THE DISABLED PEDESTRIAN: HUMAN FACTORS

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1972

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1973

submitted in partial
fullfilment of the
requirements for the
degree of
MASTER OF CITY PLANNING

June 1974

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PREFACE

This thesis, The Disabled Pedestrian: Human Factors is an attempt to identify and focus on the issues associated with those persons who are mobility impaired. The intent, however, is to help fill the broad gap that exists in the knowledge about the physical nature of the disabled and their interaction in the planning and design of street spaces for comfortable and convenient use. At present, there seems to be a great need for more data and information concerning external environments for the disabled in order to facilitate integration. This project is to try to put together data on what has, is and should be done and to try to work out some directions for requirements enabling disabled persons greater mobility as pedestrians.

Firstly, it is a misnomer to consider the disabled an all encompassing homogeneous group. For this study it was necessary to establish a set of principles which addressed the mobility limiting problems of the disabled pedestrian. According to the nature and extent of the disability the following distinctions can be made:

- Ambulant disabled people whose power of locomotion is not restricted by external aids but whose mobility may be impaired by old age, which affects strength, heart rate, vision, hearing and psycho-motor capabilities.
- Semi-Ambulant disabled people whose power of locomotion seriously restricted by canes, crutches, and other walking aids, tripods and wheel frames. Thus a need for vertical security carries a balance problem during mobility.
- Non-Ambulant disabled people whose power of locomotion is so impaired that they are restricted to wheelchairs and the use of arm power. Also their seated position affects their visual and motor ranges.

Since it is very difficult to adjust the accessibility and serviceability of the pedestrian environment to the requirements of each and every

different form of disability, the scope of this thesis will be to optimize performance criteria for pedestrain environments to include those independent or who could be made independent disabled persons within the full spectrum of a maximizing percentile, i.e., 90% of the persons catagorized above.

Chapter one focuses on the concept of human factors and its application in the process of developing a model for man/environment interaction.

Chapter two focuses on the who and how many disabled pedestrians there may be.

Chapter three analyzes the concept of mobility and its human costs -- energy, capabilities, and limitations.

Chapter four which is divided into two sections, actually explains the human factors both on the subjective and technical level. It gives some insight into some of the physiological and psychological factors of disability that affect the planning and design of pedestrian spaces.

Chapter five translates the human factor elements into a rational environmental operational standards manaul for pedestrian spaces.

Finally the pictorial appendix is easy to handle and still contains the most essential data. I have concentrated on the requirements of the disabled person and basic data for freedom of movement which can be obtained from the sketches containing information on dimensions and motor and sensory zones of the disabled persons.

Thesis Supervisor: John A. Steffian
Title: Associate Professor of Architecture

INTRODUCTION

The Disabled Pedestrian

Fruin notes the disabled pedestrian as follows:[1]

An estimated 12 million persons in the United States have serious disabilities which limit their mobility and the activities and work that they do. The seriously disabled include 500,000 wheelchairs, 2 million orthopedically impaired children, and 5 million cardiac cases.

Each year 100,000 children are born with birth defects that will force them to use crutches, braces or wheelchairs for the rest of their lives. In addition to serious disabilities, many millions are limited by age induced phenomena or by minor sight deficiencies or other physical impairments which limit their locomotive capabilities. Added to the ranks of permanently disabled persons (pedestrians) are persons temporarily disabled due to accidents, persons encumbered with baby carriages, heavy baggage or packages, and women labored in pregnancy. The ranks of the disabled have been expanding much faster than the general population growth because:

- medical advances have decreased the number of accidental deaths, thus increasing the number of disabled
- longer average life spans have increased the number of aged and infirmed;
- more leisure time, greater personal mobility and expanded opportunities for recreation have increased accident exposure for all persons.

Because of thoughtless architectural barriers, many of those persons

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[1] Fruin, John J., Pedestrian Planning and Design, Metropolitan Associates of Urban Designers and Environmental Planners, Inc., Church St. New York, New York, Box 722.

have been denied opportunities for education, employment, and recreation. Although they comprise a large segment of the public, they have been denied access to many "public" places, building and transit systems. This has relegated many of the aged and disabled to the status of disenfranchised citizens, denied the use of streets, free access to courts, polling places or public educational and cultural institutions. There are instances where the disabled is a handicapped citizen unable to attend court to attend their own interests. At best, they are often required to use freight elevators, facilities commonly used for refuse removal. The common barriers to the aged and handicapped include: steps or curbs that are too high, long flights of stairs; inaccessible elevators; steep and narrow walks; gratings in walkways; doors that are too narrow, revolve or are hard to open; too narrow aisles in theatres, stations, and other public gathering places; and lack of accommodation for wheelchairs. In addition, little if any consideration has been given to improving the mobility and safety of the blind and partially sighted, by supplementary auditory or tactile means. Needless to say, every effort should be made to improve the personal mobility and quality of life for these persons subjected to daily hardships connected with their disabilities. Furthermore, improvements made for the aged and the disabled are improvements which ease the mobility for all.

