanging objects, but are also less sensitive to some kinds of environmental information, such as paving changes, or shorelines.

A large number of electronic mobility aids have also been developed, but they have not been widely accepted by visually impaired travelers, and are used by only a very small number of people.

Several things should be noted about visually impaired pedestrians. First, they are generally older and may have multiple disabilities. Second, most people classified as "severely visually impaired" have some usable vision and can benefit from visual cues such as contrasting paint and good lighting and signs. Third, there is a wide range of visual disabilities that must be considered: poor central vision, poor peripheral vision, color blindness of various types, loss of acuity, and so on. Fourth, because they lack visual cues, visually impaired people rely more on their mental maps than do sighted people.

Because of their abilities and disabilities and travel strategies, certain situations are particularly difficult or even hazardous for the
For orientation, complex plans with irregular angles and twisting paths make it particularly difficult to maintain orientation, and should be avoided wherever possible. For mobility, some situations may be hazardous in that they might cause hurt to travelers; others may be barriers in that their design prevents people without sight from using them effectively. Because many travelers use a long cane, overhanging objects such as tree limbs, phone booths, or guy wires are particular hazards. Unexpected stairs and other level changes may be also be hazardous. It is very difficult for a visually impaired person to cross large undefined open spaces such as a parking lot or paved plaza, or in fact to travel where a path is not well defined. Other specific hazards and barriers are discussed in the design detail section, below.

The abilities and needs of visually impaired people may be clearer if we consider the situation of a visually impaired pedestrian negotiating a hypothetical crossing structure. We will assume that the pedestrian is a cane traveler with little functional vision who is traveling along a sidewalk. The first task he faces is to find where to turn off the sidewalk. Based on the information from the cane and other senses, the pedestrian must try to find the correct place to turn. This is a double problem: the turn must be detected and bypassed, and the turn must be identified as the correct turn and distinguished in some way from all other turns in the sidewalk the designer can be of assistance here by providing the turn off with some recognizable distinguishing features or landmark that can be detected by cane. This may take the form, for example, of a signpost at the edge of the sidewalk at the intersection with the turnoff as illustrated and this would provide information for people with low vision while, at the same time, acting as a landmark for these with no vision.

There are other useful alternative solutions and these are discussed in the Design Details section which deals with signage media and cues.

Assuming the pedestrian has now found the correct turn, there remains the problem of finding the structure itself. In many situations, the traveler must cross a large open space or parking lot before encountering the actual access ramp or stairs. As stated above, this is often a very difficult task for visually impaired people. Cane users, particularly, typically navigate using shorelines and may inadvertently veer when crossing an undifferentiated open space. This search may, of course be hazardous as well as difficult. An overhanging limb or sudden level change may cause a traveler injury or embarrassment. The solution to this problem is to avoid it. The connection from sidewalk to the crossing structure should take the form of a walkway with defined edges that can be used as a shoreline; and this walkway should be provided across the parking lot or open space.

When this open space has been negotiated, the traveler must find the entrance to the ramp or stairs; he must be sure that what he encounters is the actual ramp or stairs rather than another part of the structure or some other building. Again it is the responsibility of the designer to ensure that the approach path to the structure is direct and unambiguous. At that point the traveler must ascend to the actual crossing. This is usually fairly easy, especially in situations with well designed handrails that are smooth and that turn before the stair or ramp turns to give the visually impaired user some warning.

Once on the crossing, a visually impaired pedestrian may have relatively little difficulty if the structure is simple. However, if there are choices, such as between a ramp and stair, or between two different egress points, the task is much more difficult. The pedestrian must find the
correct turn and understand where it will lead to on the ground. Unexpected level changes, and particularly sudden down stairs may be quite hazardous.

After the down-egress has been found, the traveler must face problems similar to the approach: maintaining orientation, finding the appropriate sidewalk, and so on, and the design solutions are similar.

To the sighted, the scenario above may seem difficult or impossible. In fact, many visually impaired people do equally difficult or more complex things every day. There is some debate among visually impaired people themselves as to how much the environment should be adapted to suit their needs. As the examples show, there are a number of low cost planning and design principles that can be incorporated into almost all crossing structures to aid wayfinding and orientation, as well as more elaborate countermeasures that can be used when the situation demands. These are summarized below.

The overall design implications of these hazards and barriers are:

<table>
<thead>
<tr>
<th>PLANNING REQUIREMENTS</th>
<th>BARRIER OR HAZARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keep routes as simple as possible use simple geometric forms with right angles.</td>
<td>Complex routes make orientation and mental mapping difficult.</td>
</tr>
<tr>
<td>Avoid end conditions directly off parking lots, plazas or grassy fields. Provide shorelines and walkways.</td>
<td>Open undefined spaces makes orientation and mobility difficult.</td>
</tr>
<tr>
<td>Locate crossing structures at logical points in the pedestrian network. Mark entry and exit and conditions.</td>
<td>Poor connections with the area's overall pedestrian network may cause disruptions of a travelers' overall mental map of the area.</td>
</tr>
</tbody>
</table>
PRELIMINARY PLANNING

Designs that incorporate solutions to the mobility problems of the critical groups and other disabled people will be quite different from designs that do not. At all stages of the design process therefore the criteria for accessibility must be considered; they cannot be grafted successfully onto the finished design at the end of the process. In the section that follows four parts of the design process will be treated briefly in order to illustrate the major accessibility concerns that may affect design decisions. The four parts are as follows:

1. the choice of a site
2. site and preliminary planning
3. configuration of the crossing structure
4. detail design

SITE SELECTION

An appropriate location for the pedestrian crossing structure will depend on the primary engineering and planning considerations, however the following check list should be considered before making a final choice of a site. The design details section will provide further elaboration. The factors below will apply to both sides of any proposed crossing structure site.

<table>
<thead>
<tr>
<th>ITEM</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>IF the sidewalks or walkways leading to the site are too steep for wheelchairs...</td>
<td>THEN reject the site.</td>
</tr>
<tr>
<td>IF the sidewalks/walkways leading the site are inaccessible...</td>
<td>THEN reject the site or plan to within the scope of the project to make them accessible.</td>
</tr>
<tr>
<td>IF the proposed site is far from the existing pedestrian walkway it will be difficult for blind people to find, and will be difficult for people with limited stamina reach...</td>
<td>THEN give preference to a closer site.</td>
</tr>
<tr>
<td>IF the crossing structure for the proposed site will require long ramps and stairs, then fewer disabled people can use them. Also, long ramps require larger sites, so...</td>
<td>THEN give preference to a site that crosses on grade, or a site that requires short ramps and stairs.</td>
</tr>
</tbody>
</table>
• IF there are any steps in the paths that a blind person may not expect...
  • THEN avoid steps or provide warning strips in front of them.

• IF the layout is used by people with little or limited stamina who need a place to rest...
  • THEN provide seating adjacent to the paths, or structures.

• IF an emergency occurs and a telephone is needed...
  • THEN provide a location for a telephone.

CONFIGURATION OF THE CROSSING STRUCTURE

The general layout of the crossing structure itself will probably be undertaken at the same time that the site planning takes place. For the disabled, the crossing structure design should be checked against the following:

CROSSING STRUCTURE CHECK LIST

<table>
<thead>
<tr>
<th>ITEM</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>IF the crossing structure layout is complex and difficult for someone with no vision or someone with low intelligence to visualize...</td>
<td>THEN choose a simple more direct layout.</td>
</tr>
<tr>
<td>IF the walkway curves or if directional changes are less than 90°...</td>
<td>THEN use straight walkways and 90° intersections where possible.</td>
</tr>
<tr>
<td>IF there is more than one exit from the structure...</td>
<td>THEN make each exit distinctly different to avoid confusion.</td>
</tr>
<tr>
<td>IF the proposed structure has only ramps or only stairs...</td>
<td>THEN provide ramps and stairs.</td>
</tr>
<tr>
<td>IF the ramps are too steep or too long...</td>
<td>THEN redesign the ramp.</td>
</tr>
<tr>
<td>IF a helical ramp is to be used...</td>
<td>THEN use a gentler gradient.</td>
</tr>
<tr>
<td>IF a ramp is used...</td>
<td>THEN select a material with an increased coefficient of friction.</td>
</tr>
<tr>
<td>IF the ramp directs the users out into a road or a parking lot...</td>
<td>THEN provide a barrier between the ramp and the vehicular area.</td>
</tr>
<tr>
<td>IF a stair is to be used...</td>
<td>THEN follow the guidelines for riser/tread dimensions, layout and detail.</td>
</tr>
</tbody>
</table>
SITE AND PRELIMINARY PLANNING

The site selection checklist will assist in the final choice of an appropriate location for the crossing structure. The next step is to plan the crossing structure and to relate it to the site that has been chosen. The proposed layout of the site must be evaluated using the following check list:

### SITE PLANNING CHECK LIST

<table>
<thead>
<tr>
<th>ITEM</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>• IF the entrance to the site is not obvious to people with low or no vision...</td>
<td>• THEN provide landmarks and signs.</td>
</tr>
<tr>
<td>• IF the route from the site entrance to the crossing structure passes through a parking lot or open space...</td>
<td>• THEN provide a detectable route for the blind.</td>
</tr>
<tr>
<td>• IF the paths are curved they are more difficult for the blind to follow and to visualize...</td>
<td>• THEN use straight paths by preference.</td>
</tr>
<tr>
<td>• IF the layout is complicated it will be hard for the blind to understand...</td>
<td>• THEN use simple and direct layouts.</td>
</tr>
<tr>
<td>• IF the paths leading to the crossing structure are narrow...</td>
<td>• THEN the path must be wide enough for people and wheelchair to pass.</td>
</tr>
<tr>
<td>• IF the paths leading to the structure have steps...</td>
<td>• THEN provide a ramp as well.</td>
</tr>
<tr>
<td>• IF the paths leading to the structure ramp steeply...</td>
<td>• THEN choose a route with acceptable gradients, and provide steps as well.</td>
</tr>
<tr>
<td>• IF the path is to be a graded track...</td>
<td>• THEN construct a path that will have a continuous, hard, stable surface.</td>
</tr>
<tr>
<td>• IF there any places where a blind pedestrian may inadvertently stray and into the path of a motor vehicle...</td>
<td>• THEN separate vehicles and pedestrian areas by curbs or other devices that are detectable to the blind.</td>
</tr>
<tr>
<td>• IF there any places where blind pedestrian may fall into a drop off, or culvert...</td>
<td>• THEN drop off must be protected with rails.</td>
</tr>
<tr>
<td>• IF there any low overhanging trees or structures that a person with low vision may bump into...</td>
<td>• THEN realign the path to avoid the overhang, or design to avoid any constructed overhang.</td>
</tr>
</tbody>
</table>
• IF handrails are not provided...
• THEN provide handrails at the correct height.

• IF the layout is such that someone with poor vision may inadvertently encounter a stair or similar drop off...
• THEN redesign the layout with stairs, etc. that are not in the direct route of travel.

• IF there are no guardrails on the structure...
• THEN guardrails of the correct height must be provided.

• IF there is a likelihood that vandals may damage the light fittings...
• THEN select electric fittings that are resistant to attack.

• IF any part of the structure or components project into the walkway below head level...
• THEN redesign the layout to projections.

DETAIL DESIGN

The design details that follow constitute the remainder of the manual. Recommendations for the visual elements of pedestrian crossing structures and their end condition are provided. The design detail section is laid out so that the design engineer can understand the problem for which an appropriate design solution can be applied. Understanding the problem permits the development of alternative solutions where the recommendations are appropriate for the particular project.
problems

Some disabled people find it difficult or impossible to move in crowds. They may lose their balance when bumped, or may have difficulty maneuvering in crowds.

Walkways, are frequently too narrow to permit passage of persons in wheelchairs, or semiambulant persons using prostheses.

recommendations

A1 DIMENSIONS

A1.1 The walkway widths within a crossing components, structure approach and end conditions should be designed to projected pedestrian traffic density; however, the following minimum dimensions should be observed:

A1.2 Minimum clear widths of walkways shall be 36" (.914 m), and 48" (1.220 m) for one-way and two-way traffic, respectively.

A1.3 Where walkways are narrow, wheelchair turning and passing areas should occur at appropriate intervals, depending on slope, length of walk or corridor, visibility, adjacent surfaces, and purpose of walk.
problems

Some handicapped people have difficulty in traveling or walking across lawns.

recommendations

A1.4 Minimum clear widths of walkways to permit turning around or the passing of two persons in wheelchairs, shall be 60" (1.52 m), 64" (1.63 m) preferred.

A1.5 For 90° turns at T-intersections of walks, a 36" (.9 m) minimum clear width for each branch of the walk allows sufficient space for wheelchair turning.

A2 SURFACES

A2.1 Walk surfaces should be stable and firm and finished, with a relatively smooth but slip resistant material (See, Section B Ramps, For Slip Resistant Materials).
problems

Surfaces with many paving joints, or with uneven textures, are difficult and uncomfortable to travel over, both for ambulatory disabled and people who use wheelchairs.

Uneven paving joints can cause trips and falls, especially for people with balance problems. Weeds in paving joints may also cause accidents.

Gravel or loose material is difficult or impossible for wheelchair users and other disabled persons to travel over, as is mud and any other irregular surfaces.

recommendations

A2.2 Expansion and construction joints in the crossing structure should be held to a maximum of ¼" (.013 m). Avoid joint filler expanding above surface. A flush joint is necessary. Wherever possible, eliminate the use of joints in walkway surfaces. Avoid the use of surfaces constructed from small paving units which may tend to move independently and cause uneveness.

A2.3 Avoid unsealed gravel, cobblestone, and corrugated textures, except where used as warning or cueing surfaces. (See Cues, Section E).

A2.2 Maximum Permissible Size of Construction Joints

A2.3 Surfaces to be Avoided
problems

Many wheelchair users experience difficulty passing from one kind of surface to another where the two surfaces meet.

Where walks pass parking lots and other areas paved with the same material as the walk, people with poor vision may wander off the walk unintentionally.

For the elderly and those with limited vision, bright sunlight and shadows, or highly reflective surfaces make it difficult to see the walkway.

recommendations

A2.4 Joints between adjoining surface materials should be flush, however, a maximum of \( \frac{1}{8} \)" (.006 m) vertical height differences is allowed without edge treatment. Changes in level between \( \frac{1}{8} \)" (.006 m) and \( \frac{1}{2} \)" (.013 m) shall be beveled with a slope no greater than 1:2.

Changes in level greater than \( \frac{1}{8} \)" (.013 m) shall comply with recommendations concerning ramps (See Ramps, Section B).

A2.5 Where the walk passes an adjacent area (such as a parking lot) which is paved with the same, or a similar material, a physical barrier or a textured surface separation between the two areas should be provided (See Cues, Section E).

A2.6 Avoid glare by using surfaces with a low reflectance factor.

A2.4 Surface Transition to be Kept Flush
problems

Walkways are frequently poorly maintained. Potholes, bumpy, uneven, and cracked surfaces may prevent someone in a wheelchair from using the walkway; and for those with poor vision or balance, the walkways may be dangerous.

Trash on the walkway may cause people to slip and fall. Soft trash may be picked up by the wheels of wheelchairs, and transferred onto the hands of the users.

In many communities, snow is not cleared from the walkways. In some communities the snow plows dump snow from the streets onto the sidewalks. In both these cases, the walkway may become impassable to the elderly and disabled.

Disabled people have as much difficulty in traversing steeply sloping walkways as they do with ramps.

recommendations

A2.7 Walkways must be carefully maintained.

A2.8 Sidewalks and walkways must be regularly serviced to keep them free from trash.

A2.9 Walkways must be cleared of snow on a priority basis, within a reasonable period of time.

A.3 GRADIENTS

A3.1 A walkway gradient that exceeds 5% should be treated as a ramp (See Ramps, Section C).

A2.5 Recommended Edges for Walkway Boundaries on an Over/Under Crossing
problems

Many individuals, especially the visually impaired, people with balance problems, and those in wheelchairs, have difficulty traveling in a straight line on sidewalks and walkways that have a noticeable slope to one side. The slope causes them to veer in the direction of the slope.

Many walkways do not drain properly and puddles and ice form. This is hazardous for everyone, and especially to those with poor vision.

Pedestrians with poor vision (and others) using walkways that abut potential hazards are in considerable danger if they should trip or inadvertently step off the edge of the path.

Repair and building sites not kept clear of debris are a frequent barrier.

Protective barriers at repair sites are often not detectable to the blind.

recommendations

A3.2 Transverse slopes of walks should be reasonably level in cross-section. A transverse slope, not greater than 1 in 50, is acceptable.

A3.3 All walkways must be graded such that the formation of puddles and ice is avoided.

A4 HAZARDS

A4.1 If a hazardous area exists next to (or within) a walk or pedestrian area, provide means to protect pedestrians from the danger (See Barricades, Section D).

A4.2 Protective barriers must be detectable by people who use canes for guidance (See Barricades, Section D).
problems

Certain types of trees are more likely to drop leaves and branches onto walkways beneath them. This may cause trips, slips and falls.

Tree branches that overhang walkways may not be seen by visually impaired people. Some types of trees and bushes with thorns are particularly hazardous if they project into walkways.

Trees and bushes with surface root systems may cause walkways to break apart with resulting danger to people in wheelchairs and other disability groups.

recommendations

A4.3 Trees planted adjoining walkways should be carefully chosen to minimize debris.

A4.4 On walkways, the space needed for pedestrians must be kept clear of overhanging branches and shrubs.

A4.5 On adjoining walkways, avoid the use of trees and bushes with surface root systems.

A4.4 Trees and Shrubs may become barriers

A4.4 Walkways should be kept clear of overhanging branches and shrubs
Ramps are sometimes too narrow for a wheelchair, and much too narrow for a person in wheelchair to pass anyone.

