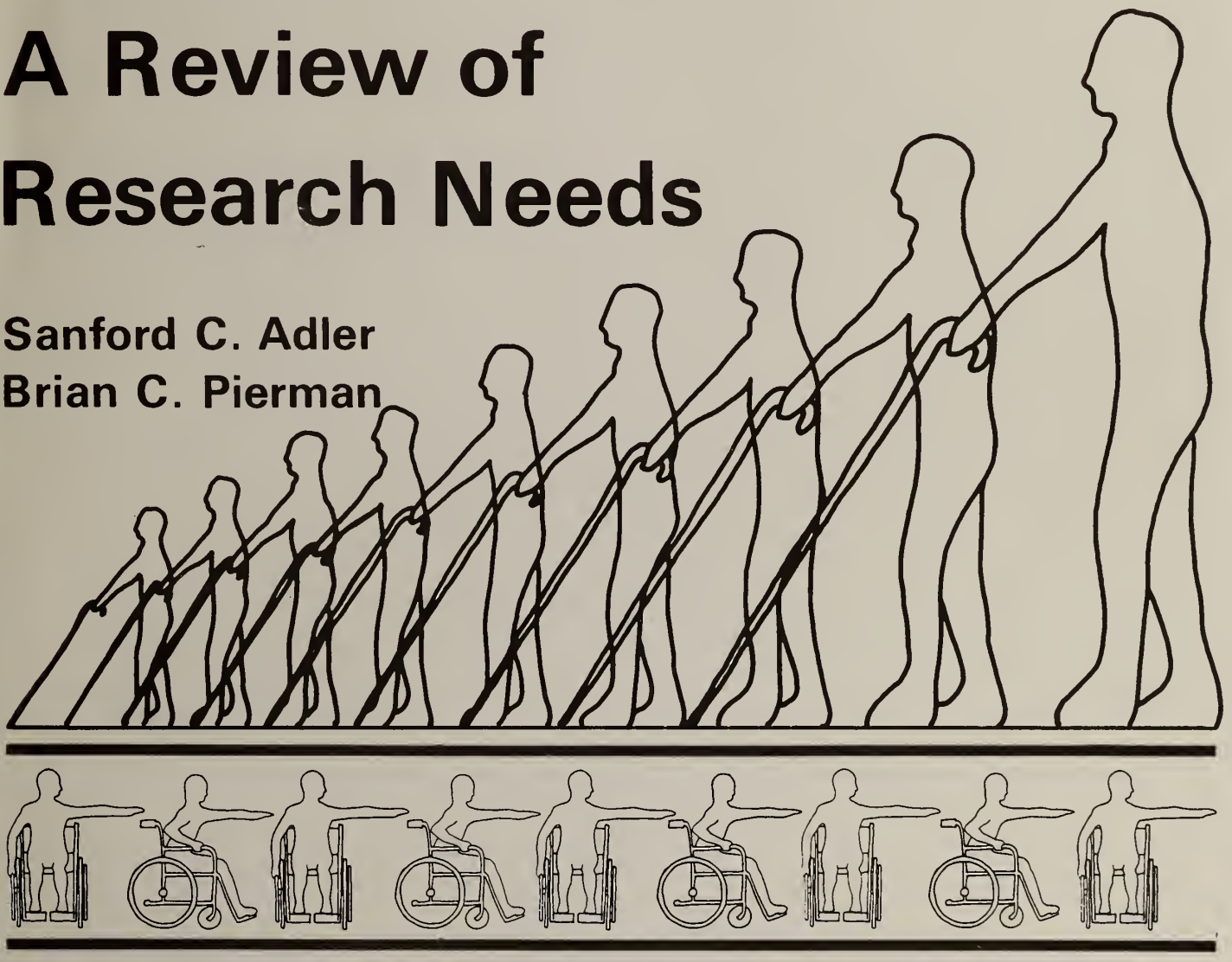
NBSIR 81-2245

BUILDING ACCESSIBILITY FOR THE DISABLED:

A Review of Research Needs

Sanford C. Adler
Brian C. Pierman



March 1981

Center for Building Technology
National Engineering Laboratory
National Bureau of Standards
DEPARTMENT OF COMMERCE

NBSIR 81-2245

ACCESSIBLE BUILDINGS FOR THE DISABLED: A REVIEW OF RESEARCH NEEDS

Sanford C. Adler
Brian C. Pierman

Environmental Design Research Division
Center for Building Technology
U.S. Department of Commerce
National Bureau of Standards
Washington, DC 20234

March 1981

Prepared for
Architectural and Transportation Barriers Compliance Board
330 "C" St., S.W.
Washington, DC 20201

U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, *Secretary*
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

ABSTRACT

This report traces the evaluation of public policy on accessible environments, discusses the need for development of a research basis for the design of accessible buildings including accessibility standards for both new and existing buildings, summarizes the results and research recommendations of both the Conference on Fire Safety for the Handicapped held at NBS on November 26-29, 1979 and the joint ATBCB/NBS Conference on Accessibility Guidelines held in Bethesda, Maryland on October 31 - November 1, 1979, and presents an overview of current NBS accessibility research plans.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

Special thanks to Dr. Bernard Levin of the Center for Fire Research for reviewing section two on Fire and Life Safety and to Mr. George Turner, Mr. Jenkins Washington, and Dr. Francis Ventre for comments on and revisions of the final report. Mrs. Ana Salazar is acknowledged for guiding the preparation of the report through several revisions.

SI CONVERSION UNITS

In view of the present accepted practice for building technology in this country, common U.S. units of measurement were used throughout the report. In recognition of the position of thte United States as a signatory to the General Conference on Weights and Measures, which gave official status of the International System of Units (SI) in 1960, the table below is presented to facilitate conversion to SI units. Readers interested in making further use of the coherent system of SI units are referred to: NBS SP 330, 1977 Edition, The International System of Units; and ASTM E621-78, Standard Practice for the Use of Metric (SI) Units in Building Design and Construction.

Table of Conversion Factors to SI Units

To Convert From	To	Multiply By
inch	millimeter	25.4*
inch	meter	$2.54^* \cdot 10^{-2}$
foot	meter	$3.048^* \cdot 10^{-1}$
lb (force)	netwon	4.4482
lb (mass)	kilogram	0.4536
lb/in^2	pascal	6.897×10^3
lb/ft^2	pascal	47.880
ton/ft^2	pascal	95.760×10^3
lb/ft^3 (mass)	kg/m^3	16.018
lb/ft^3 (equivalent force)	N/m^3	157.14

* Exact value, others are rounded to five digits.

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

1.1 DEFINING THE AFFECTED POPULATION

The Federal Architectural and Transportation Barriers Compliance Board (ATBCB) estimates that 40 million Americans have chronic physical disabilities or activity limitations.

In addition, there are, at any particular time, approximately 8 million Americans temporarily disabled due to pregnancy, short-term injury, or illness. Improved medical techniques for saving the critically injured or ill and an expanding population of older persons are increasing the number of disabled individuals every year. Yet, the built environment continues to be designed to accommodate the "able-bodied," thereby perpetuating isolation and dependence of disabled individuals and elderly people. Architectural barriers affect everyone: indirectly, through the loss of contributions that handicapped individuals can make to society, and directly, when we personally must face a chronic or acute disability.

Not everyone who is disabled can be classed as handicapped. Conversely, not everyone who is handicapped is necessarily disabled.

"Disability" is a term which implicitly compares what a person can or cannot do to what he or she is generally expected to do, in terms of a reference population of "able-bodied" people of comparable age. For example, a small child who cannot open a heavy door is not considered disabled.

"Handicapped" is a term which compares what a person can or cannot do to a required level of performance, without regard for the person's age, sex, or other physical characteristics. In this respect, a small child who cannot open a heavy door is handicapped. In the context of buildings and their sites, a handicapped person is anyone who is hampered in his or her mobility or functioning as a result of building design, the choice of hardware and equipment and/or the design of outside spaces. Some building elements (barriers) handicap everyone. Others are discriminatory; they present severe and/or unreasonable restrictions to people with specific disabilities.

1.2 THE BUILT ENVIRONMENT

People have individual and social needs which cannot be met by the natural environment. A built environment provides protection from extreme weather, safeguarding of food and other valuables, privacy, and security. These needs clearly point out that a building is, by design, a barrier (intended to keep something in or out). The idea that building features can be obstacles for all citizens has been addressed by Jones [16]:*

---

* References are located at the end of the report.

> If we consider that the environment has traditionally been designed for the average, 'able bodied' adult (of average weight, hearing, eyesight, stamina, and reaction time) then the rest of the population which does not match up to this standard is by definition handicapped. It is estimated that 60 percent of the total population of the United States is handicapped at any one time in their use of the environment.

He also notes that,

> Any changes that are made to the environment to aid the severely handicapped population will also help all people to lead easier and safer lives.

Buildings should be designed to be barriers where adverse or undesirable ends are concerned, but barrier free to legitimate building use.

Cost effective solutions to this technical challenge can be achieved if:

1. the built environment is adapted to accommodate the widest possible range of users, and

2. an individual's abilities are enhanced wherever possible by personal aids to help him/her interface with appropriately designed buildings.

A wheelchair is an obvious example of a personal aid with which a properly designed building can be fully accessible.

This report addresses the building part of the solution with a primary focus on the barrier free design concept.

1.3 BARRIER FREE DESIGN

Architects traditionally design buildings for an idealized "average" user who might be characterized as a "large, healthy, adult male in his late teens or early 20's" [19]. Typical designs accommodate a small number of people in their prime of life who have maximum physical and mental capabilities. When we consider the normal life cycles that all people must experience, everyone is handicapped at some time by building design.