This qualitative design of a pedestrian environment for the disabled requires a basic understanding of the related human characteristics and human capabilities -- an analysis of human factors. The physical dimensions of their body and mobility aids determine working widths of doorways and passageways, and affect the practical capacity on stairs and walkways. Psychological (subjective data) preferences of bodily contacts with others is a determinant of inter-person spacing in gueuing and other crowded pedestrian environments. Normal human locomotion involves many complex characteristics of balance, timing and even human sight, imagine just how difficult this movement must be for those with disabilities. Natural free-speed locomotion requires spacial components for pacing and for human sensing and reaction. Human locomotion exhibits difficult characteristics on different surfaces, on level surfaces, and on stairs, with the latter requiring much more expenditure of energy and attention to design because of safety. The perception of urban space is related to its coherence of expression. Confused spacial design lowers human receptivity to aesthetics and other secondary visual inputs.[1]

Insufficient considerations of disabled human space requirements has resulted in inadequate design of many areas where pedestrians may be required to circulate. Different environments logically require the application of different qualitative , as well as quantitative, design standards. The pedestrian design rationale for shopping areas would not apply to transportation terminals and it follows that airport terminal standards would not directly apply to rapid transit facilities. Each has its' own traffic patterns, physical restraints and individual environmental requirements, but underlying each is a human performance factor essential to the individual performance of disabled users. To date no evaluation or consideration

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[1] Fruin

of these human conveniences have been made. Since human convenience is a primary consideration in environmental design, pedestrian design standards must be based on a relative scale of this factor.

In analyzing the pedestrian environment for the disabled outlined from the following (next sheet) outline of the pedestrian planning process are the factors and variables which this thesis needs to take into account in consideration of a human factor application of disability to pedestrianism. One may notice we are only concerned with the actual physical qualities, be they man or environment in determining the capabilities and limitations affected in a man/environment interaction. The project deals with the general objectives of a disabled pedestrianism improvement program, studying procedures and techniques and some methods of plan implementation.

The following pages of matrices and outlines detail the performance criteria, within the full spectrum of the pedestrian environment that this thesis attempts to analyze and evaluate in regards to the disabled pedestrian.

ENVIRONMENTAL FRAMEWORK

Pedestrian Environment	Environment Elements		Environmental Inventory	
	Corridor	Movement Pattern	Intensity of Path	Road surfaces, slopes, gradient, percent and degree
			Choice of Route	width,length,time,signing - directional,situational,functional,locational,auxilliary
Circulation Planning Edge Vegetation Landform Building	Interchange	Nodal Elements	Supports	squares,blockspace,parks,mini-par plaza,malls,turn lots, informatic centers,public transit stop
	Interaction	Distribution of Generators	Terminal area Supports Decision Points	coordination of major links along networks interrelated location of major generators
	Banking	Vehicle Storage	internal external enclosure	Major Parking Lots
Urban Design View Panorama Feature Enclosed Focal	Intermittent Components	Identifiability	supports	development of landmarks,accentuation of distinctive or unique architectural of typographic features
		Incidental Activities	supports	street functions - benches,kiosk, sidewalk stands, impediments display - bus stop,vendors,billboards,newstand,
Elements Intrinsic (already standing) Dependent (direct result of pedestrian path)		Visual Diversity	supports	sidewalk features - graphics,sign posting,telephones,fireplugs, mailboxes,trash receptacles, planting,lighting,traffic control devices