**Recommendations**

**B1** DIMENSION OF RAMPS

**B1.1** Widths

The minimum width of ramps, at any point along their length, should be based on the type, direction, and volume of flow of the traffic. However:

1. Minimum width shall be 36" (.91 m).
2. For two-directional flow, minimum width shall be 48" (1.2 m).
3. For two wheelchair users to pass, minimum width shall be 60" (1.52 m).
**problems**

Disabled people cannot use ramps that are too steep or too long.

**recommendations**

B1.2 Lengths and Gradients

Lengths and gradients of ramps are closely interrelated. The accompanying chart gives maximum allowable vertical heights for various ramp slopes, and linear distances.

<table>
<thead>
<tr>
<th>Maximum Vertical Height</th>
<th>Ramp Slope</th>
<th>Maximum Linear Distance Exclusive of Rest Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 ft. / 2.7 m</td>
<td>1:10.1 to 1:11.0</td>
<td>91-99 ft. / 28-30 m</td>
</tr>
<tr>
<td>14 ft. / 4.3 m</td>
<td>1:11.1 to 1:13.0</td>
<td>156-183 ft. / 48-56 m</td>
</tr>
<tr>
<td>16 ft. / 4.9 m</td>
<td>1:13.1 to 1:15.0</td>
<td>210-241 ft. / 64-73 m</td>
</tr>
<tr>
<td>20 ft. / 6.0 m</td>
<td>1:15.1 to 1:16.0</td>
<td>303-312 ft. / 92-98 m</td>
</tr>
</tbody>
</table>

B1.3 Cross Slopes

The cross slope of ramp surfaces must not be greater than 1:50.

B2 LANDINGS AND PLATFORMS

B2.1 Adequate level platforms at the top and bottom of each ramp run for starting, stopping, and turning must be provided.

B2.2 Minimum clear width of landing shall be at least equal to the width of the largest ramp run leading to it. If ramps change direction at landings, the minimum clear width shall be 60" (1.53 m).

B1.3 Maximum Recommended Cross Slope of Ramp Surface
problems

Intermediate landings are required on long ramps for the wheelchair user to stop and rest.

recommendations

B2.3 Minimum length of landings and platforms at the top and bottom of ramps shall be 66" (1.67m).

B2.4 The required location of intermediate landings is related to ramp gradient and length. The accompanying chart gives maximum allowable distances to intermediate landings by ramp slope.

<table>
<thead>
<tr>
<th>Intermediate Landing Location</th>
<th>a. linear distance</th>
<th>b. vertical height</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Ramp Slope</th>
<th>1:10</th>
<th>1:12</th>
<th>1:14</th>
<th>1:16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Vertical Height Landing</td>
<td>9ft. (2.7m)</td>
<td>14ft. (4.3m)</td>
<td>16ft. (4.9m)</td>
<td>20ft. (6.1m)</td>
</tr>
<tr>
<td>1st. a.</td>
<td>45ft. (13.7m)</td>
<td>69ft. (21m)</td>
<td>83ft. (23.2m)</td>
<td>45ft. (13.7m)</td>
</tr>
<tr>
<td>b.</td>
<td>5.7ft. (1.73m)</td>
<td>3.9ft. (1.79m)</td>
<td>5.9ft. (1.79m)</td>
<td></td>
</tr>
<tr>
<td>2nd. a.</td>
<td>-</td>
<td>124ft. (37.7m)</td>
<td>148ft. (45m)</td>
<td>170ft. (51.7m)</td>
</tr>
<tr>
<td>b.</td>
<td>10.3ft. (3.13m)</td>
<td>10.5ft. (3.19m)</td>
<td>10.7ft. (3.25m)</td>
<td></td>
</tr>
<tr>
<td>3rd. a.</td>
<td>-</td>
<td>-</td>
<td>192ft. (58.4m)</td>
<td>215ft. (65.4m)</td>
</tr>
<tr>
<td>b.</td>
<td>-</td>
<td>13.7ft. (4.16m)</td>
<td>13.5ft. (4.1m)</td>
<td></td>
</tr>
<tr>
<td>4th. a.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>245ft. (74.5m)</td>
</tr>
<tr>
<td>b.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>15.4ft. (4.68m)</td>
</tr>
<tr>
<td>5th. a.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>275ft. (83.6m)</td>
</tr>
<tr>
<td>b.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>17.3ft. (5.26m)</td>
</tr>
<tr>
<td>6th. a.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>305ft. (92.7m)</td>
</tr>
<tr>
<td>b.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>19.2ft. (5.84m)</td>
</tr>
</tbody>
</table>
problems

Some disabled people with balance problems are concerned about slipping or falling on ramps.

Some ramps have open sides and there is a danger that wheelchairs, walking aids, etc., may slip over the ramp's edge.

recommendations

B2.5 Minimum length of intermediate landings shall be 56" (1.42m).

B3 HANDRAILS

For details of handrails and railings (See Handrails, Section D).

B3.1 Ramp Edge Protection

Ramps should be constructed to prevent wheelchairs, walking aids, and feet from slipping off ramp sides.
problems

Ramps without handrails are difficult for some disabled people to ascend or descend.

Some disabled people, particularly those using crutches, are vulnerable to slips and falls on ramps in wet weather.

Many disabled people, particularly those with braces, prostheses, and crutches, prefer steps to ramps.

recommendations

B3.2 No handrails are required on sloping surface walkways with 5 percent or less slope.

If a ramp rises more than 6" (.15 m) vertical in a single run, or if the horizontal projection of the ramp is greater than 72" (1.75 m), then it should have handrails on both sides. Where sidewalks have gradients greater than 5%, hand railings on the street side may be omitted.

B4 RAMP SURFACES

B4.1 Surface materials of ramps should be slip resistant. (See table "RAMP AND WALKWAY SLIP RESISTANCE" on following page.)

Ramps should be designed to prevent snow and ice, water, and litter from accumulating on the surface, and the surface should be easy to clean and to keep clear.

B5 AUXILIARY STAIRS

B5.1 Steps should be provided in addition to ramps to provide for access for persons with certain leg disabilities.
RAMP AND WALKWAY SLIP RESISTANCE

To find a ramp or walkway surface material with adequate slip resistance:

- From the table at the top find the required Coefficient of Friction for the gradient to be used, then
- From the table at the bottom select a material whose Coefficient of Friction matches or exceeds the figure.

Coefficient of Friction Necessary for Slip Resistance

<table>
<thead>
<tr>
<th>Gradient</th>
<th>Level</th>
<th>1:20 (5%)</th>
<th>1:18 (5.55%)</th>
<th>1:16 (6.25%)</th>
<th>1:14 (7.14%)</th>
<th>1:12 (8.33%)</th>
<th>1:10 (10%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum preferred for external surfaces</td>
<td>.50</td>
<td>.551</td>
<td>.556</td>
<td>.561</td>
<td>.573</td>
<td>.582</td>
<td>.603</td>
</tr>
<tr>
<td>Minimum acceptable for external surfaces</td>
<td>.40</td>
<td>.450</td>
<td>.455</td>
<td>.461</td>
<td>.472</td>
<td>.481</td>
<td>.502</td>
</tr>
<tr>
<td>Minimum acceptable for roofed areas</td>
<td>.30</td>
<td>.350</td>
<td>.355</td>
<td>.361</td>
<td>.372</td>
<td>.381</td>
<td>.402</td>
</tr>
</tbody>
</table>

Slip Resistance: Coefficient of Friction for Selected Walkways Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Leather (Dry)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Brushed Concrete - New Against the Brush</td>
<td>.75</td>
</tr>
<tr>
<td>2. Asphalt Tile - Waxed Heavy Use Area</td>
<td>.56</td>
</tr>
<tr>
<td>3. Smooth Metal - Rusted Slightly</td>
<td>.54</td>
</tr>
<tr>
<td>4. Asphalt - Parking Lot, Old</td>
<td>.53</td>
</tr>
<tr>
<td>5. Checker Plate - Rusted Moderately</td>
<td>.50</td>
</tr>
<tr>
<td>6. Quarry Tile - Unglazed 6&quot; x 6&quot; Tiles</td>
<td>.49</td>
</tr>
<tr>
<td>7. Thermoplastic - Used, on Cross Walk</td>
<td>.45</td>
</tr>
<tr>
<td>8. Brick Pavers - on Stair, New, No Finish</td>
<td>.43</td>
</tr>
<tr>
<td>9. Exposed Aggregate - Pea Gravel Heavy Traffic</td>
<td>.41</td>
</tr>
<tr>
<td>10. Granite - Stairs, Old, Exterior - Well Used</td>
<td>.40</td>
</tr>
<tr>
<td>11. Plywood &quot;A&quot; Side - With Grain, No Finish</td>
<td>.39</td>
</tr>
<tr>
<td>12. Plywood &quot;A&quot; Side - Against Grain No Finish</td>
<td>.38</td>
</tr>
</tbody>
</table>
problems

Many of the accidents and much of the difficulty experienced by elderly and disabled pedestrians occurs at changes in level.