> ...all people pass through stages of ability and disability: children who have not yet attained adult strength, stature, or mental processes; pregnant women who, even without complications suffer reduced stamina, mobility, agility and balance; persons who tend the very young and are encumbered by carrying infants, maneuvering baby vehicles or moving hand-in-hand with toddlers ...(and);...aging persons who are subject to progressive loss of physical, perceptual, and mental faculties. [19]

In addition, many people suffer temporary disabilities due to illness or injury.

Perhaps the only difference between an "average" person and a person who was born with or acquired a disability early in life is that the disabled person never experienced that period of mid-life in which they were "temporarily able-bodied" and were not handicapped by the built environment.

The goal of accessible design cannot be approached by putting a "young healthy adult male" in a wheelchair and designing for his perceived needs. Accessible designs must be responsive to the different and sometimes conflicting needs of people and their different and sometimes multiple disabilities.

An alternative to traditional building design is barrier free design which permits a wide range of able-bodied and disabled people to freely use the built environment. This requires an examination of the range of abilities of anticipated users and the design criteria necessary to accommodate them.

1.4 CHARACTERIZATION OF DISABILITIES

Steinfeild et al. [23] have developed a graphic conceptual model that assists the architect in visualizing disabilities relevant to building design. The ideogram, called the Enabler, represents a person's abilities as a basis for design. Fifteen different disability concerns are represented in the following logical format.

1. Mental functioning

   - difficulty interpreting information

2. The senses

   - severe loss of sight
   - complete loss of sight
   - severe loss of hearing

3. Internal body regulation

   - prevalence of poor balance
   - incoordination

4. Motor impairment

   - limitations of stamina
   - difficulty moving head
   - difficulty reaching with arms
   - difficulty in handling and fingering
   - loss of upper extremity skills
   - difficulty bending, kneeling, etc.
   - reliance on walking aids
   - inability to use lower extremities
   - extremes of size and weight

The Enabler ideogram is illustrated in figure 1.

In addition to the above categories, designers also need to be concerned about a building user who cannot feel temperature or pressure, cannot speak, or is incumbered by multiple disabilities.

The Enabler improves the designer's awareness of different disabling conditions and highlights what must be considered in barrier free design. However, the device fails to provide detailed technical guidance regarding solutions when a disability is recognized as problematic. One method to ensure end results is the development of a sound basis for accessibility standards that are used by architets and designers. The next section describes legislation which has provided the basis for development and enforcement of current accessibility standards and guidelines.

1.5 BRIEF HISTORICAL REVIEW AND SUMMARY OF KEY LEGISLATION

National efforts to make buildings accessible to people with disabilities date back to the 1950's.

1.5.1 The First National Standard

In 1959, the President's Committee on Employment of the Physically Handicapped, in conjunction with the Veteran's Administration, published a Tentative Guide -- Facilities in Public Buildings for Persons with Ambulatory Impairments.

In response to this document, the Public Building Administration issued a directive which stated: "All new Federal buildings shall provide easy access of wheelchairs to the first floor entrance lobby. Where entrance steps are unavoidable, ramps and handrails must be provided." [23]

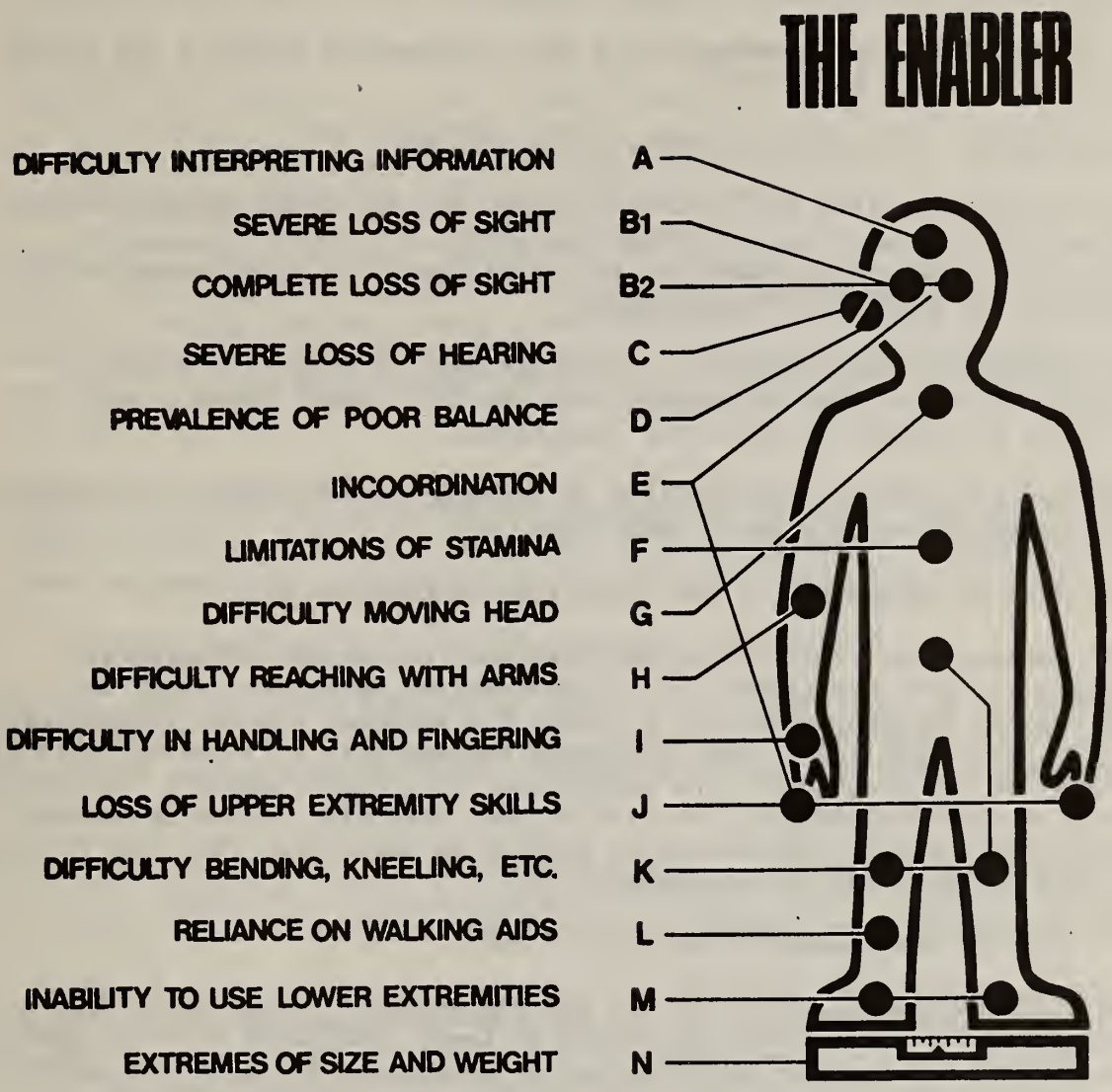
With the support of the President's Committee and the National Easter Seal Society, the American National Standards Institute, Inc. (ANSI) published the first significant accessibility standard: ANSI A117.1-1961, Specifications for Making Building and Facilities Accessible to, and Usable by, the Physically Handicapped. This standard was revised in 1980.

By 1965, 24 States had initiated implementation of the ANSI standard or similar requirements [11]. In most instances, however, there were no provisions to assure compliance.

1.5.2 PL 89-333 Vocational Rehabilitation Act of 1965

Section 15 of the Vocational Rehabilitation Act of 1965 authorized formation of the National Commission on Architectural Barriers. The Commission examined how and to what extent architectural barriers affected the disabled, reviewed what was being done by public and other groups to eliminate existing barriers and prevent their incorporation in new constructions, and prepared plans and proposals for further action.

The Commission report, Design for All Americans (1968) [10], included recommendations that dealt with the need for: greater public awareness: legislative action to assure that new construction intended for public use or built



Adapted from Steinfeld, Edward, et al., Access to the Built Environment: A Review of Literature, HUD-PDR-409, April 1979, U.S. Dept. of Housing and Urban Development, Wash., D.C. (Figure 1, p. 75).

Figure 1. The Enabler

with public funds would be accessible; revisions of existing building codes to assure that renovations of existing buildings and privately funded "public use" new construction be accessible; and assignment of implementation responsibility to specific government agencies.

Many of the Commission's recommendations were implemented within a few months with passage of Public Law 90-480.

1.5.3 PL 90-480, Architectural Barriers Act of 1968

The Architectural Barriers Act of 1968 requires all buildings (except private residential and some military buildings) constructed, altered, leased, or financed by the Federal government to be "so designed and constructed as to be accessible to the physically handicapped."

The General Services Administration, the Department of Housing and Urban Development, the Department of Defense, and the U.S. Postal Service were authorized to prescribe standards for compliance.

PL 90-480 did not address accessibility of transportation systems, an oversight which was corrected by passage of Public Law 91-205.

1.5.4 PL 91-205, Amendments to the Architectural Barriers Act (1970)

PL 90-205 amended the Architectural Barriers Act to extended accessibility requirements for the handicapped to all construction authorized under the National Capitol Transportation Act of 1960, the National Capitol Transportation Act of 1965, and Title III of the Washington Metropolitan Area Transit Authority, responsible for construction of the Washington, D.C. subway system. Following a court test of this legislation, the D.C. Transit Authority agreed to provide accessible facilities in response to an injunction preventing them from opening any stations not equipped with elevators [23].