User Requirements	Environment Sub-System Components	open space	intensity of path	choice of route	parks	squares	places	malls	transit stops	linkages	routine coordination	sidewalk furniture	traffic device signs	signing	lighting	benches	concession area	vendor	newstand	kiosks	materials handling	air control	air temp	surfacing materials	windows	doors	roofs	storage system	energy sources	energy distribution	space dividers	exterior walls	communication system	information system
conditioned air																																		
illumination	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●				●									●	●
acoustics	●		●	●									●																				●	
stability																																		
durability																																		
reliability	●																																	
health	●	●	●	●					●			●	●		●	●								●										
safety	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●								●										
activity support	●	●	●	●	●	●	●	●	●			●	●	●	●	●	●	●	●	●				●									●	●
work efficiency	●	●	●	●	●	●	●	●	●	●		●	●		●	●								●										●
maintainability																																		
esthetics																																		
waste management																																		
potable water																																		
food handling																																		
communications	●		●	●	●	●	●	●	●	●			●	●			●	●	●	●				●									●	●
adaptability	●	●	●	●	●	●	●	●	●				●			●								●									●	●
accessibility	●	●	●	●	●	●	●	●	●								●	●	●	●				●									●	
azotic quality																																		
queuing space	●		●	●				●	●	●		●	●			●	●	●	●	●				●										●
orientation	●	●	●	●	●	●	●	●	●			●	●	●	●	●	●	●	●	●				●									●	●
security	●	●	●	●				●	●	●		●	●		●	●	●	●	●	●				●									●	●

The Projects Focus within the full spectrum of the Pedestrian Environment

	Reconnaisance Study	Safety	Security	Convenience	Continuity	Comfort	System coherence	Attractiveness	Land Use	Origin	Destination	Trip generation	Travel system	Traffic volumes	Tickets	Laws and Finance	Costs	Benefits	Financing	Meeting goals	Objectives	Reports	Meeting	Implementation	Schedules	Financing	Operation
Define Goals	●	●	●	●	●	●	●																				
Objectives	●	●	●	●	●	●	●																				
Standards	●	●	●	●	●	●	●																	●			
Study Design		●	●	●	●	●	●		●																		
Inventory									●																		
Data collection									●																		
Analysis									●																		
Forcast									●																		
Alternative plans																								●			
Presentation																								●			
(approval) community																											
Plan selection																								●			
Design phase																											

The projects focus within the full spectrum of the Pedestrian Planning Process

	Transit	Auto	Taxi	Walk	Walk time	Save face	Walk reliability	Fatigue	Handicaps	Exercise	Comfort	Others	Work	Shop	Business	Cultural	Social	Other	Terrain	Walking distance	Traffic signal delay	Energy outputs	Image interest	Weather protection	Security	Other	Office	Store	Industrial	Theatre	Museum	Government	Historical	School	Residential	Other
Start Node				●	●																															
Mode of Arrival				●	●																															
Personal variables				●		●	●	●	●	●	●	●																								
Trip purpose				●																																
Path variables				●															●	●	●	●	●	●	●	●										
Hand use				●																																
End Node				●																																