Many people cannot climb steps and stairs at all.

recommendations

C1 STAIRS GENERALLY

Avoid the necessity for level changes wherever possible.

Ramps (or elevators) should be provided as an alternative route to stairs.

C2 STAIR WIDTHS

C2.1 Minimum width between walls: 36" (.914 m); 38" (.965 m) preferred.

C2.2 Minimum width for two-way traffic: 60" (1.5 m); 69" (1.75 m) preferred.

C2.1 Recommended Minimum Width Between Walls
Accidents may occur where stairs lead directly into walkways.

Long flights of stairs are difficult for some disabled people to climb, because there is no opportunity to pause and rest. Accidents on long flights are likely to be more severe.

Very short flights may not be noticed by people with poor vision.

C3.3 Stairway/Walkway Setback
problems

Many people have difficulty with steps, especially steps with high risers and narrow treads.

recommendations

C5 TREADS AND RISERS

All steps in a flight must have uniform tread widths and uniform riser heights.

C5.1 Minimum tread depth must be not less than 11" (.280 m).

C5.2 Safe and comfortable tread /riser relationships:

<table>
<thead>
<tr>
<th>Risers</th>
<th>Treads (in inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>6½</td>
<td>11 11½ 12</td>
</tr>
<tr>
<td>6</td>
<td>11 11½ 12 12½ 13</td>
</tr>
<tr>
<td>5½</td>
<td>11 11½ 12 12½ 13</td>
</tr>
<tr>
<td>5</td>
<td>11 11½ 12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Risers (in millimeters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>178 280 290</td>
</tr>
<tr>
<td>165 280 290 305 320</td>
</tr>
<tr>
<td>152 280 290 305 320 330 340 355</td>
</tr>
<tr>
<td>140 280 290 305 320 330</td>
</tr>
<tr>
<td>127 280 290 305</td>
</tr>
</tbody>
</table>

Ice and water on steps are likely to cause accidents.

C5.3 For exterior use, the treads should slope approximately 1/8" in 12" (1:100 mm) towards the nosing, in order to shed water and to prevent ice formation.

C5.3 Tread Slope
problems

Projecting nosings make it difficult for people with prosthetic legs to climb stairs because their feet tend to catch in the projecting nosing.

recommendations

C6 TYPES OF STEPS

Stair nosing projections must be carefully designed to eliminate the necessity of dropping the toe to clear the nosing. Step nosing types are shown below.

C6.1 Steps shall not have abrupt (squared) nosings.

C6 Accessible and Inaccessible Step Nosing Types
problems

Many disabled people have difficulty in maintaining their balance on steps.

recommendations

C6.2 Non-projecting chamfered nosings, or 1/2" (.125 m, maximum) rounded nosings are preferred.

C7 SURFACES

C7.1 Tread surfaces should be slip resistant.

C7.2 Where possible, stair nosings should visually contrast with treads and risers to make them more visible.

C8 TACTILE SIGNALS

Where steps or stairs are located within a walkway such that they may be a hazard to people with visual impairments, a tactile warning signal should be provided.
problems

People with visual impairments may not be able to detect the underside of a low stair.

recommendations

C8.1 Extent

The tactile strip should be at least 24" (.610 m) wide and should extend at least 36" (.915 m) from the hazard, and be the full width of the hazard.

C8.2 For details of tactile strip see Signage and Cues (Section E).

C9 HAZARDOUS LAYOUTS

C9.1 No part of a stair should be constructed to overhang a walkway at, or below, head height.

Unless the overhang projects 4" (.102 m), or less into the walkway, the overhang should be at least 6'8" (2.03 m) net clear above the walkway.

For stair handrails, railings, see Handrails (Section D).
problems

Handrails are needed for ascending and descending ramps and stairs for balance and security. Many elderly and disabled people cannot negotiate ramps and stairs unless there are handrails.

recommendations

D1 WHERE REQUIRED

Stairways of more than two steps, and ramps that rise more than 6" (.015 m) on a single run should have handrails on both sides.

Guardrails are needed where falls to a lower level are possible. Special attention should be given to the open sides of platforms and stair and ramp landings.

D2 HEIGHTS

D2.1 Height, Stair Handrails:

33"-36" (.838 m-.914 m) measured vertically from the top of the handrail to the surface of the tread at the nosing.

D2.2 Height, Guardrails:

42" (1.06 m) minimum measured from the top of the rail to the surface of the floor finish.

Often, the height of a guardrail is unsufficient to prevent a person from falling to a lower level.
**provisions**

Handrails that are too high or too low for the users may be hazardous.

Some handrails are inadequate because they do not extend sufficiently far to assist people as they use the first and last riser.

**recommendations**

D2.3 Height, Ramp Handrails:

33"-36" (.838 m-.914 m) measured vertically from the top of the handrail to the surface of ramp below.

D2.4 Height, handrails for children and people of small stature:

16"-25" (.406 m-.635 m) measured vertically from the top of the hand-rail to the surface of the tread at the nosing.

D3 HANDRAIL EXTENSIONS

D3.1 Handrails should extend horizontally a minimum of 12" (.305 m) beyond the top of a stair.
problems

recommendations

D3.2 Handrails should extend beyond the bottom riser for a distance equal to the tread width, and then continued horizontally for 12" (.305 m).

D3.3 Handrails should extend horizontally a minimum of 12" (.305 m) beyond the top or bottom of a ramp.

D3.1 Stair Handrail Extension

D3.3 Ramp Handrail Extension
problems

People with reduced vision may bump into handrails that project into walkways. These projections may not be detected using long cane techniques.

Handrails are often inadequate because they cannot be grasped comfortably.

recommendations

D4 HANDRAIL PROJECTIONS

D4.1 No handrails should project into walkways. The ends should return to the floor or adjoining walls.

D5 HANDRAIL CONTINUITY

D5.1 Handrails to stairs and ramp landings should continue along at least one side of a landing.

D6 HANDRAIL SHAPE

D6.1 Handrail section design should allow hands to use natural grip. See types in sketch D6.2.
problems

To be able to use stairs, some people need to use the handrail continuously.

Handrails that are fixed too close to the wall cannot be grasped.

recommendations

D6.2 Where handrail section is deeper than 2" (.051 m) the upper portion of the section should be shaped so that the hand may grip rail securely. The same applies when the width of the section is wider than 2½" (.064 m).

D6.3 All edges should be chamfered or eased.

D6.4 The gripping surface of continuous handrails should not be interrupted by goosenecks, newel posts, or other construction elements or obstructions.

D7 HANDRAIL SUPPORTS

D7.1 Handrails mounted on a wall should have a free space between wall and handrail of a minimum of 1½" (.038 m).

D6.2 Handrails Which Do Not Allow Natural Opposing Grip

D6.2 Handrails Allowing Natural Opposing Grip
problems

Handrails of metal may become too hot in summer or too cold in winter for use out of doors.

recommendations

D7.2 Wall brackets for handrails should be affixed to the underside of rails.

D7.3 Avoid rough textured finishes on walls behind handrails.

D7.4 Recessed handrails should not be used.

D8 HANDRAIL MATERIALS

D8.1 Handrail surfaces should be smooth, but not slippery.

D8.2 Handrails that are exposed to sunlight or very cold conditions should be constructed of materials that are poor conductors of heat such as wood, or plastic.
Overcrossings are often enclosed by chain link fencing. This might prove to be hazardous if grabbed by someone falling or someone in a wheelchair trying to stop.

**problems**

**recommendations**

D9 BALUSTRADES AND PROTECTIVE ENCLOSURES

D9.1 Spacing between members (vertical or horizontal) should be less than 4" (.0100 m), since a child's head may become caught between widely spaced balusters.

D9.2 Balustrades and other protective enclosures should be constructed of materials that will minimize the potential for injury if suddenly grasped.

D10 LOAD CAPACITY

D10.1 All handrails should be designed to withstand bending moments from a 250 lb. (113 kg.) horizontal concentrated load. Fasteners and mountings of support should withstand a 250 lb. (113 kg.) shear load and a 250 lb. (113 kg.) tensile load.

**D9.1 Horizontal Spacing**

**D9.1 Vertical Spacing**
problems

People with limited vision may trip or fall at street repair sites because they don't have adequate warning.

Chains that are used for barricades may be hazardous to people with low vision and visually impaired people who use canes. People with low vision may not see the chain and trip over it, and chains that are higher than 27" above the ground may not be detected by visually impaired people using long cane techniques.

recommendations

D11 BARRICADES

D11.1 Detection of Barricades

Barricades must be detectable by all pedestrians.

All barricades must be detectable by standard long cane techniques used by persons with severe impairments of vision (i.e., chains and barricades must not be more than 27" (.685 m) from the ground.

Barricades should be equipped with both visual and auditory warning devices where possible.

D11.2 Types of Barricades

Avoid the use of chain type barriers.