1.5.5 PL 93-112, The Rehabilitation Act of 1973

The Iowa study (Accessibility - The Law and the Reality: A Survey to Test the Application and Effectiveness of PL 90-480 in Iowa), published in 1974, concluded that the law had not met the stated intent of Congress. The study recommended stronger enforcement, improved design standards, and intensive education of Federal agency responsibilities under the existing law [6]. In 1973, major legislation was passed which specifically dealt with these issues.

There are four sections of PL 93-112 that have direct bearing on accessibility for the disabled.

1. Section 501 requires Federal agencies to develop and implement affirmative action programs for hiring, placement, and advancement of handicapped individuals, including provision for meeting any special needs.

2. Section 502 created the Architectural and Transportation Barriers Compliance Board (ATBCB), composed of the heads of each of the following agencies (or their designees): Departments of Health, Education, and Welfare; Transportation; Housing and Urban Development; Labor; Interior; General Services Administration, United States Postal Service; and Veterans' Administration.

   The principle duties of the ATBCB were to ensure compliance with the Architectural Barriers Act of 1968, conduct research and investigations relating to architectural, transportation, and attitudinal barriers, and where necessary issue non-compliance rulings. The membership and responsibilities of ATBCB were expanded in 1974 and 1978 (discussed under 1.5.6 and 1.5.7).

3. Section 503 requires every employee doing business with the Federal government under a contract for more than $2,500 to have an affirmative action plan for handicapped employees. The contractor must also make reasonable accommodation to the physical and mental limitations of handicapped employees, unless such accommodations would impose an undue hardships on his business.

4. Section 504 provides that "no otherwise qualified handicapped individual shall, solely by reason of his handicapped, be excluded from the participation in, be denied the benefits of, or be subjected to discrimation under any program or activity receiving Federal financial assistance.

1.5.6 PL 93-516 Amendments to the Rehabilitation Act (1974)

In 1974, the Department of Defense was added to the membership of the ATBCB, the Secretary of Health, Education and Welfare was made Chairman, and a Consumer Advisory Panel was created to provide guidance, advice, and recommendations to the ATBCB.

In addition, section 502(d) was strengthened such that a noncompliance order issued by the ATBCB affecting any Federal department became final and binding on that agency and could include withholding or suspension of Federal funds.

1.5.7 PL 95-602 Rehabilitation, Comprehensive Services, and Developmental Disabilities Amendments of 1978

Title I of PL 95-602 amended the Rehabilitation Act of 1973, making major changes in the membership and authority of the ATBCB.

Membership in the ATBCB was expanded to include the Department of Justice and 11 public members appointed by the President. At least 5 of the public members shall be handicapped individuals. The first Chairman (Max Cleland) was selected by the President to serve for a period of 2 years. Future chairmen shall be elected by the Board for a oneyear term.

The Board's jurisdiction was expanded to include telecommunications devices and rolling stock (trains, buses, etc.). The Board was also authorized to bring civil action in Federal courts to enforce rules.

In addition, the Board, in consultation and coordination with other concerned agencies, is required to "establish minimum guidelines and requirements . . . for the standards issued pursuant to the Architectural Barrier Act" [22]. This new statutory responsibility is the basis for the NBS/ATBCB Accessibility Guidelines Project.

PL 95-602 also authorized the establishment of a National Institute of Handicapped Research (NIHR) to promote and coordinate research with respect to handicapped individuals. The NIHR will be assisted in carrying out its responsibilities by an Interagency Committee on Handicapped Research and receive policy guidance from a National Council on the Handicapped.

The Interagency Committee on Handicapped Research is chaired by the Director of NIHR and consists of such members as the President may designate, including representatives from the Department of Health, Education and Welfare, the National Institutes of Health, the Veterans Administration, the National Aeronautics and Space Administration, the Department of Transportation and the National Science Foundation.

The National Council on the Handicapped has 15 members, at least 5 of whome are handicapped individuals or parents or guardians of handicapped individuals. The primary duty of the Council is to establish general policies for and review the operation of the NIHR.

NBS has assisted NIHR in the development of a 5-year plan for research on the handicapped.

1.6 RECENT NBS RESEARCH ACTIVITIES RELATING TO ACCESSIBILITY

Characteristics of a building that provide increased safety, security, or accessibility have a direct effect on both the well being of building users and the efficiency of activities underway. Conversely, other parameters, such as characteristics of materials, often have greater importance to the maintenance and longevity of a building and less direct effect on its occupants. Only those considerations that influence the building and user interface are discussed in this section. Abstracts of most NBS publications dealing with buildings and building use can be found in the series, Building Technology Publications, Fire Research Publications and NBS List of Publications 85: Consumer Product Technology [9, 15, 20].

The following are a small sample of the recent NBS reseach relevant to the accessibility of buildings.

1.6.1 Noise in Buildings

NBS has conducted extensive research on noise in and around buildings. The background noise level in a building is very important to individuals with hearing impairments. Noise levels that are annoying or distracting to individuals with normal hearing can totally interfere with residual hearing of a person with a hearing impairment, making speech communication difficult or impossible.

In 1976, NBS published a guide to noise control [7] which offers practical solutions to ordinary noise problems that occur at home, work, school, and in the community. The remedies included noise prevention as well as noise reduction techniques. More recent work has examined noise criteria for buildings [25] and development of a design guide for reducing transportation noise in and around buildings [21].

1.6.2 Slip-Resistance of Walkways

Falls on floors represent a serious building design and maintenance problem. The National Safety Council reports that slips and falls are the major building-related causes of accidental death and injury [2]. In 1976, over 8 million falls resulted in 1.6 million disabling injuries and 14,896 deaths. In more than half of the falls, slippery surfces were identified as a major contributing factor. This problem is especially important to people who have a gait problem or use walking aids such as crutches or canes.

Since 1924, NBS research has focused on quantitative measurements of the slip-resistance of shoe and flooring surfaces and on the development of measurement devices. In 1977, the NBS-Brungraber Portable Slip-Resistance tester was developed. This device overcame many of the limitations of earlier portable test devices. A detailed discussion of NBS slip-resistance research is contained in A History of Walkway Slip-Resistance Research at the National Bureau of Standards [3]. This report summarizes NBS research in the area of walkway and shoe slip-resistance measurement since 1924 and outlines current activities that will provide a technical basis for slip-resistance measurement.

1.6.3 Safety on Stairs

For each year since 1974, the Consumer Product Safety Commission (CPSC) has determined that stairs, ramps, and landings are among the most hazardous consumer products in the United States. Improper stairway design presents special problems for individuals with reduced vision and individuals with reduced mobility of the lower limbs. NBS research in this area has included review and analysis of epidemological data on stair accidents, development of theoretical models of stair use, videotape and film analysis of stair use patterns and direct field observations and physical measurements of stairways. The most recent report of this work, Guidelines for Stair Safety [5], summarizes the research findings and provides design guidelines for improved stair safety. These guidelines are directed toward 7 major categories of stairway design and construction: (1) structural integrity and quality of stairs, (2) physical attributes of stair surfaces, (3) appearance of stair surfaces, (4) handrails, (5) physical attributes of the surrounding stairway environment, (6) appearance of the surrounding stairway environment, and (7) signs and symbols. In general, the recommendations offered in this report derive from the premise that stairway accidents are caused by human perceptual errors which are frequently triggered by some flaw in the design or construction of stairways themselves. For example, patterned carpeting is sometimes installed on stairs in such a way that it is very difficult to see where one stair tread ends and the next begins.

1.6.4 Human Behavior and Communication Needs in Building Emergencies

Considerable information is available on what must be done to insure the structural integrity of a building under emergency conditions. A major literature review on emergency communication needs in high rise buildings was completed by Glass and Rubin in 1979 [12]. This document contained a section on the communication needs of the disabled. However, comparatively little is known about the needs (and reactions) of building occupants during fire or other emergencies.

NBS has investigated problems related to emergency egress, pedestrian movement in buildings, lighting, color, size, shape and placement of signage; emergency signaling and communication needs; and computer modeling for human behavior in fires. Numerous publications on these topics are abstracted in NBS Special Publication 457 [9].

1.7 TECHNOLOGY GAP

Legislative action helps to clarify national goals but does not always create the resources essential to achieving them. In particular, Federal regulatory agencies are seeking additional technical information to develop the rational basis for regulation. This technology gap is evident when one considers the status of codes and standards relating to accessibility.

There are currently over 75 different codes or standards relating to building accessibility [14]. These codes or standards often have different or even conflicting requirements. In a study by Harkness and Groom, 13 major codes were examined with respect to 39 specifications, and only 8 points of agreement were found. Similar results were found in the ATBCB/NBS review of codes and standards, discussed later in this report.

The following two sections of this report discuss accessibility research needs in relation to normal use of buildings (accessibility requirements) and emergency use of building (fire and life safety) by people with disabilities.

2.0 FIRE SAFETY FOR THE HANDICAPPED

2.1 BACKGROUND

Recent progress in making public facilities available to the handicapped and in deinstitutionalization of the more severely handicapped has increased the need for greater efforts to ensure the safety of the handicapped in fire and other emergencies. On November 26-29, 1979, the National Bureau of Standards hosted a Conference on Fire Safety for the Handicapped where 80 experts discussed the problems of the handicapped in fire emergencies.

The Conference on Fire Safety for the Handicapped was the first national conference to give serious and concentrated attention to the safety of the disabled in fire and other emergencies. The conference was structured to maximize the exchange and the evaluation of ideas, possible solutions, and experiences with specific solutions in the area of fire safety and the handicapped. The major work of the conference was conducted by seven panels that met in parallel: Overview, Alarm Systems, Egress, Refuge, Self-protection, Management Actions, and Emergency Service Actions.