The projects focus within the full spectrum of

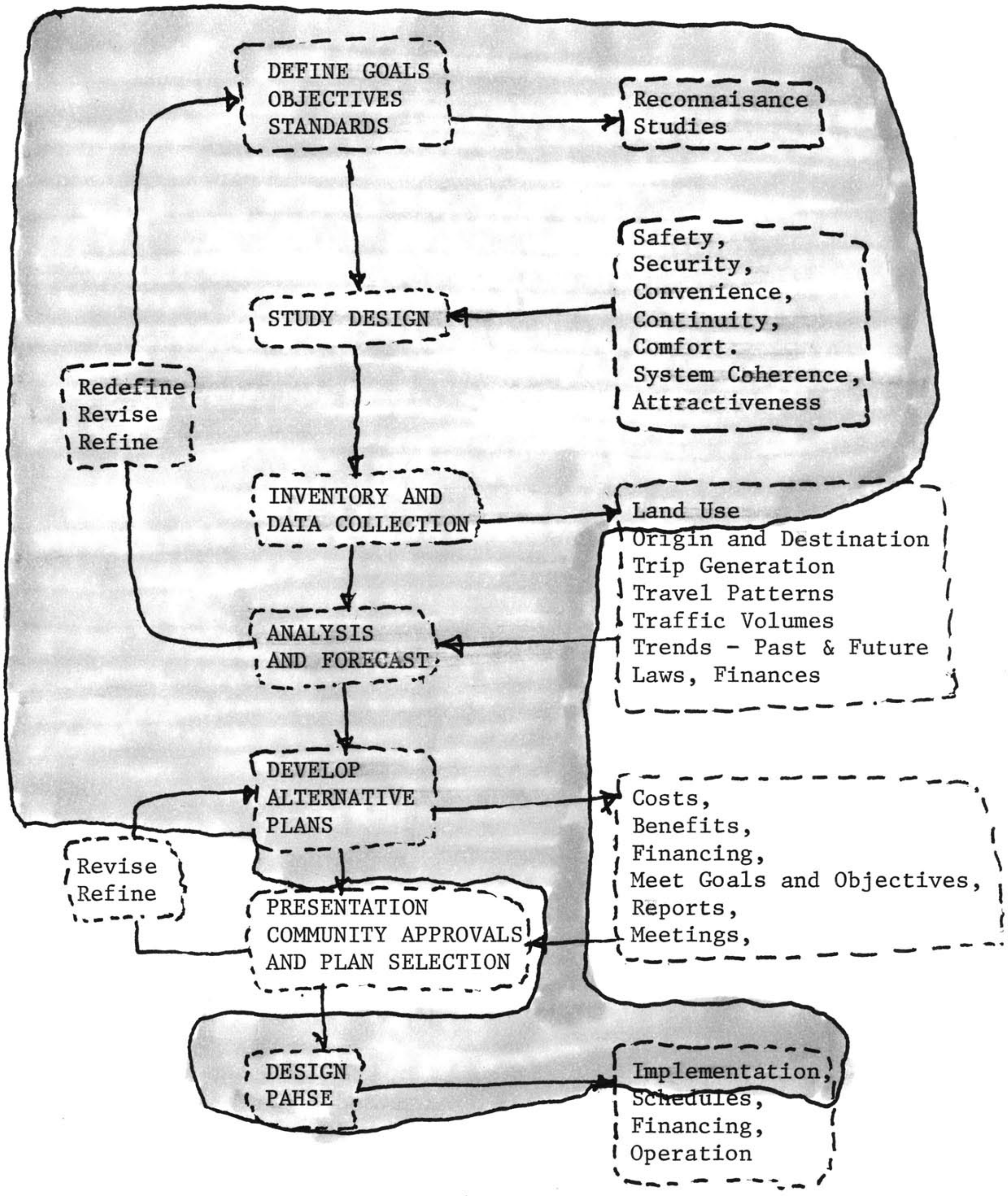
Pedestrian Trip Variables

	User Forcasts	Growth components	Characteristics	Personality	Traffic volumes	Patterns, peaks	Composition	Facility type	Traffic type	Safety	Space restraints	Economic restraints	Convenience	Flow charts	Service vacancies	Service time	Working distances	Grade change	Load	Unload	Wait	Tickets	Baggage	Manpower	Computer simulation	Walks	Doors	Stairs	Pedmovers	Waiting space	Platforms begin	Signs	Machanical aids	Controls	Lighting	Finishes	Furniture	System closeness	Visual aesthetics	Design operability	Maintainability	Manpower, economics	Construction phase
Preliminary plan	●		●				●			●	●		●				●	●								●		●	●	●		●		●	●	●	●						
Goals	●		●				●			●	●		●				●	●								●			●	●		●		●	●	●	●						
Objectives	●		●				●			●	●		●				●	●								●			●	●		●		●	●	●	●						
Study plan	●		●				●			●	●		●				●	●								●			●	●		●		●	●	●	●						
Goals	●		●				●			●	●		●				●	●								●			●	●		●		●	●	●	●						
Objectives	●		●				●			●	●		●				●	●								●			●	●		●		●	●	●	●						
Pedestrian traffic demand	●		●				●			●	●		●				●	●								●			●	●		●		●	●	●	●						
Design service standard								●	●	●	●	●	●														●																
System requirements										●	●	●	●	●	●	●	●	●	●	●	●					●	●	●	●	●		●		●	●	●	●						
Functional Elements																										●						●			●	●	●	●					
Preliminary																																						●	●	●	●		
Preliminary space design																										●						●		●	●		●	●	●	●	●		
Final space design			●				●			●	●	●	●		●	●	●	●	●	●	●					●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●