Fencing used as barricades should be free of projections or appendages dangerous to pedestrians on adjacent walkways, playing fields, or other public spaces.
problems

Signs are often located where they are too high and the information is too small to be seen and read.

recommendations

E1 GENERAL

E1.1 All signage and information systems directed at pedestrians must take into account the needs of the elderly and disabled.

E2 LOCATION OF SIGNS

Graphic information in the pedestrian environment should be positioned and sized so that it will be easily visible and legible.

E2.1 Signage should be located within the normal angles of view—from 10 degrees above to 10 degrees below eye level for a standing person, and from 15 degrees above to 15 degrees below eye level for a seated person.

E2.1.1 Angle of View for Wheelchair Bound Individual.

E2.1.2 Angle of View for Ambulatory Individual.
problems

Some elderly and disabled people have limited head movement.

Signs are frequently obscured by parts of the crossing structures and trees.

Pedestrians may not notice signs that are fixed below head height. This is hazardous.

Signs are often very difficult to read.

The size of the characters on signs is sometimes too small to read.

recommendations

E2.2 Signage positioned directly facing the path of travel is the most easily visible. Most people can distinguish signage within an angle of 30 degrees to either side of their face, without moving their head.

E2.3 Signs must not be located where they will be obscured.

E2.4 Signs must be designed and located so that they will not become a hazard or an obstacle to the pedestrian (See Street Furniture, Section G).

E3 SIGN LEGIBILITY

The legibility of signs depends on the distance between the viewer and the sign, the relationship between the height of the characters and the width of the stroke, the color contrast between the characters and the background, and the print font.

E3.1 The size of characters must be determined on the basis of the probable viewing distance.
People without functional vision cannot read signs unless they can feel the characters.

**problems**

**recommendations**

E3.2 For readability, characters on information signs should fall within the following proportions:

- Stroke width to height 1:5 to 1:10
- Character width to height 3:5 to 1:1

E3.3 Raised characters that can be felt are most suitable for persons with visual impairments. The characters should be raised at least 1/32" (.0008 m), the height should be at least 5/8" (.0015 m).

E3.4 Provide a contrasting color between character and background.

E3.5 The print style should be simple. Elaborate styles are more difficult to read.

E3.6 Light colored characters on a dark background are most legible to the elderly.

E3.7 For the small percentage of severely visually impaired people who can read braille the most critical signs should be reproduced in this form as well as in letters.

Raised Characters Detectable to the Visually Impaired
problems

Steps, stairs, curb ramps and other elements that may not be detected by visually impaired people are hazardous.

recommendations

E4  THE INTERNATIONAL SYMBOL OF ACCESSIBILITY

The International Symbol of Accessibility should be displayed:

--at the beginning of accessible paths leading to the crossing structure if other paths are not accessible. If a path is not accessible, a sign should direct people to the nearest accessible route.

--to identify dedicated parking spaces for the handicapped.

E5  TACTILE SIGNALS ON WALKING SURFACES

Tactile signals on walking surfaces can be used to provide information for visually impaired cane users if the appropriate materials are selected.
problems

Where the junction between a walkway and a street is not clearly separated by a curb, a planter, a curb ramp, or some similar construction, there is a danger that those with impaired vision may wander into the street.

recommendations

E5.1 Where steps, stairs, or similar abrupt vertical grade changes are located within a walkway such that there is a danger that people with impaired vision may not perceive the hazard and fall, tactile floor surface signals should be provided (See Steps, Stairs, Section D7).

E5.2 The junction between a walkway and a street must be clearly detectable by people with impaired vision. The junction may be formed by curbs, planters, rough surface textures, low walls, curb ramps, etc.

E5.2 Detectable Junction Between Walkway and Street
problems

If tactile strips are too small, they may not be detected. If they are set too close to the hazard or environmental point about which they are intended to provide information, then the pedestrian may not have sufficient space and time to react to the strip.

If tactile strips are too large, they will become ineffective because information for the users will be too far from the potential hazard.

At oblique angle street crossings, where the crosswalk is set at angles other than 90 degrees to the curb, visually impaired pedestrians may stray out of the crosswalk into the lane of moving traffic.

recommendations

E5.3 Tactile strips, to provide information on potential hazards, should extend for the full width of the hazard, should be at least 24" (.610 m) in depth, and should extend at least 36" (.915 m) from the hazard.

E5.4 Tactile strips should not extend further in any direction than is necessary for the information to be conveyed.

E6 LINEAR TACTILE GUIDES

Linear tactile strips can be used to define the edge of a walkway as an aid to visually impaired pedestrians.

E6 Detectable Crosswalk Markings
problems

It may be difficult for a visually impaired person to navigate across large open spaces which have no street furniture or other locational landmarks.

Street furniture is used by the visually impaired as locational landmarks. But too much furniture tends to be confusing and obstructive.

recommendations

E6.1 Paths for pedestrians (particularly for those with poor vision) across large open paved areas can be usefully by the choice of an appropriate material for the walkway—a material that is detectably different from that of the surrounding surface or by the use of a detectable edge strip at each side of the walkway.

E7 STREET FURNITURE STRIP

Section H1.3, Street Furniture, illustrates how street furniture can be located within a strip of sidewalk dedicated for this purpose, which also has a surface that is detectable by the visually impaired, and the edge of which can provide an additional 'shoreline'.
problems

Overcrossings are often located where pedestrians have to cross parking lots, fields or other open spaces to reach them. This makes wayfinding difficult for the visually impaired.

recommendations

E8 LAYOUTS FOR THE VISUALLY IMPAIRED

By careful design of elements of the pedestrian walkways, the layout can be improved to assist the visually impaired in locating such things as the boundaries of crosswalks, perceiving the direction of crosswalks, and in reducing ambiguities.

E9 SHORELINES AND OTHER DIRECTIONAL AIDS

E9.1 If possible, structures should be sited so as to provide an obvious path between the pedestrian system and the structure.

E9.2 Cane-detectable shorelines or pathways should be provided to help provide a distinct route to the crossing structure.

E9.1.1 Detectable Strip (Grass or Mat) as a Shoreline Device.

E9.1.2 Planter Used as Shoreline Device.
Approach paths to crossing structures are sometimes difficult to locate for visually impaired people; they may be difficult to detect and once detected may be difficult to identify as the correct path.

**recommendations**

E9.3 In situations where accessibility by the visually impaired is likely to be frequent, where power is available and without close residential neighbors, a sound-emitting device (tweeter) may be used to indicate the location of the overcrossing.

E10 LANDMARKS AND OTHER PLACE CUES

E10.1 Where possible, approach paths should turn off main pedestrian routes using right angle turns, and should be paved.

**E9.3 Location of Sound Emitting Device (Tweeter).**
The overall layout of a crossing structure may be difficult for a visually impaired person to comprehend.

**recommendations**

E10.2 Landmarks may be placed at important turns.

E10.3 Where possible, landmarks should be used that make a sound when struck by a cane (see E5).

E10.4 Shorelines may be added in the path of travel to indicate a key decision point.

E11 TACTUAL/HAPTIC MAPS, AUDIO TAPES AND OTHER CUES

E11.1 In situations where particularly frequent use by visually impaired people is anticipated, such as near a school, a tactual/haptic map may be developed that describes the site using symbols pedestrians can feel with their fingers.

E11.1.1 This map may be produced on a Thermoform-type device and issued as a portable map or may be permanently mounted on the site.

E11.1.2 No standard mounting position has yet been established, but as visually impaired people are often instructed to stay to the right, a location to the right of the approach and at a comfortable height (perhaps 30" to 48") (.760 m to 1.2 m) is suggested.

E10.2 Directional Box (Planter) Used as Landmark and Directional Aid.
problems

recommendations

E11.1.3 Tactual maps should be used in conjunction with a cane-detectable landmark, (see G3).

E11.1.4 Since no standard symbols have yet been established, tactual maps should be developed by a professional mobility and orientation specialist.

E11.1.5 Tactual/Haptic maps are useful for a relatively small proportion of the visually impaired population because many visually impaired people lack map-reading ability or training.

E11.2 In situations with heavy use by visually impaired people, tape recorded announcement may be used to describe the crossing structure.

E11.2.1 The recording may be a continuous loop.

E11.2.2 The tape recording may be mounted on site (in situations with electricity and where the noise would not disturb neighbors) or may be produced as a cassette that can be carried by the pedestrian.

E11.2.3 Because they do not require special training, audio tapes are useful for a broader range of visually impaired people than are on-site tactual/haptic maps but are more susceptible to vandalism and may require greater upkeep.

E11.2.4 Audio tapes should be developed by professional orientation and mobility specialists.
The wide range of abilities represented by visually impaired people makes it difficult to develop a single set of orientation cues.

**recommendations**

E11.3 Cues that impact several senses called "redundant cues", are preferable to cues that affect a single sense such as a bright light may also produce noticeable warmth.

E11.3.1 Where possible cane-detectable landmarks should produce a sound when struck by a cane as well as feeling different than their surroundings (See E5).

E11.4 Where possible a wide range of cues should be used.