In addition, six workshops were held in preparation for the conference during August and September 1979. The workshops were: Codes and Standards, Emergency Preparedness Planning, Building Design, Education, Consumer Interests, and Products.

Detailed final reports of each of the panels and workshops, the text of speeches delivered during the plenary sessions, and supplementary comments by some participants are all contained in an NBS publication, Fire and Life Safety for the Handicapped [17]. The major findings of the panels and Conference which deal with building design and use are summarized below.

2.2 CONFERENCE FINDINGS RELATING TO BUILDING DESIGN AND USE

2.2.1 Basic Problems and Issues

(1) Lack of Data

There is currently inadequate understanding of: the capabilities of handicapped persons; the number and distribution of handicapped persons likely to utilize various buildings; the experiences handicapped people have had in fire situations; the interaction of handicapped and able-bodied persons in life threatening situations and a lack of rational models to predict their interaction.

(2) Building Code Classifications

The occupancy classifications traditionally used in building codes do not fully account for the occupants' degree of familiarity with the facility or the extent of interrelationships among the occupants.

(3) Communication Systems

Emergency communications systems do not provide all occupants with sufficient information to assist them in executing appropriate behavior.

(4) Fire Emergency Planning

There is generally a lack of evacuation planning to address the needs of handicapped building occupants.

(5) Education and Training

There appears to be inadequate education and training for professionals and the public (including handicapped people) on the special needs of the handicapped in fire emergencies or on how to deal with these needs.

2.2.2 Recommendations

(1) Involvement of Disabled People

Disabled persons should be involved in all phases of the development, implementation, and evaluation of all elements of fire safety.

(2) Alarm, Signal and Communication Systems

Consideration should be given to an alarm box of standardized shape, color, texture, operation and color. Where a fire alarm system is required, every person who is expected to take independent action in a fire emergency should be alerted by a standardized visual, audible, or tactile signal. Directions to exits or places of refuge should include standardized signage.

(3) Egress Requirements

At least two means of egress from the area of fire should be provided for all building users. The first should be an accessible exit route which may include a fire-safe elevator (discussed below). The second means of egress may be: a ramp or other barrier free means of vertical movement; an assistance plan to make an otherwise non-accessible exit route accessible; or an area of refuge.

Additional research is required to define the requirements for a fire-safe elevator. Minimum requirements would cover accessibility, fire and smoke protection for elevator shafts and waiting areas, standby power, and safe egress at the discharge level.

(4) Areas of Refuge

(a) New Construction

All new buildings must have a plan to evacuate the disabled or to protect them in an area of refuge. The area of refuge must be large enough to accomodate the anticipated users (both able-bodied and disabled) and have adequate

fire-resistancy. At a minimum, provisions must be made for adequate ventilation and smoke control, two-way communication, and a stairway or fire-safe elevator to provide for possible rescue.

(b) Existing Buildings

Areas of refuge can be required in existing buildings when proposed renovations or additions exceed some specified percent of the total value of the building. However, as a minimum, all existing buildings that are accessible to the handicapped should have a plan to evacuate or protect occupants in an area of refuge. Additional measures such as compartmentalization of the building, provisions of staging area for rescue, or fire-safe elevators may be needed.

A major research effort should be undertaken to develop a system for rating the fire safety level of an accessible building.

5. Physical Barriers to Egress

Conference participants noted that several recommendations in the new American National Standard A117.1-1980, "Specifications for Making Buildings and Facilities Accessible to and Useable by Physically Handicapped People" conflict with the existing building and life safety codes or do not provide life-safety solutions. It was suggested that the provisions of this newly-revised standard which deals with fire-safety be carefully examined.

6. Behavior Aspects of Egress

The available data on behavior during fire emergencies needs to be more widely disseminated, studied, and discussed. For example, what constitutes an effective, unambiguous alarm and appropriate instructions for people with cognitive disabilities? Why do people often appear to take substantial amounts of time between the sounding of an alarm and attempting egress? Answers to these and other questions are important in building design and evacuation planning.

Additional research needs were identified at the Bethesda Conference on Accessibility Guidelines, which is discussed in the next section of this report.

3.0 ACCESSIBILITY GUIDELINES

3.1 BACKGROUND

In July 1979, the Architectural and Transportation Barriers Compliance Board (ATBCB) requested assistance from the NBS Center for Building Technology (CBT) in evaluating the technical basis of existing and proposed accessibility standards. A conference was planned that brought together technical experts in the field of building accessibility. They consisted of Federal and State government officials, architects, consultants, and standards writers knowledgeable in the topic of accessibility standards provisions and the corresponding research basis.

NBS provided administrative and technical assistance required to conduct a two-day conference that was held on October 31 and November 1, 1979 at Bethesda, Maryland. The participants are listed in table 1.

Three major issues were pursued at the conference:

1. The evaluation of existing standards to determine elements of adequate technical merit that could provide the basis for interim Accessibility Guidelines;
2. Identification of technical research issues related to elements or aspects of existing standards that are not presently technically adequate.
3. Establishment of research priorities related to these issues.

Prior to the Conference, CBT conducted an evaluative study of the provisions of existing accessibility standards and guidelines as an expedient for the conference. The existing draft of the proposed American National Standards A117.1-1980 (now officially designated) was used as the basis of comparison [4]. This task was accomplished during August through October by a separate team of NBS staff members. The official designation of this team was the Accessibility Standards Evaluation Team - ASET. ASET members were selected based on their past experience in required topics such as stairs, ramps, and visual alerting. Appendix 1 is a list of ASET team members.

Nineteen documents representative of the best accessibility standards and guides available were selected by the ATBCB staff and reviewed by the ASET team. Appendix 2 is a complete list of the documents, which include ANSI A117.1 (April 1, 1979 draft), four Federal agency documents, 12 documents based on State codes, and design standards from Australia and Canada.

Following the evaluation of specific topics in all of the documents by ASET members, a summary document was prepared utilizing a format which permitted easy and direct comparison on an item by item basis. Some comparisons specifically on doors appears in Margulis [18]. The summary and other materials were then provided to the NBS/ATBCB Conference on Accessibility Guidelines.

A summary of the results of the conference follows.

Table 1

Participants in NBS/ATBCB Conference on Accessibility Guidelines

Invited Technical Experts

Miss Barbara Allan
Easter Seal Society of Washington
521 Second Avenue, West
Seattle, Washington 98119

Mr. Michael A. Jones
Kramer, Chin and Maya, Inc.
1917 First Avenue
Seattle, Washington 98101

Mr. Robert Lynch
8325 Via De Encanto
Scottsdale, Arizona 85258

Mr. Robert Dale Lynch
Loeffer, Johnson and Associates
Parkway West and Route 60
Box 15508
Pittsburgh, Pennsylvania 15244

Mr. Ronald L. Mace
Barrier Free Environments, Inc.
P.O. Box 30634
Raleigh, North Carolina 27612

Mr. Paul Muldawer
33 Ponc de Leon Avenue, N.E.
Atlanta, Georgia 30308

Mr. Pierce Ossman
Maryland Codes Administration
2525 Riva Road
Annapolis, Maryland 21401

Mr. Robert Small
University of Washington
Department of Architecture
Mail Stop J020
Seattle, Washington 98195

Government Agency Representatives

GSA
Mr. Richard Broderick
PCD
General Services Administration
19th & E Streets, N.W.
Washington, D.C. 20405

Mr. Robert Spowls
PCD
General Services Administration
19th & E Streets, N.W.
Washington, D.C. 20405

USPS
Mr. Joseph Thompson
Program Information Division
U.S. Postal Service
475 L'Enfant Plaza, West, S.W.
Washington, D.C. 20260

DoD
Mr. Robert Shibley
DAEN-MPE-B
Department of the Army
Washington, D.C. 20314

HUD
Dr. Robert Wehrli
Office of Independent Living
Dept. of Housing and Urban Development
451 Seventh Street, S.W.
Washington, D.C. 20410

ATBCB
Mr. Robert M. Johnson
Executive Director
Architectural Transportation and Barriers Compliance Board
Washington, D.C. 20201

Mr. Harold Reitan
Director of Technical Services
Architectural Transportation and Barriers Compliance Board
Washington, D.C. 20201

Mr. John Weber
Architect
Architectural Transportation and Barriers Compliance Board
Washington, D.C. 20201

NBS
Mr. Sanford Adler
Research Engineer
Environmental Design Research Division
National Bureau of Standards
Washington, D.C. 20234

Dr. Stephen T. Margulis
Research Psychologist
Environmental Design Reseach Division
National Bureau of Standards
Washington, D.C. 20234

3.2 GENERAL COMMENTS OF CONFERENCE PARTICIPANTS

Based on the general evaluation of existing accessibility standards and guidelines the conference members reported that any document on this subject should adhere to certain basic rules that ensure usefulness and efficiency. These follow:

1. The basic document should be as short as possible, stating minimum or maximum requirements only. Recommendations (as opposed to requirements) can be stated in an appendix or in a separate "Applications Manual."

2. The document should be written in enforceable language. Terms like "reasonable number" of "useable" are not adequate.

3. Graphics should be clear and consistent with the text. Graphics not essential should be placed in an appendix or supplementary document.

4. Where specific requirements are based on research, the research should be identified.

5. Requirements which are not based on documented research or proven experience should be identified as "preliminary."

6. How the Guidelines are to be applied to remodeling, retrofitting, rehabilitation and historic preservation should be clarified. These areas present far more problems of implementation than does new construction.