The projects focus within the full spectrum of the

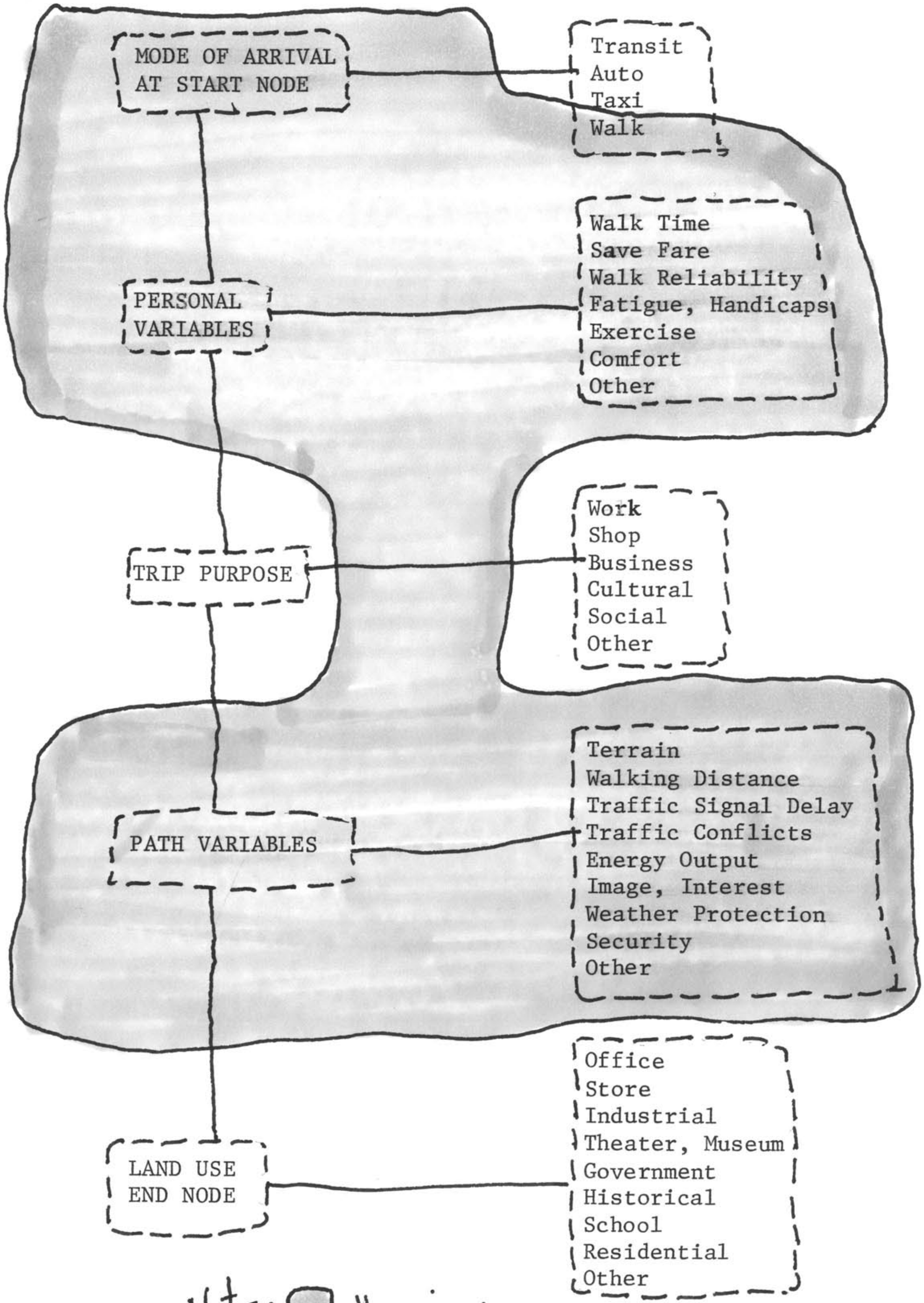
Pedestrian Design Elements

THE PEDESTRIAN PLANNING PROCESS



NOTE: ▨ thesis focus

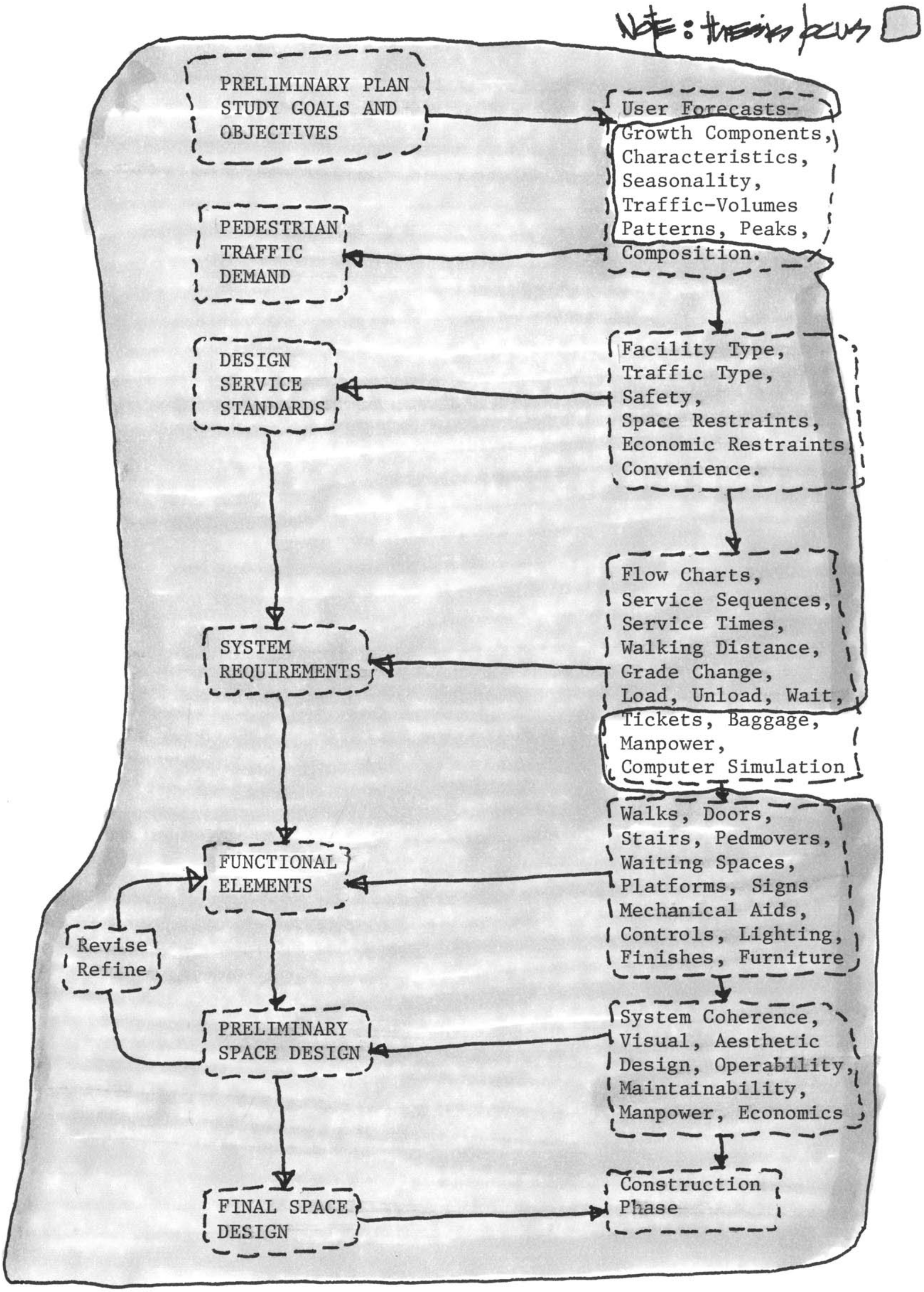
PEDESTRIAN TRIP VARIABLES



Note: ▨ thesis focus

ELEMENTS OF PEDESTRIAN DESIGN

Building and Street Spaces



THE MODEL

The process of development of our pedestrian environment for human use was essentially one of evolution. Through the use of that particular space it was possible to identify its deficiencies and to modify that space accordingly, so that the next generation of environments would better serve its purpose in actual use. Experience then was the primary basis for improvement and further adaption.

But today's built environments have been modified to respond to the adaption level of those individuals who can be considered the average anithropometric measure of man. (Anthropometric meaning having prescribed physiological measure of performance and competence in getting around a mobility state). While we frequently hear of the "average" or "typical" man this is in one sense, an illusive, will of the wisp concept. In the domain of human anthropometric there are probably few, if any, people who can qualify as average - average in each and every respect. The average is a numerically devised arithmetic means of some quantitative measure (height, weight, etc.). While the average man is then something of a myth and if average is recognized for what they are (arithmetic mean), there are however, certain types of design problems which can optimally be resolved by designing the facility, environment, or equipment for the average person who is expected to utilize it. However, there are certain circumstances in which these designs based on the average person would not be satisfactory. Thus, if there is any "limiting" factor in the situation; limiting in the sense that persons below or above a given standardization (physiological fit) dimension could not be accommodated -- we must employ a different principle of designing to accommodate and suit those body needs charactized by the standardized population stereotype.

To optimize the procedures for urban analysis and design, one must know the dimensions of the limiting factors of the user groups involved in the process. What planning and design that has been done has tended to restrict the performance levels of those user groups whose anthropometric make up is not compatible with those standardized measures of man. Thus this thesis tends to analyze the concept of human factors as applied to urban analysis and design. The emphasis will focus on the disabled pedestrian. (disability refers to those persons handicapped in their mobility due to conditions resulting from chronic organ or neurological impairment, birth defects, orthopedic injuries and age induced phenomena) The development of a body of information and principles that would be applicable to these and other problems is primarily dependent upon research, judgmental factors, experience and design simulation process. At present there is very little information available about some areas of human performance of the disabled as related to man/environment interaction, and at least partial information about certain others, but in most areas the information available are almost virtual information voids. Such design deficiencies can be attributed to two systems -- the human dysfunction system and the environmental dysfunction system. The deficiencies can be attributed in part, to the fact that such systems being more elaborate than that which people previously had used created human factor problems than were characteristics of previous systems. And since some environments are designed and produced spontaneously and from scratch there was no opportunity to benefit from previous experience in the use of earlier models, and lastly the evolution process failed to evolve new users to new technologies and methods.