E11.3.1 "Checkered" Metal Plate as a Landmark Warning of Adjacent Stair. Note: "Checkered" metal plate performs as a redundant cue as it emits distinct sound on contact and also offers a texture detectable by cane users.
problems

recommendations

E11.5 Both raised letters for the totally blind and large symbols and significant color and intensity contrast, for partially sighted people should be used in signage. (see E3).

E11.6 Significant visual contrast should be combined with cane-detectable shorelines and tactual cues to differentiate the correct path from background or to indicate approaching hazards or choice points. Paving materials or paint may be used to create these cues (see E5).

E11.6.2 Texture Strip as Shoreline Device: Aiding the Location or Crossing Structure. Also Reduces Potential for Straying From Walkway into Parking Lot.

E11.6.1 Grass Area Performs as Shoreline Aiding Mobility of Long Cane User.
### RECOMMENDATIONS FOR DETECTABLE MATERIALS

<table>
<thead>
<tr>
<th>Surface Finish</th>
<th>Surface Configuration</th>
<th>Under Base</th>
<th>Base</th>
<th>Detection Method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Width</td>
<td>Spacing</td>
<td>Depth</td>
<td></td>
</tr>
<tr>
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<td>1/16</td>
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<tr>
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<td>Sandpaper squares on steel</td>
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<td>1/2</td>
<td>1/16</td>
<td>1 3/4&quot; Cavity</td>
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### Highly Recommended

| Neoprene with grooves cemented to concrete | 2 | 1/4 | 1/16 | 1 1/4" Cavity | Concrete | T |
| Thermoplastic squares | 1/2 | 1/2 | 1/16 | Concrete | Concrete | T |

### Recommended

| Concrete | 1/4 | 1/4 | 1/16 | Concrete | Concrete | T |
| Neoprene Strips | 2 | 2 | 1/16 | Concrete | Concrete | T |
| Grooved concrete | 1/4 | 2 | 1/4 | Concrete | Concrete | T |
| Thermoplastic | 1/4 | 2 | 1/16 | Concrete | Concrete | T |
| Grooved concrete | 2 | 1/4 | 1/4 | Concrete | Concrete | T |
| Sandpaper squares | 1/2 | 1/2 | 1/16 | Concrete | Concrete | T |
| Grooved concrete | 3/4 | 1/8 | 1/8 | Concrete | Concrete | T |
| Neoprene squares | 3/4 | 1/2 | 1/8 | Concrete | Concrete | T |
| Grooved concrete | 1/2 | 1 | 1/16 | 1 1/2" Cavity | Concrete | S/T |
| Solid Neoprene | Solid sheet | 1/8 | Concrete | Concrete | T |
| Sandpaper squares | 1/2 | 1/2 | 1/16 | Concrete | Concrete | S |

### Not Recommended

<table>
<thead>
<tr>
<th>T = Texture</th>
<th>S = Sound</th>
<th>S/T = Sound and Texture</th>
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<tr>
<td>55</td>
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</table>
problems

The elderly, and those with some types of visual impairment, need higher levels of illumination than is recommended for the general public.

Many elderly and handicapped persons are particularly concerned about the apparent risk of crime in poorly lit areas.

recommendations

F1  ILLUMINATION FOR CROSSING STRUCTURE AND APPROACH

Lighting levels in pedestrian crossing structures should be at least as high as those recommended by the Illuminating Engineering Society.

F1.1  In high crime areas, pedestrian ways should be well lit—preferably double the usual recommendations, but never less than 0.5 footcandles (5 lux).

<table>
<thead>
<tr>
<th>PEDESTRIAN WALKWAYS</th>
<th>COMMERCIAL</th>
<th>INTERMEDIATE</th>
<th>RESIDENTIAL</th>
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<td>Footcandle lux</td>
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<td>0.9 10</td>
<td>0.6 6</td>
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<td>2.0 22</td>
<td>1.0 11</td>
<td>0.5 5</td>
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<td>BUILDING SITES</td>
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<td></td>
<td>Values are given in minimum average maintained horizontal footcandles, and lux.</td>
</tr>
<tr>
<td>Entrances</td>
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<td></td>
<td></td>
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<tr>
<td>Grounds</td>
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<td></td>
<td></td>
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<tr>
<td>Self Parking</td>
<td>1.0 11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attendant Parking</td>
<td>2.0 22</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Crosswalks traversing roadways in the middle of land blocks and at street intersections should be provided with additional illumination producing from 1.5 to 2 times the normal roadway lighting level.
problems

External stairs, typical of crossing structures, are potentially hazardous and require carefully designed lighting.

Elderly and disabled pedestrians are concerned that drivers may not be able to see them crossing the street at night.

Vandalism of light fixtures is a particularly prevalent problem associated with crossing structures.

recommendations

F1.2 Steps, stairs and ramps must be well lit. The light sources should be designed so that if one source fails, a second source will continue to provide light.

F1.3 Avoid the use of lighting sources that produce a glare condition in the field of view of people traversing stairs and ramps.

F2 END CONDITION

F2.2 It is important to ensure that pedestrian crosswalks and refuge islands are adequately illuminated at night.

Where warranted, special crosswalk illumination should provide an average illumination level within the crosswalk area of at least 7.0 horizontal footcandles (75 lux) and conform to the design criteria set out in report no. FHWA-RD-76-9, "Fixed Illumination for Pedestrian Protection."

F3 VANDALISM

Light fixtures should be of vandal-proof design and located so as to discourage tampering.
problems

Moveable street furniture (trash receptacles, portable signs, etc.) are sometimes put where they obstruct movement and block the way for wheelchairs.

Street furniture sometimes blocks the passage of people in wheelchairs and other handicapped people.

recommendations

G1.1 Street furniture must not be positioned where it will act to reduce the calculated pedestrian traffic flow below the estimated need.

Street furniture must not be positioned where it will obstruct pedestrian traffic.

G1.2 Street furniture must not be positioned such that it reduces any part of the crossing structure or approaches below 32" (.813 m).

G1.2 Recommended Street Furniture Spacing
**problems**

Most street furniture is placed near the curb, but sometimes trash containers or temporary signs are placed where they obstruct movement.

Street furniture is used by the visually impaired as orientation landmarks as they move around the city.

---

**recommendations**

G1.3 Wherever possible, furniture on walkways should be located within a strip close to the curb. This strip should be no wider than is absolutely necessary.

The furniture strip should be surfaced with a material different from that of the sidewalk, to act as a protective buffer to any roadway, and to provide additional orientation information for those with poor sight. Where it is not possible to surface the whole strip, a 12" (.305 m) wide barrier can be used. The surface of the strip should not be so uneven that it will prevent wheelchair users crossing it to gain access to cars.
problems

Some street furniture, such as a fire hydrant, has sharp projecting surfaces which may be hazardous.

Low, overhanging signs, etc., are a hazard to the visually impaired and those with limited vision.

recommendations

G1.4 Avoid the use of street furniture which has potentially sharp edges or projections.

Where street furniture with projecting sharp edges or projections must be used, it should be located outside the pedestrian walkway.

G2 OVERHANGING PROJECTIONS

G2.1 Pylon or post-mounted telephone enclosures, signs, etc., must not project into the walkway of the over/under crossing structure such that people with poor sight may bump into them.
**problems**

Free standing signs that are placed below head height are hazardous to pedestrians, and particularly to people who are visually impaired.

**recommendations**

G2.2 Any sign, or other object that projects into, or overhangs a walkway by more than 4" (.102 m), should be fixed at a level where it will not be a hazard—80" (2.03 m) minimum from the bottom of the object to the ground. However, if the object is no higher than 27" (.685 m) from the ground, then it may overhang or project by any amount.

G2.3 Locate signs close to the edge of the walkway, but traffic signs (not the pole) in urban locations should not be closer than 24" (.6 m) from the curb.

G2.2 Maximum Permissible Overhang Projections of Pylon Mounted Enclosures

G2.3 Height of Signs and Projections Overhanging Walkways of an Over/Under Crossing Structure
problems

Some disabled people cannot enter regular phone booths.

Pay phones located off the sidewalk on a soft shoulder may not be accessible to those in wheelchairs.

Telephones, coin slots, and controls are often too high to reach, by individuals in wheelchairs.

recommendations

G3 PUBLIC TELEPHONES

G3.1 Public telephones should be accessible to the disabled.

G3.2 Exterior telephones should be accessible by way of a hard and level surface.

G3.3 Telephones should be mounted on walls, free standing pylons, or in enclosures without doors. Pylons and enclosures should not form obstacles for people in wheelchairs, or people with poor vision.

G3.4 The entrance to a telephone enclosure should have a clear width of at least 30" (.760 m).

G3.5 Fixed seats in telephone enclosures should not obstruct access to the telephone.

G3.6 The highest operable part of the telephone should be no more than 54" (1.37 m) from the ground.

G3.6 Maximum Height of Telephone
problems

Telephone cords are sometimes too short.

Some people with limited manual dexterity cannot use dial telephones.