7. The Guidelines should build as much as possible on the revised ANSI A117.1. The revised ANSI standard is likely to be widely accepted at the State and local level as a basis for regulation.

3.3 TECHNICAL COMMENTS OF CONFERENCE PARTICIPANTS

The following specific comments relate to existing standards provisions as identified during the conference and by follow-up letters from the technical consultants. Research priorities are identified in section 3.4.

3.3.1 Minimum Requirements

1. Description of accessible sites and exterior facilities might not adequately address some "outside" settings, such as special queues and loading zone requirements related to transportation facilities.

2. It is not clear who in the Federal sector has jurisdiction for accessible housing.

3.3.2 Space Allowances and Reach Ranges

1. A minimum width for wheelchair passage of 48" would permit a pedestrian traveling in either direction to pass a person in a wheelchair.

2. Turning requirements for wheelchairs should be research based since it is important to define the smallest adequate space.

3. A clear floor space of 48" in an alcove requiring a side approach is not adequate.

4. Side reach ranges based on people in wheelchairs may not be appropriate for people who use walking aids or who have limited flexibility.

3.3.3 Accessible Route

1. Appropriate location of passing spaces for wheelchairs has not been adequately researched.

2. An 80" minimum clear head room requirement may not be appropriate for corridor space.

   Semi-ambulatory people who use walking aids (canes, etc.) may prefer stairs over ramps. Hences, stairs may be part of an accessible route.

4. Question raised: Why is only one means of egress regarded as acceptable for handicapped people when two means of egress are required for ambulatory people?

3.3.4 Ground and Floor Surfaces

1. The concept of "relatively non-slip" is unenforceable. Research is needed to establish quantitative requirement.

2. Carpet requirements are not well documented. Research needed on carpets.

3. Current requirements for gratings reduce but do not eliminate the hazard. Needs research.

3.3.5 Parking and Passenger Loading Zones

1. Minimum number or minimum ratio of parking spaces for use by disabled drivers must be established.

2. The location of accessible parking should specify a maximum distance from an accessible entrance.

3. Parking space description should be expanded to specify a maximum slope in any direction of 1:50 and a firm, stable, smooth, "non-slip" surface.

4. Current requirements do not cover minimum vertical requirement for vans, which are commonly used by disabled drivers.

3.3.6 Curb Ramps

Curb ramps have become a significant cause of lawsuits. There is a need for additional research concerning slope, surface texture, and design of sides. Curb ramp design for narrow sidewalks is a challenge.

3.3.7 Ramps

1. Research on slope appears to be wheelchair-oriented; additional work is needed to validate recommended slope for people with foot drag, arthritis, etc.

2. Minimum ramp width of 36" does not permit two-way traffic.

3.3.8 Stairs

1. Current requirements do not consider fire egress by ambulatory disabled.

2. Closed risers should be required.

3. People dependent on handrails need continuity on an intermediate landing. Research needed.

3.3.9 Elevators

1. A question was raised about the feasibility of adding an audible call registration feature to lobby call buttons.

2. Further definition of smallest acceptable cab size is required. Size sufficient to hold one wheelchair and attendant would be adequate.

3. Current elevator illumination level requiements may not be adequate.

4. Suggested that "flush type" control buttons not be permitted.

5. It would be helpful if a call receipt light or indicator were incorporated into an emergency communication system.

6. Handrail requirements should be specified.

3.3.10 Windows

Research is needed on operability, location, and minimum number.

3.3.11 Doors

1. Revolving doors and turnstiles shall not be part of an accessible route.

2. Language on "clear width" should be clarified.

3. General consensus that 18" jamb clearance was necessary. Need for greater clearance would have to be documented by research.

4. A 3/4" threshold for sliding doors is not necessary since a 1/2" threshold is possible with existing hardware.
5. If a door is accessible then it must have accessible hardware. Mounting height of hardware should be specified.

6. More research is needed on door closures to assure they can meet needed door closing and opening requirements.

7. Location of operating switch for power assisted doors should be specified.

3.3.12 Drinking Fountains and Water Coolers

1. Minimum number should be one per floor.

2. Additional research is needed on spout height.

3.3.13 Water Closets and Toilet Stalls

1. Forty-eight inch wide enclosure are not acceptable.

2. Water closet height range of 17 to 19" appears to be an acceptable, though not necessarily optimal compromise.

3. Guidelines should cover location and maximum projection of all types of dispensers and shelves.

4. Require a 60" stall (possible 54") with the 36" stall being an additional option.

3.3.14 Urinals

1. Urinal height specification should state a required length for an elongated rim.

2. Maximum height of flush control should be 48".

3.3.15 Lavatories and Mirrors

1. Floor clearance should be 27".

2. Clear floor space under lavatory should be consistent with rest of standard.

3. Maximum hot water temperature should be restricted to 120°F. A maximum operating force for faucets should be specified.

4. Height measurement for mirrors should be addressed to the lower reflective edge, rather than the frame. The appendix may be an appropriate location to discourage the use of tilted mirrors.

3.3.16 Bathtub and Shower Stalls

1. Additional research is needed on size and location of grab bars.

2. If provided, enclosures should "not obstruct required clear space."

3. A requirement for a maximum hot water temperature of 120° should be added.

4. Shower stalls should not have curbs or thresholds higher than 1/2".

3.3.17 Toilet Rooms

(1) Minimum number should be one per floor for each sex. Research should be done on the feasibility of one separate accessible unisex toilet per floor.

(2) Medicine cabinet shall be located with a shelf no higher than 44" above the floor space.

(3) Structural strength requirements of handrails, grab bars, and tub and shower seats should be rewritten in a simple form.

3.3.18 Alarms

Additional research is needed to determine the specific needs for audible and visual alarms. The stated requirements are not quantitatively related to sensory needs.

3.3.19 Tactile Warnings of Signage

Additional research is required. Some groups feel it should be optional; others mandatory.

3.3.20 Assembly Areas

An appendix can offer guidance on how to locate accessible seats in assembly areas.

3.4 RESEARCH PRIORITIES DELINEATED BY CONFERENCE PARTICIPANTS

Several important research topics were identified during the ATBCB/NBS Conference on Accessibility Guidelines. After the Conference, the technical experts were mailed a list of the major research topics identified at the conference and asked to rank them by order of importance. The responses which ranked all of the major topics were fairly consistent and collectively result in four groups. Topics within each group have nearly the same priority. The groups are listed below in decreasing order of priority.

3.4.1 Group 1 (Highest priority):

1. Develop minimum design characteristics (fire resistance, ventilation, communication linkages, etc.) for areas of refuge useable by disabled people in fires or other emergencies.

2. Develop design requirements for fire safe elevators.

3. Evaluate current and provide technical basis for future requirements for tactile alerting on walkways.

4. Evaluate current and provide technical basis for future requirements for visual alerting.

3.4.2 Group 2

1. Evaluate current and provide technical basis for future requirements for auditory alerting.

2. Evaluate current and provide technical basis for future requirements for tactile alerting and signage on walls, doors, maps, etc.

3. Develop performance tests for carpets and other surfaces which might impede locomotion by the disabled.

4. Evaluate current door opening and closing technology.

3.4.3 Group 3

1. Review research on curb ramps, including accidents associated with curb ramp placement and design.

2. Improve signage in buildings.

3. Develop a quantitative test procedure for measuring the slip-resistance of walkway surfaces.

4. Review research on slope of ramps and relate to needs of users with mobility handicaps who are not in wheelchairs.

3.4.4 Group 4

1. Study door use patterns.

2. Collect and publish ergonomic data relating to door use capabilities.

3. Review research on space requirements for wheelchair use in toilets, on ramps, alcoves, etc.

4. Develop and implement a data bank on accessibility research.

The technical experts were encouraged to submit other research topics which they believed were important. These additional topics are listed below.

3.4.5 Additional Topics

1. Study the relationship between disabilities and aging, with particular attention to multiple disabilities.

2. Study the impact of metrication of building component sizes on accessible design.

3. Study the useability of window hardware devices by disabled. Note that natural ventilation is becoming an energy saving feature on many buildings.

4. Review the special building needs of the developmentally disabled.

5. Conduct research to determine the maximum reasonable distance between rest areas along the horizontal walkway.

6. Reevaluate the slope, rise, and edge protection requirements for ramps.

7. Study the shape and size of stair nosing and the use of open risers as factors in stair safety.

8. Determine the appropriate location and operating characteristics of platform lifts.

9. Conduct additional research on elevators to determine minimum cab size, location of hall lanterns, the need for and location of handrails, and the use of raised vs. recessed controls.

4.0 CURRENT NBS RESEARCH ON BUILDING ACCESSIBILITY

4.1 TECHNICAL APPROACH

Building effectiveness for the handicapped may be evaluated by examining the relationships between the needs of the disabled individuals and building characteristics. The needs of handicapped people are influenced by 1) necessary activities or tasks, 2) capabilities that can be applied to tasks, and 3) the frequency and nature of the activities. A building can be evaluated as part of a building complex, as a single entity in itself, according to its inherent parts or elements--doors, corridors, or elevators and finally by the materials that form those elements. The test of building effectiveness is the efficiency of the building and its parts in supporting the activities of handicapped as well as able-bodied people in both routine and emergency use.