The purpose of analyzing the human factors associated with the disabled pedestrian are to develop a set of urban analysis system performance criteria. The focus of assessment will assess the levels of performance of those afflicted with mobility, limitations to identify the corresponding environmental framework to support that identified limitation.

The problem arises can one design a system to design a model without first knowing what the designed system is to be, and not finally but sufficiently. A design system should meet the requirements of those for whom it is designed. It was in this latter point that I defined the purpose. I realized I needed to know for whom I was constructing a model and obviously for what use.

It was felt that a valid argument was made that the focus and integrating force of the model should be the human performance factors of the disabled pedestrian. A literature survey reinforced that belief since these considerations were excluded in the basic design goals of most of the literature. But, if I were to develop a model to whom should I address it? Should it be used by those who design, those who maintain, those who work and live on them, or all three?

A concerned public can do little unless it is informed. An informed public can support positive environmental change and attempt to suppress negative environmental change only if it knows which is which. Activist groups, sensing possible fl$\overset{a}{o}$ws in the system, have opposed in-city branches of the interstate highway system. College students have effectively disrupted the educational system of universities. In one case there is a resistance to a proposed innovation in the environment. In the other case there is an attempt to disrupt an entire system without suggesting the focuse the environmental replacement will take. Neither kind of activity will in the long run, produce useful results unless it is based on some logic of desired change. That is the public picture, The private picture is that the individual who creates environmental designs, on the one hand, and the individual who live with these designs, on the other, would be better served if all were better informed. This study has me convinced that designers are not attempting to create functional environments which support the normal activities of its users; rather they are attempting to create eye-catching products which suggest an image of status and success -- and which will sell despite its level of convenience. A designer should know all the things a user group will need and do or want to do as Deasy[12] suggests: a user should know all the things his user group does and he should know what he can expect from the built product in terms of those activities. Knowing these things both can improve the environment, one by creating designs, the other, by knowing how to use the designed environment effectively.

What do we need to know about the system? We need to know how the design of the man/environment system for the disabled pedestrian relates to achivement of objectives. Not behaviorial objectives but physical objectives. Appearing to have been somewhat lengthy making these points as background for a statement of purpose of the model; it is because this is a large issue, widely discussed and not discussed in the current literature and is necessary to set the stage for an objective which is as much a human factor objective, as a methodological objective, as an reality or learning and communication objective at any pragmatic level.

First we must define the elements of and criteria for human performance evaluation. Within the man/environment system, there are four relatively distinct types of criteria which in various context may be pertinent indication of human behavior. These are human performance measures, physiological issues and indices subjective responses, and accident frequences.[Fruin]

(1) Human performance measures - In a strict sense human performance must be considered in terms of various sensor, mental, and motor activities. For specific environmental situations, however, it is usually difficult if , not impossible to measure human performance in strictly human activity terms since such performance is inextricably intertwined with performance characteristics of the physical equipment being used. Thus the wheeling performance of a wheelchair user is not entirely the function of the wheeler, but is also in part the consequence of the wheelchair. (its make correction size, etc.) To illustrate two sets of system with the same objective namely that of traversing 1/2 mile in the shortest space of time. One of the systems is a "walker" and the other is a "wheelchair user". The likelihood that (perhaps inevitability that the walker system would get there first tells us only which system is fastest - this would be a system performance criteria). It tells us nothing about human performance, it could be that the wheelchair user system is doing a better job of wheeling (in terms of human motor and coordination) than the walker is in walking.

The strictly human performance can be so inextricably mixed up with the physical properties of the system and specific physical activities it requires that it is virtually impossible in such a situation to separate strictly human performance criteria from performance of the total system of which the individual is a part.

The state of affairs does not mean that we can never obtain useful information about human performance abilities. For many practical purposes performances may be measured and rated under conditions in which the task and any associated equipment and procedures are constant. Thus we can compare the relative wheeling abilities of several wheelers but for such a purpose they should all use the same or comparable wheelchairs. When the physical aspects of the system are held constant,differences in the man/equipment system performance may be presumed to reflect individual differences in the human performance levels of the system. Since human performance is in large part a function of the characteristics of the system being used, the primary emphasis in human factors investigation is in terms of measuring systems performance, and the objective is that of developing systems that are reasonably optimal in the scores.