Water fountains are often located where disabled people cannot use them.

recommendations

G3.7 The length of cord from the telephone instrument to the head set should not be less than 29" (.735 m).

G3.8 Whenever possible, telephones should have push button controls.

G3.9 Telephone books should be accessible to those in wheelchairs. Loose books should be on tethers.

G4 DRINKING FOUNTAINS

G4.1 Drinking fountains and water coolers should be located where they will be accessible. They should be placed on a paved area, not on a soft surface.
problems

Many drinking fountains are too low, or too high, for people in wheelchairs.

Some people cannot lean over to drink.

recommendations

G4.2 If drinking fountains or water coolers are located in an alcove or a recess in a walkway, then the recess must be not less than 30" (.76 m) wide. If the depth of the alcove is 24" or greater, the recess must not be less than 36" (.915 m) wide. The underside of the fountain should be not less than 27" (.685 m) from the ground, the height of the spout should be no more than 36" (.915 m) from the ground; the fountain should allow at least 8" (.205 m) for the knees.

G4.3 Drinking fountains and water coolers should permit a 4" high (.100 m) cup to be filled from the water flow.

G4.4 The trajectory of the stream of water should be parallel to the front of the unit.

G4.5 The spouts should be at the front of drinking fountains and water coolers.

G4.2 Dimensions of Drinking Fountains
**problems**

Many people have little strength or dexterity in their hands.

Some disabled people cannot use certain types of trash receptacles and mail boxes.

Hinged-door openings are difficult for some people to use.

Some people need to lean against trash containers while putting trash into them.

**recommendations**

G4.6 Controls shall be operable by hand without the need for grasping or twisting.

G4.7 If free-standing coolers or drinking fountain units have spouts above 36" (.915 m) from the floor, then they should have a spigot for cups within 36" (.915 m) of the floor, or an auxiliary fountain at a lower height.

G5 MAIL AND TRASH RECEPTABLES

G5.1 Trash receptacles and mail boxes should be operable using a single hand movement.

G5.2 The stability of the receptacle should be adequate so that it will not easily tip over if leaned upon.

G5.3 The opening of a trash receptacle and a mail box should not be more than 36" (915 mm) above the ground.
problems

People who use crutches and those with prosthetic limbs may slip on manhole covers. Others with impaired vision may trip on an improperly sealed cover.

Gratings may be a hazard to the wheels of wheelchairs, and to people who use crutches.

recommendations

G6 MANHOLE COVERS, GRATINGS

G6.1 Manhole covers, gratings, etc. should not be located where pedestrians must travel over them.

G6.2 If manhole covers, gratings, inspection covers, etc. occur within walkways, then they should be made as visible as possible by the use of colored markings.

G6.3 If manhole or other covers occur within walkways, they should be finished with a non-slip surface.

G6.4 When gratings occur within walkways, the bars should present a maximum clear opening of $\frac{1}{8}$ in ($0.0127$ m) in the narrow direction, and the long dimension should be at right angles to the direction of travel.
DEFINITIONS OF TERMS:

Barricades: Elements placed at dangerous areas to prevent pedestrians from encountering the danger.

Cues: Messages conveyed by audible visible or tactile means, without the use of language.

Footcandle (lux): The unit of measurement for the amount of illumination falling on a surface.

Guardrail: An element similar to a handrail which functions as a barricade. To prevent a pedestrian from falling off the edge of a platform.

Handrails: Elements placed on stairs and ramps to provide continuous support and to aid pedestrians in ascending or descending.

Lumen: The unit of measurement for the amount of light energy given off by a light source.

Media: Information systems used for conveying messages.

Ramp: Any part of a constructed pedestrian circulation surface with a slope greater than 5 percent.

Rise: The vertical distance covered by a flight of steps.

Riser: The upright face of a step.

Signage: Messages conveyed by means of graphic symbols or lettering.

Stairs: A series of steps, with or without landings, giving access from level to level.

Step: One unit consisting of a riser and a tread.

Street Furniture: Temporary or permanent equipment or structures that occur on or close to the crossing structure, with the purpose of facilitating either pedestrian or vehicular activity (e.g., sign posts, traffic light poles, parking meters, waste receptacles, telephone etc.)

Run: The horizontal distance covered by a flight of steps.

Tread: The horizontal surface of a step.

Walk, Walkway: Exterior pathways at grade level with a gradient less than five percent that form part of the crossing structure or its approaches.
<table>
<thead>
<tr>
<th>Topic</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCESSIBLE NETWORK</td>
<td>INTRO</td>
</tr>
<tr>
<td>APPROACH</td>
<td>INTRO</td>
</tr>
<tr>
<td>AUXILIARY LIGHTING</td>
<td>F1.1</td>
</tr>
<tr>
<td>AUXILIARY STAIRS</td>
<td>B5</td>
</tr>
<tr>
<td>BALUSTRADES</td>
<td>D9</td>
</tr>
<tr>
<td>BARRICADES, DETECTION</td>
<td>D11.1</td>
</tr>
<tr>
<td>BARRICADES, TYPES</td>
<td>D11.2</td>
</tr>
<tr>
<td>BARRIERS</td>
<td>DS</td>
</tr>
<tr>
<td>BOUNDARIES, WALKWAYS</td>
<td>A2.5</td>
</tr>
<tr>
<td>CHANGE IN LEVEL</td>
<td>A2.4</td>
</tr>
<tr>
<td>COMMUNITY</td>
<td>INTRO</td>
</tr>
<tr>
<td>COMPONENT</td>
<td>INTRO</td>
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<tr>
<td>CONFIGURATION OF CROSSING STRUCTURES</td>
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<tr>
<td>CONTINUITY</td>
<td>D5</td>
</tr>
<tr>
<td>CONSTRUCTION JOINTS</td>
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<tr>
<td>CRITICAL GROUP</td>
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<tr>
<td>CROSS SLOPES</td>
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<tr>
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<tr>
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<tr>
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<td>DETECTION OF BARRICADES</td>
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<tr>
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EDGE PROTECTION ........................................ B3.1
ELEMENT ................................................. INTRO
END CONDITION ........................................ INTRO, F1.2
EXTENSIONS, HANDRAILS ............................... D3

GENERAL, SIGNAGE AND MEDIA CUES .......... E1
GENERAL, STREET FURNITURE ....................... G1
GRADIENT ................................................ A3.1, A3.2, A3.3
GRATINGS ................................................ G6
GRIPPING SURFACE, HANDRAIL ...................... D6.4
GUARDRAIL HEIGHT ...................................... D2.2

HANDRAILS, RAILINGS, BARRICADES ............... D
  Balustrades ........................................... D9
  Continuity ............................................. D5
  Detection of Barricades ............................. D11.1
  Extensions .............................................. D3
  Gripping Surface ..................................... D6.4
  Guardrail Height ..................................... D2.2
  Handrails for Children ............................... D2.4
  Heat Conductability ................................ D8.2
  Load Capacity ......................................... D10
  Materials ............................................... D8.1
  Projections ............................................. D4
  Ramp Handrail Height ................................. D2.3, B3
  Shape .................................................. D6.1, D6.2, D6.3
  Stair Handrail Height ................................ D2.1
  Supports ................................................ D7.1, D7.2
  Texture on Walls ..................................... D7.3, D7.4
  Types of Barricades ................................. D11.2
  Where Required ........................................ D1