At the present time many handicapped accessibility requirements appear in standards without corresponding objective criteria or replicable test methods to determine compliance. Examples include requirements for alerting of the handicapped and for non-slip walking surfaces, where criteria to evaluate success are absent. Likewise, meeting the needs of the handicapped is not likely to be done if society finds the price onerous. Cost-effective choices must be made where cost refers not only to fiscal outlay but also to the costs of inconvenience to the able-bodied. Thus, rational methods are required for use by designers and policy-makers in making choices among candidate technologies.

The role of NBS is to provide an adequate technical basis for criteria and test methods intended to improve handicapped accessibility. In all of these categories the research must reach basic and fundamental aspects of the problem to provide the necessary technical soundness lacking in existing handicapped requirements.

4.2 GOALS AND OBJECTIVES

NBS Planning Report No. 4 Measurement Standards for the Handicapped, outlines the NBS role in research and development relating to the needs of disabled individuals [8].

The National Bureau of Standards has a strong supporting role to play in the development of a coherent Federal research and development effort for disabled individuals. The primary NBS role will be to contribute traditional Bureau services that are requested and funded by the Federal agencies that have specific mandates in this area and to coordinate these contributions with the NIHR.

In building technology, the current approach to accessibility and safety for disabled individuals emphasizes the evaluation of the accessibility of individual building components such as doors, ramps, and surfaces. This research will 1) enhance the usefulness of buildings to the handicapped during routine activity, 2) reduce the risk of accidents in buildings 3) determine the requirements for escape or refuge to the handicapped during emergencies, and 4) evaluate the

economics of effective accessible designs that benefit both the handicapped and the able-bodied at reasonable expense.

The longer term goal is to develop methods and mechanisms for a system-wide assessment of building and site accessibility and safety. This will be achieved by considering critical functional aspects of the user/environment and user-user interaction during routine as well as emergency use of buildings. For example, building modifications to accomodate individuals with a particular disability should not be implemented in a way which decreases the useability of the building by individuals who are able-bodied or have a different disability.

Research thrusts follow from an examination of what people need to do in buildings. To achieve a satisfactory interaction during routine use, the disabled must be able to safety arrive, enter, negotiate and leave a building without excessive physical, mental or emotional strain. During an emergency, provisions must be made for the disabled to either safely exit the building, or find safe refuge therein. These functions can be portrayed in a sequential chart as shown in Figure 2, which contains critical elements that must be considered to ensure handicapped accessibility by the handicapped.

A detailed research plan is being prepared to elucidate research needs of both routine as well as emergency tasks of the handicapped. At the present time critical thrusts are planned to deal with accessibility issues identified during the two conferences discussed in this report. These initial research thrusts are discussed in the following section.

4.3 INITIAL RESEARCH THRUSTS

The purpose of delineating early research thrusts is to ensure that the early work both addresses the major concerns of other Federal agencies as well as defines the more basic and fundamental long term aspects of the accessibility problem. In addition, the quality of the long range research planning is enhanced when initial work is so focused. By integrating the critical issues of previously related conferences and fact finding activities, the essential thrusts of fire egress/refuge, building entry, walking surfaces, communications, and movement models were defined. These thrusts accommodate the problems of greatest concern, at the same time providing a framework with which to organize specific research projects.

4.3.1 Building Entry

The major objective of this thrust is to develop quantitative test methods and performance criteria for forces (opening, closing and latching-unlatching forces) required to operate doors.

Every building user must interact with the door. Doors have multiple functions (security, life safety, privacy, environmental and climatic control) which are addressed by door design, location, type and hardware. Conflicts between door functions have often been resolved in a way that creates accessibility problems

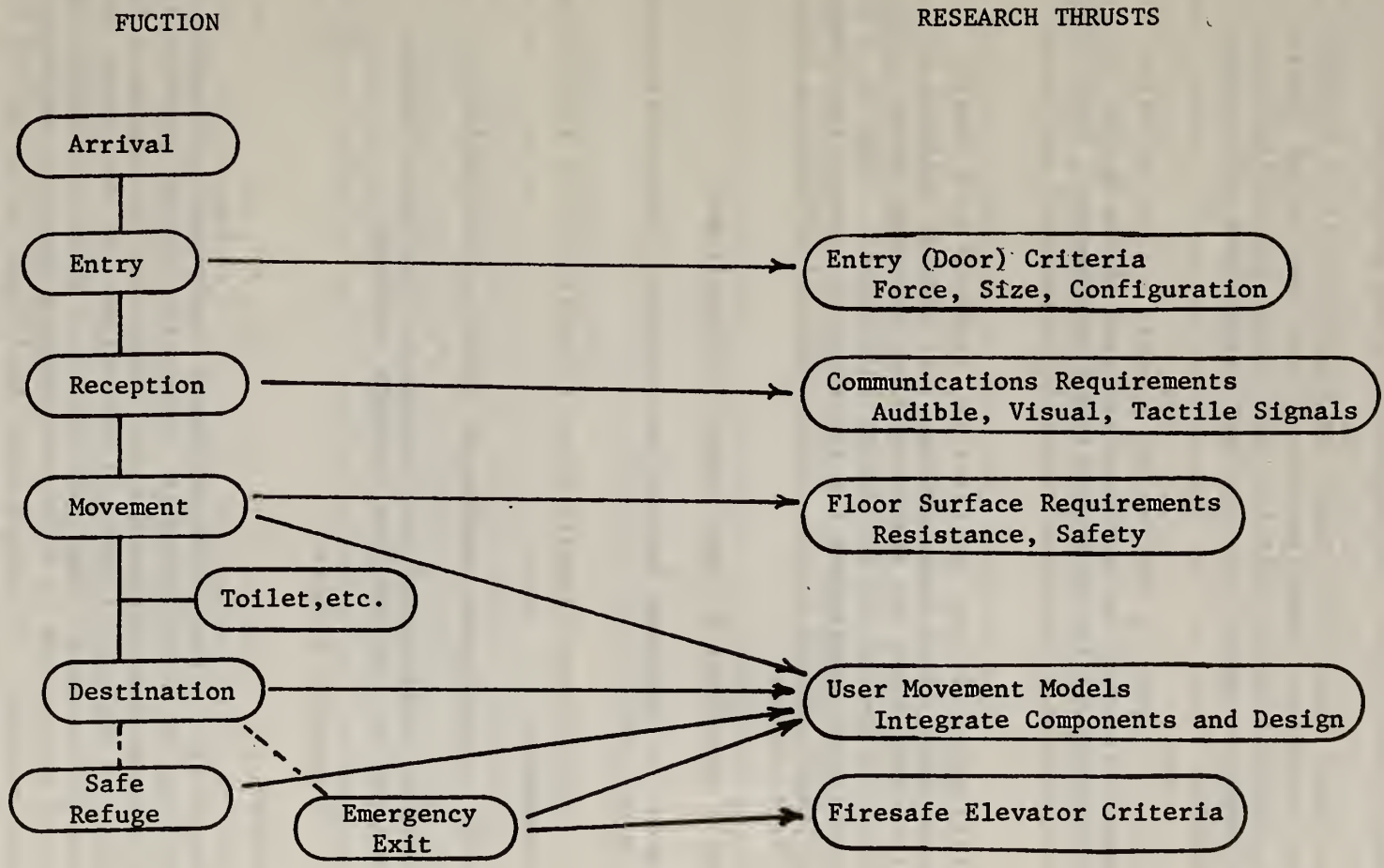


Figure 2. User Functions Versus Research Thrusts

for people with movement disabilities. These problems can be addressed by integrated analytical studies of door opening and closing technology, ergonomic measurement of human capabilities, and the study of door use patterns. [18]

Presently used and likely future door operating hardware will be assessed, including field and laboratory investigations of door opening and closing forces, distances, temporal characteristics, and design and configuration practices that influence accessibility. Current regulations will also be identified and evaluated.

To better understand corresponding user needs, generic characterization of relevant human capabilities will be developed and used in the design of instrumentation and procedures for measuring human performance. Pilot tests for ergonomic classification will be conducted with a selected sample of volunteers.

An analysis and field study of door use patterns, combined with limited ergonomic testing and basic field measurements, will also be utilized to develop portable instrumentation for measuring door operating forces. This will provide an efficient method for regulatory enforcement. Finally, a laboratory will be designed and constructed for the study of interactive forces (wind, racking, setlement, closer thrust, pressurization) influencing door opening/closing effectiveness.

The initial work will contribute to such longer term goals as:

1. Preliminary model of door/user interaction including force, distance and temporal characteristics.

2. Development of a laboratory capability for investigation of interactive door force parameters.

3. Test methods for critical door opening and closing characteristics.

4. Provide performance criteria and test methods to cognizant standards committees as basis for revised door assembly standards.

5. Design Guide for Accessible Doors.

4.3.2 Walkway Surfaces

The major objective of this thrust is to delineate fundamental mechanisms of handicapped movement and surface-prosthetic interaction related to handicapped locomotion as well as the characterization of friction and resistance to wheeled movement resulting in an analytical model of mechanism/floor and energy transfer. Two topics are important in this thrust, the safety of persons encountering slippery surfaces and the success of those encountering dense or resistant surfaces that impede movement. To ensure safer buildings, measuring the slip resistance and other characteristics of crutch and similar devices on a variety of walkways surfaces is required under laboratory and field conditions. A test methodology to characterize the slip and trip potential on non-smooth surfaces

and the interface between adjacent but different walkway surfaces is also required. To ensure more useful buildings, an analytical model to predict the resistance of walkway surfaces to movement by people using wheelchairs, and the determination of floor surface characteristics which affect the free movement of people with gait irregularities or who use crutches, braces, or canes is required. The mobility and manipulative capabilities and limitations of persons with handicaps will be assessed and ergonomic measures of human movement established to assist in test method and performance criteria development for building systems. Proposed requirements will be viewed to assure that solutions for the disabled do not unfavorably affect the fully ambulatory.