HAPTIC MAPS ............................................... E11
HAZARDS, STAIRS ......................................... C9
HAZARDS, WALKWAYS ................................. A4
HEAT CONDUCTABILITY OF RAILINGS ............. D8.2
HEIGHT OF PROJECTIONS .............................. G2.2
<table>
<thead>
<tr>
<th>ILLUMINATION LEVELS</th>
<th>F1.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTERNATIONAL SYMBOL OF ACCESSIBILITY</td>
<td>E4</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>INTRO</td>
</tr>
<tr>
<td>Accessible Network</td>
<td>INTRO</td>
</tr>
<tr>
<td>Approach</td>
<td>INTRO</td>
</tr>
<tr>
<td>Community</td>
<td>INTRO</td>
</tr>
<tr>
<td>Component</td>
<td>INTRO</td>
</tr>
<tr>
<td>District</td>
<td>INTRO</td>
</tr>
<tr>
<td>Element</td>
<td>INTRO</td>
</tr>
<tr>
<td>End Condition</td>
<td>INTRO</td>
</tr>
<tr>
<td>Priority Accessible Network</td>
<td>INTRO</td>
</tr>
<tr>
<td>Route</td>
<td>INTRO</td>
</tr>
<tr>
<td>Structure</td>
<td>INTRO</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LANDINGS, RAMP</th>
<th>B2</th>
</tr>
</thead>
<tbody>
<tr>
<td>LANDINGS, STAIRS</td>
<td>C3</td>
</tr>
<tr>
<td>LANDMARKS, GENERAL</td>
<td>DS</td>
</tr>
<tr>
<td>LANDMARKS, SIGNAGE &amp; MEDIA CUES</td>
<td>E10</td>
</tr>
<tr>
<td>LANDSCAPING</td>
<td>A4.3, A4.4, A4.5</td>
</tr>
<tr>
<td>LAYOUTS, FOR VISUALLY IMPAIRED</td>
<td>E8</td>
</tr>
<tr>
<td>LEGIBILITY OF LAYOUT</td>
<td>E3</td>
</tr>
<tr>
<td>LENGTH OF RAMPS</td>
<td>B1.2</td>
</tr>
<tr>
<td>LIGHTING</td>
<td>F</td>
</tr>
<tr>
<td>Auxiliary Lighting</td>
<td>F1.1</td>
</tr>
<tr>
<td>End Condition</td>
<td>F1.2</td>
</tr>
<tr>
<td>Illumination Levels</td>
<td>F1.1</td>
</tr>
<tr>
<td>Reflectance Factor</td>
<td>F1.3</td>
</tr>
<tr>
<td>Security Lighting</td>
<td>F3</td>
</tr>
<tr>
<td>Vandalism</td>
<td>F4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LINEAR TACTILE GUIDES</th>
<th>E5</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOAD CAPACITY, HANDRAILS</td>
<td>D10</td>
</tr>
<tr>
<td>LOCATION OF CROSSING STRUCTURE</td>
<td>SD</td>
</tr>
<tr>
<td>(Checklist)</td>
<td></td>
</tr>
<tr>
<td>LOCATION, SIGNAGE AND MEDIA CUES</td>
<td>E2</td>
</tr>
<tr>
<td>LOCATION, STREET FURNITURE</td>
<td>G1, G2.3</td>
</tr>
</tbody>
</table>
MAIL RECEPTACLES ............................................. G5
MAINTENANCE, OF WALKWAYS .............................. A2.7, A2.8, A4.4
MANHOLE COVERS ............................................. G6
MANUAL WHEELCHAIR USER PROFILE .................. DS
MATERIALS, HANDRAIL ........................................ D8.1
MOBILITY, OF VISUALLY IMPAIRED ..................... DS

NOSINGS, STAIRS ............................................... C6
NOSINGS, VISIBILITY OF ................................. C7.2

OVERHANGING PROJECTIONS .............................. G2

PLACE CUES ..................................................... E10
PLATFORMS ....................................................... B2
PRIORITY ACCESSIBLE NETWORK ....................... INTRO
PROJECTIONS, HANDRAILS ................................ D4
PUBLIC TELEPHONES ........................................ G3
PYLON MOUNTED STRUCTURES ........................... G2.2

RAMPS .............................................................. B
Auxiliary Stairs ................................................. B5
Cross Slopes .................................................... B1.3
Edge Protection ............................................... B3.1
Gradients ......................................................... B1.2
Handrails ......................................................... B3
Landings ........................................................... B2
Lengths ............................................................. B1.2
Platforms .......................................................... B2
Slip Resistance .................................................. B4.1
Widths .............................................................. B1.1
| REFLECTANCE FACTOR, WALKWAYS                  | A2.6 |
| RISERS, STAIRS                                | C5   |
| ROUTES                                        | INTRO |
| RUNS, STAIRS                                  | C4   |

| SCHEMATIC DESIGN                              | SD   |
| Configuration (Checklist)                     | SD   |
| Location of Crossing Structure (Checklist)     | SD   |
| Site Planning (Checklist)                     | SD   |

| SECURITY LIGHTING                             | F3   |
| SHAPE, OF HANDRAIL                            | D6.1, D6.2, D6.3 |
| SHORELINES                                    | DS   |

| SIGNAGE AND MEDIA CUES                        | E    |
| General                                       | E1   |
| Haptic Maps                                   | E11  |
| International Symbol of Accessibility         | E4   |
| Landmarks                                     | E10  |
| Layouts for the Visually Impaired             | E8   |
| Legibility                                    | E3   |
| Linear Tactile Guides                         | E5   |
| Location of                                   | E2   |
| Place Cues                                    | E10  |
| Shorelines and Directional Aids               | E9   |
| Street Furniture Strip                        | E7   |
| Tactile Signals on Walkway Surfaces           | E5   |
| Tactual                                       | E11  |

| SITE PLANNING (CHECKLIST)                     | SD   |
| SLIP RESISTANT SURFACE, RAMPS                 | B4.1 |
| SLIP RESISTANT SURFACE, WALKWAYS              | A2.1 |
| STAIRS                                        | C    |
| Hazards                                       | C9   |
| Landings                                      | C3   |
| Nosings                                       | C6   |
| Risers                                        | C5   |
| Runs                                          | C4   |
| Surfaces                                      | C7.1 |
| Tactile Signals                               | C8   |
| Treads                                        | C5   |

72
<table>
<thead>
<tr>
<th>Topic</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visibility of Nosings, Widths</td>
<td>C7.2, C2</td>
</tr>
<tr>
<td>STREET FURNITURE</td>
<td>G</td>
</tr>
<tr>
<td>Drinking Fountains</td>
<td>G4</td>
</tr>
<tr>
<td>General</td>
<td>G1</td>
</tr>
<tr>
<td>Gratings</td>
<td>G6</td>
</tr>
<tr>
<td>Height of Projections</td>
<td>G2.2</td>
</tr>
<tr>
<td>Location in Relation to Curb</td>
<td>G2.3</td>
</tr>
<tr>
<td>Mail Receptacles</td>
<td>G5</td>
</tr>
<tr>
<td>Manhole Covers</td>
<td>G6</td>
</tr>
<tr>
<td>Overhanging Projections</td>
<td>G2</td>
</tr>
<tr>
<td>Public Telephones</td>
<td>G3</td>
</tr>
<tr>
<td>Pylon Mounted Structures</td>
<td>G2.2</td>
</tr>
<tr>
<td>Sharp Projections</td>
<td>G1.4</td>
</tr>
<tr>
<td>Strip</td>
<td>G1.3</td>
</tr>
<tr>
<td>Trash Receptacles</td>
<td>G5</td>
</tr>
<tr>
<td>SUPPORTS, HANDRAIL</td>
<td>D7.1, D7.2</td>
</tr>
<tr>
<td>SURFACES TO AVOID</td>
<td>A2.3</td>
</tr>
<tr>
<td>SURFACES, STAIRS</td>
<td>C7.1</td>
</tr>
<tr>
<td>TACTILE SIGNALS, STAIRS</td>
<td>C8</td>
</tr>
<tr>
<td>TACTILE SIGNALS, WALKWAYS</td>
<td>E5</td>
</tr>
<tr>
<td>TACTUAL MAPS</td>
<td>E11</td>
</tr>
<tr>
<td>TEXTURES ON WALLS, HANDRAIL</td>
<td>D7.3, D7.4</td>
</tr>
<tr>
<td>TRANSVERSE SLOPE, WALKWAYS</td>
<td>A3.2, A3.3</td>
</tr>
<tr>
<td>TREADS, STAIRS</td>
<td>C5</td>
</tr>
<tr>
<td>TYPES OF BARRICADES</td>
<td>D11.2</td>
</tr>
<tr>
<td>VANDALISM</td>
<td>F4</td>
</tr>
<tr>
<td>VISIBILITY OF NOSINGS, STAIRS</td>
<td>C7.2</td>
</tr>
<tr>
<td>VISUALLY IMPAIRED USER PROFILE</td>
<td>DS</td>
</tr>
<tr>
<td>Topic</td>
<td>Section</td>
</tr>
<tr>
<td>------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>WALKWAYS</td>
<td>A</td>
</tr>
<tr>
<td>Change in Level</td>
<td>A2.4</td>
</tr>
<tr>
<td>Construction Joints</td>
<td>A2.2, A2.4</td>
</tr>
<tr>
<td>Gradient</td>
<td>A3.1, A3.2, A3.3</td>
</tr>
<tr>
<td>Hazards</td>
<td>A4</td>
</tr>
<tr>
<td>Landscaping</td>
<td>A4.3, A4.4, A4.5</td>
</tr>
<tr>
<td>Maintenance</td>
<td>A2.7, A2.8, A2.9, A4.4</td>
</tr>
<tr>
<td>Reflectance Factor</td>
<td>A2.6</td>
</tr>
<tr>
<td>Slip Resistant Surfaces</td>
<td>A2.1</td>
</tr>
<tr>
<td>Surfaces to Avoid</td>
<td>A2.3</td>
</tr>
<tr>
<td>Transverse Slope</td>
<td>A3.2, A3.3</td>
</tr>
<tr>
<td>Walkway Boundaries</td>
<td>A2.5</td>
</tr>
<tr>
<td>Widths</td>
<td>A1.1, A1.2</td>
</tr>
<tr>
<td>WIDTH, RAMP</td>
<td>B1.1</td>
</tr>
<tr>
<td>WIDTH, STAIRS</td>
<td>C2</td>
</tr>
<tr>
<td>WIDTH, WALKWAYS</td>
<td>A1.1, A1.2</td>
</tr>
</tbody>
</table>