The work will also result in performance tests to evaluate candidate floor surfaces relative to movement needs of the handicapped and design guidelines to assist in making optimal decisions on flooring materials.

Among expected milestones for long term research are:

1. Develop a model of user/surface interaction including critical physical parameters related to disability and floor surfaces.

2. Report laboratory and field studies to characterize slip resistance, bulk resistance, and other conditions of representative flooring.

3. Provide draft performance test methods for wheelchair movement, slip resistance, and bulk and trip resistance, to cognizant standards bodies.

4. Develop a design guideline for movement surfaces.

4.3.3 Building Communications

The major objective associated with this thrust is to develop methods to quantify, predict and validate the effectiveness of acoustical signals, visual signals, and tactile signals for handicapped communication in emergencies and for routine use in buildings by identifying threshold levels for signal detection, recognition and understanding, by developing methods for evaluating candidate signals for ability to propagate or communicate in normal and emergency building environments, and by developing guides and performance draft criteria for signals.

The effort must begin to identify and fill knowledge gaps in building signaling technology and recommend criteria for evaluating the effectiveness of signals that provide information and alarm to handicapped and non-handicapped building occupants. The investigation and analysis includes classification of the special needs of the handicapped, identification of threshold levels of signals that can be perceived by the handicapped, documentation of building practices and equipment now in use, and the development of methods to evaluate existing buildings for signaling retrofit.

Based on the handicapped needs and other technical data, laboratory and field testing will identify required signal levels, signal spectra, temporal characteristics of signals, masking, and environmental decrements of signal effectiveness.

For routine building use, the signal must provide information for direction finding and location and movement in the building. In emergency situations, building users must addtionally be able to activate an alarm system or be alerted to an emergency, and be informed of actions they must take to provide for their own safety.

Finally, conflicts between needs of handicapped building users and overall solutions that might degrade the safety or required activity of any other user group will be identified.

Among milestones that are associated with this thrust are:

1. A review of the technical literature on psychophysical capabilities of the handicapped.

2. A field investigation to characterize spectral, visual, temporal and physical parameters of signals.

3. Development of preliminary design criteria for communications devices.

4. An analysis of representative building configurations and signaling situations, prepare methodologies for full scale testing of signals in selected sensory modalities.

5. Completion of full scale field testing of candidate signals for new and existing buildings, based on newly developed performance criteria for signals.

6. Completion of to complete a design guide, including criteria and test methods, to verify in-situ performance of signaling systems.

4.3.4 Movement Models and Cost-effective Accessibility Designs

The major objective of this thrust is to develop scenarios for simulation models to evaluate handicapped persons' accessibility and evacuability in candidate building configurations, and to determine the cost-effectiveness of building retrofit and new construction options. Retrofit of existing buildings is by far the greatest challenge, both from a design and a cost perspective. However, making the large number of existing buildings accessible provides a greater near-term benefit than making new buildings accessible.

Computer simulations of pedestrian behavior in buildings and sites are useful in evaluating alternative design configurations in response to anticipated patterns of building use. Simulations are a cost effective way to compare many design options for possible use in new construction or building rehabilitation. Developed initially to simulate fire evacuation actions of the able-bodied, the concept will be expanded to include characteristics of handicapped building occupants.

This will require developing the capability to model special needs and capabilities of handicapped persons, interactions between handicapped and non-

handicapped building occupants, and interactions between occupants and components of the physical environment. Resulting models will simulate spatial negotiation, an essential dynamic process which underlies building configuration planning.

Impairments to perceptual, cognitive and general capabilities are known to affect spatial negotiation. Consequently the simulation of impaired spatial behavior under realistic scenarios will be extremely useful for the evaluation of candidate building configurations and for corresponding cost/benefit analyses of building design options.

Likewise, cost/benefit methodologies required to evaluate efficient design decisions have received little attention at this time, yet are critical to optimization of accessible design. Basic concepts are required for the evaluation of benefits related to design options.

Finally, codes and standards represent the primary agent for dissemination of improved accessibility requirements. Presently, wide variations exist in both procedures for applying new provisions to building rehabilitation as well as in the actual technical provisions. Field investigations and case studies of the problems encountered in applying accessibility provisions to existing buildings are required, as well as the development of a methodology for the acceptance of alternate approaches where new requirements cannot be achieved.

Among the expected milestones are:

1. a model of perceptual, cognitive and motor behavior applicable to analyzing spatial negotiation by handicapped persons,

2. prototype computer simulation programs derived from the theoretical model,

3. a demonstration project evaluating the simulation's applicability from architectural, safety, and economic viewpoints,

4. a cost/benefit methodology for the evaluation of alternative accessiblity design options,

5. recommendations and alternatives for the "use provisions" in standards and codes.

4.3.5 Fire Egress/Refuge

The major objective of the initial work in this thrust includes the development of an analytical model for predicting smoke distribution in elevator shafts and publication of a guide for smoke control design to permit safe use of elevators by handicapped in a fire emergency. This will be accomplished by conducting full scale studies of smoke movement, measuring leakage coefficients in doors and shaft walls, both in the laboratory and in the field, and by developing a mathematical model from physical principles which will predict the effect of pressure distribution on smoke movement.

The handicapped person in a building is at a disadvantage during a fire emergency if he or she lacks mobility. The normal person has the use of stairways which are located at prescribed maximum distances according to building regulations. The person with limited mobility may not be able to use the stairways and needs an alternate method of evacuation. This problem has been highlighted by the requirements that public buildings be made accessible to the handicapped. With the provision for access to the handicapped, adequate provision must also be made for their evacuation in case of emergency.

One viable method for moving the handicapped vertically is the use of the elevators in the building. In the past, the elevators have not been allowed for emergency use since current design practices allow smoke to collect in elevator shafts, rendering the elevators useless for evacuation. Design criteria to keep smoke out of the elevator shaft, or to provide a control system insulated from the effects of the fire, would provide the handicapped with a means of evacuation when they cannot use the stairs. This requires the develop of criteria for smoke control in the elevator shaft.

An analytical model will be developed as the base for designing a smoke-free elevator shaft. This development will include: field studies to determine smoke distribution in actual building elevator shafts; the development of a mathematical model for predicting pressurization distribution and smoke movement in elevator shafts; the development of information on the leakage coefficients in shaft walls, the elevator and vestibule doors; and the development of design criteria for building a smoke-free elevator shaft. Such a guide would be based on the model which has been developed and would evaluate such issues as vestibules, automatic closing doors, pressure differentials within the building, stack effect, and other items which would affect the smoke-free integrity of the elevator shaft.

Among milestones that may result from the long term effort are:

1. Development of an analytical model of smoke movement in elevator shafts.

2. tests of elevator and vestibule doors as smoke barriers.

3. verification of an analytical model of smoke movement in elevator shafts, and

4. the development of a design guide for fire safe elevators.

5.0 CONCLUSION

The NBS has conducted long term research in the effectiveness, safety and economy of buildings for many decades. Recent work has resulted in a better understanding of the interaction of both able-bodied and handicapped persons with buildings. Safety on stairs, walkways, and around doors has been reported. Fire egress models and parameters have been established. Design optimization methods have been promulgated that improve the basic fire safety of buildings. Architectural safety glazing has been evaluated and standards improved. The movement of people in both public and private settings have been investigated and models and simulations of movement have been developed. Investigations regarding human ergonomics as well as psychophysical characteristics have defined the needs and capabilities of building users.

NBS has participated in the development of a research agenda and the definition of accessibility research needs by co-sponsoring conferences of experts to determine the pressing issues related to the handicapped in both a routine building use situation and during an emergency. From these sessions many critical weaknesses in the technical foundation of existing accessibility knowledge were identified. It was determined that many of our existing standards for fire and routine building use largely ignore the handicapped and that a corresponding intensive research effort is required to correct this shortfall.

NBS is addressing these issues. At the onset, certain critical issues have been grouped according to research thrusts. Preliminary work has begun to further define research needs. This approach provides the guidance and direction for determining fundamental and basic research needs, while at the same time developing a preliminary understanding of the most pressing existing impediments to the handicapped.

Specific research thrusts include:

1. the impediment to the handicapped of entryways and the corresponding forces, configurations and designs that presently compound accessibility at entries,

2. the investigation of movement impediments caused by walking surfaces, either slippery or bulky,

3. the investigation of communications needs of the handicapped in both routine and emergency situations,

4. the evaluation of movement models that represent the successful negotiation of the handicapped in buildings and the corresponding cost/benefit and standards improvement optimizations, and

5. the evaluation of fire egress and refuge alternatives, with mutual emphasis on fire-safe elevators.

While there are many statements of technical needs, there is not yet a consensus on national priorities for the application of science and technology for disabled people [8]. At present, NBS is developing research programs based on direct participation with researchers in this area and on close cooperation with the Federal agencies that have mandates to provide for the assessibility needs of the disabled.

Development of a basic and fundamental knowledge of the interaction between a disabled user and the built environment will form the basis of improved standards and provide a rational tool for the design of move cost-effetive buildings.

REFERENCES AND BIBLIOGRAPHY

1. Accessibility: An Approach to the Development of Design Criteria. Washington: Building Research Advisory Board, National Academy of Sciences, 1977.

2. Accident Facts. Chicago: National Safety Council, 1979 (Published annually).

3. Adler, Sanford C. and Pierman, Brian C. A History of Walkway Slip-Resistance Research at the National Bureau of Standards. Washington: National Bureau of Standards, December 1979 (NBS Special Publication 565).

4. ANSI A117.1-1980. Specifications for Making Buildings and Facilities Accessible to and Useable by Physically Handicapped People. New York: American National Standards Institute, 1980.

5. Archea, John; Collins, Belinda L. and Stahl, Fred I. Guidelines for Stair Safety. Washington: National Bureau of Standards, May 1979 (NBS Building Science Series 120).

6. Barrier-Free Design: The Law. New York: Eastern Paralyzed Veterans Association, 1976.

7. Berendt, Raymond D.; Corliss, Edith L. R. and Osalvu, Morris S. Quieting: A Practical Guide to Noise Control. Washington: National Bureau of Standards, July 1976 (NBS Handbook 119).

8. Bunten-Mines, Elaine, Planning Report No. 4: Measurement Standards for the Handicapped. Washington, National Bureau of Standards, November 1980.

9. Building Technology Publications, Washington: National Bureau of Standards, 1976 (NBS Special Publication 457, with annual supplements).

10. Design for All Americans. Washington: D.C. National Commission on Architectural Barriers, 1968.

11. First Report to the Congress of the United States. Washington: Architectural and Transportation Barriers Compliance Board, November 1974.

12. Glass, R. and Ruben, A. Fire Safety in High Rise Buildings: Role of Communications, Washington, D.C., National Bureau of Standards, April 1979 (NBS Building Science Series 115).

13. Goldsmith, Selwyn. Designing for the Disabled. London: RIBA Publications Ltd., 1976.

14. Harkness, Sara P. and Groom, James N. Building Without Barriers for the Disabled. Cambridge, Mass.: Architects Collaborative, 1976.

15. Jason, Nora H. Fire Research Publications. Washington: National Bureau of Standards, 1979 (NBSIR 80-2114: issued annually).

16. Jones, M. A. Accessibility Standards Illustrated. Springfield, Ill.: National Capital Development Board, State of Illinois, 1978.

17. Levin, B. M., Ed. Fire and Life Safety for the Handicapped. Washington: National Bureau of Standards, July 1980 (NBS Special Publication 585).

18. Margulis, Stephen T. Building Accessibility in Relation to Door Hardware, Door Users, and Door Use. Washington: National Bureau of Standards, January 1981 (NBSIR 80-2174).

19. Morgan, Michelle. "Beyond Disability: A Broader Definition of Architectural Barriers," AIA Journal. Washington: American Institute of Architects, May 1976.

20. NBS List of Publications 85: Consumer Product Technology. Washington: National Bureau of Standards, August 1977.

21. Pallett, David S.; Wehrli, Robert; Kilmer, Roger D. and Quindry, Thomas L. Design Guide for Reducing Transportation Noise in and Around Buildings. Washington: National Bureau of Standards, April 1978 (NBS Building Science Series 84).

22. Public Law 95-602: Rehabilitation, Comprehensive Services, and Developmental Disabilities Amendments of 1978 (1978).

23. Steinfeld, Edward et al. Access to the Built Environment: A Review of the Literature. Washington: U.S. Department of Housing and Urban Development, April 1979 (HUD-PDR-405).

24. Wolfensberger, Wolf. "The Normalization Principle, and Some Major Implications to Architectural-Environmental Design," Barrier Free Environments. Edited by Michael Bednar. Pennsylvania: Dowden, Hut chison and Ross, 1976.

25. Yaniv, Simone L. and Flynn, Daniel R. Noise Criteria for Buildings: A Critical Review. Washington: National Bureau of Standards, January 1978 (NBS Special Publication 499).

Appendix 1

NBS Accessibility Standards Evaluation Team*

Mr. Sanford Adler
Research Engineer

Dr. Belinda Collins
Research Psychologist

Dr. Neil Lerner
Research Psychologist

Dr. Stephen T. Margulis
Research Psychologist

Mr. Brian Pierman
Group Leader

Mrs. Ana Salazar
Secretary

Dr. Fred Stahl
Group Leader

Mr. John Stroik
Research Architect

* All team members are in the Environmental Design Research Division of the Center for Building Technology, National Engineering Laboratory, National Bureau of Standards.

Appendix 2

Documents Reviewed for NBS/ATBCB Conference

Basic Reference Document

1. [Proposed] ANSI A117.1 (1979) Specifications for Making Buildings and Facilities Accessible to and Usable by Physically Handicapped People.

Federal Agency Documents

2. General Services Administration

   U.S. General Services Administration, Public Buildings Service, Design Criteria: New Public Building Accessibility, Washington, D.C.: Government Printing Office, December 1977.

3. Postal Service

   U.S. Postal Service Real Estate and Buildings Department, United States Postal Service Standards for Facility Accessibility for the Physically Handicapped, Washington, D.C.: Government Printing Office, June 27, 1979.

4. Department of Defense

   U.S. Department of the Army, Office of the Chief of Engineers, Design for the Physically Handicapped, Manual No. 1110-1-103, Washington, D.C.: Government Printing Office, October 15, 1976.

5. Department of Health, Education and Welfare

   U.S. Department of Health, Education, and Welfare, Office of Facilities Engineering, Technical Handbook for Facilities Engineering and Construction Manual: Part 4 - Facilities Design and Construction, Washington, D.C.: Government Printing Office, August 1978.

State Documents

6. Illinois (IL)

   State of Illinois Capital Development Board, Accessibility Standards Illustrated, by M. A. Jones, Springfield, Illinois: The Capital Development Board, June 1978.

7. Massachusetts (MA)

   Commonwealth of Massachusetts, Department of Public Safety, Rules and Regulations of the Architectural Barriers Board, May 3, 1977.

8. Michigan (MI)

   The University of Michigan, The Office of Disabled Student Services, Barrier Free Design: A Design Manual
   Code, by G. Selim, Ann Arbor: The University of Michigan, 1977.

9. Minnesota (MN)

   Kiewel, H., and Salmen, J., Accessible Architecture: An Illustrated Handbook Based on Minnesota State Building Code, 1977.

10. New Hampshire (NH)

    State of New Hampshire, Governor's Commission for the Handicapped, The Architectural Barrier Free Design Code for the State of New Hampshire, 1978.

11. New Jersey (NJ)

    State of New Jersey, Department of the Treasury, Division of Building and Construction, Barrier-Free Design Regulations (For Providing Facilities for the Physically Handicapped in Public Buildings), 1977.

12. North Carolina - New Construction (NCN)

    State of North Carolina, Governor's Study Committee on Architectural Barriers and the North Carolina Department of Insurance, An Illustrated Handbook of the Handicapped Section of the North Carolina State Building Code, by R. I. Mace, 1974.

13. North Carolina - Rehabilitation (NCR)

    State of North Carolina, North Carolina Special office for the Handicapped, Department of Insurance, Accessibility Modifications: Guidelines for Modifications to Existing Buildings for Accessibility to the Handicapped, by R. I. Mace, Barrier Free Environments, 1976.

14. Ohio (OH)

    Ohio Governor's Committee on Employment of the Handicapped and Schooley Cornelius Associates, Access for All: An Illustrated Handbook of Barrier Free Design for Ohio, 1977.

15. Texas (TX)

    The University of Texas System, Office of Facilities Planning and Construction, Senate Bill No. 111 - Guidelines, by E. E. Farrera, September 1973.

16. Utah (UT)

Utah State Building Board, Planning and Design Criteria to Prevent Architectural Barriers for the Aged and Physically Handicapped, by E. H. Johnson, Fourth Edition, 1978.

17. Washington State (WA)

Small, Robert and Allan, Barbara, An Illustrated Handbook for Barrier Free Design: Washington State Rules and Regulations, 1976.

Foreign Documents

18. Australia (AU)

Standards Association of Australia, Australian Standard 1428-1977: Design Rules for Access by the Disabled, North Sydney: Standards Association of Australia, 1977.

19. Canada (CA)

National Research Council of Canada, Associate Committee on the National Building Code. Building Standards for the Handicapped 1977, Ottawa, Canada: National Research Council of Canada, 1977.

NBS-114A (REV. 2-8C)

U.S. DEPT. OF COMM. **BIBLIOGRAPHIC DATA SHEET** (See instructions)	1. PUBLICATION OR REPORT NO. NBSIR 81-2245	2. Performing Organ. Report No.	3. Publication Date March 1981

4. TITLE AND SUBTITLE

Accessible Buildings for the Disabled: A Review of Current Research Needs

5. AUTHOR(S)

Sanford C. Adler, Brian C. Pierman

6. PERFORMING ORGANIZATION (If joint or other than NBS, see instructions)

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20234

7. Contract/Grant No.

8. Type of Report & Period Covered

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (Street, City, State, ZIP)

10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

This report traces the evaluation of public policy on accessible environments; discusses the need for development of a research basis for the design of accessible buildings including accessibility standards for both new and existing buildings, summarizes the results and research recommendations of both the Conference on Fire Safety for the Handicapped held at NBS on November 26-29, 1979 and the joint ATBCB/NBS Conference on Accessibility Guidelines held in Bethesda, Maryland on October 31 - November 1, 1979, and presents an overview of current NBS accessibility research plans.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

Accessibility; Building accessibility; building research; fire safety; handicapped; life safety.

13. AVAILABILITY

☒ Unlimited

☐ For Official Distribution. Do Not Release to NTIS

☐ Order From Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

☒ Order From National Technical Information Service (NTIS), Springfield, VA. 22161

14. NO. OF PRINTED PAGES

43

15. Price

$6.50