There are, however, some circumstances where it is possible and appropriate to utilize what are more nearly "pure human performance measures; - those that are less influenced by the characteristics of any physical system. Such as traffic studies which check the time pedestrians will wait for a light to turn before starting to cross a street against the red light. Such behavior in a broad sense can be considered as performance criteria. In terms of conventional psychological research with human subjects, human performance can be ascertained in terms of such activities (criteria) as visual discrimination (usually expressed in terms of visual angle of the samllest detail that can be discriminated), auditing thresholds, net power, and reaction time in selecting the appropriate responses from any of a specified set of possible alternatives. Such human performance and information can be useful in designing systems in order to capitalize on man's strength's and to compensate for his limitations. So it becomes possible to describe human performance quantitatively in such operational environmental terms that it will then be possible to compare man's abilities with those of the environmental components on the basis of comparable (environmental support) criteria.

(2) Physiological indices - For some purposes indices of various physiological correlations are pertinent criteria in connection with man/environment interaction. Such possible indices include heart rate; blood pressure, skin response, respiration rate and many other measures. Some of these and other physiological variables are used as indices of the physiological effects on the people of various methods of activity, of activity performed with equipment of various designs, of activity periods and of activity performed and various enviromental conditions such as hot and cold.

(3) Subjective response - In some cases, occasions obtaining subjective responses of people are in order. These may be of varied types and obtained by different methods. As an example, ratings provide systmatic means of obtaining judgments of people; such ratings can range over a wide gamut,

including ratings of people and their performance, of the quality of objects, of the disability of different features of a system and of the importance of different types of information for use in a system. Any method of obtaining data may be useful criteria.

(4) Accident frequency - In pedestrian systems the safety of human beings are important criteria by which a system should be evaluated. Thus the number of injuries or deaths, would be useful in comparing one system with another. As with many criteria, it is possible that a criteria of accident frequencies is not necessarily an exclusive indicator of the relative accident liabilities of two or more systems that are being compared for some circumstances and to some degree. Individual differences in the accident susceptibility of people can affect the accident indices in making cross-system comparisons (for example, the transportation system critaeria).

In connection with the human factor aspects of such systems therefore, it is important that in the initial design of systems, human factor considerations be taken fully into account. What is meant by taking human factor considerations into account during the design stage. Such questions could include the following: should a particular warning be visual or auditory? The solution to the question and many, many other kinds of questions should be based on the availability of pertinent information about human capabilities and limitations. In a practical design problem, if pertinent information is not yet available regarding some human performance characteristics, there are two or three alternatives from which to choose.

1. One can pick answers out of thin air, this is obviously pretty risky business, although it is unfortunately a fairly common practice.
2. It may be possible to carry out some research.
3. It is possible to solicit the judgment of experts.

Therefore the purposes of our model are these:

1. To develop and to integrate data about man/environment relationships (focus on pedestrianism) for the disabled.
2. To develop and to integrate and to implement environmental design concepts - the objectives of which are to improve the relative scales (especially the micro components) in the construction of pedestrian environments for the disabled in the direction of physical (human) performance capacities, capabilities and limitations.
3. To develop a framework for analyzing pedestrian systems to optimize use.
4. To develop and guarantee the principles and standards for environmental street design.
5. To do these things in a generally comprehensible language.

The credo of functionalism which emerged in the earlier part of this century as an operational goal seemed to offer the diagram and clear and rational program for effective action. The comfortable notion of cause and effect suggest is "form follows function" was and is an appealing proposition. The most pertinent question, however, has never been systematically addressed: function of what? Among disciplines bound to a more rigorous use of such terms, a functional relationship connotes something quite precise. It connotes a specified relationship between empiracally identifiable independent and dependent variables. Other designers, such as Le Corbusier, while definitely preoccupied with problems of "form" have also spoken of "human measure" in general terms. While their artifacts have never been systematically analyzed or verified in this regard the effect of their expressed intention has been to keep alive the possibility and obligation to formulate "human-oriented" design goals. Out of this has grown a serious, even if confused, effort to systematically probe what designers have surreptitously referred to a "human need". What we really seek is a discipline which addresses itself not singularly to inside or outside,to small or large domains, but one which is technically committed to environment as an internal aspect of human biological and non-biological systems. What is required of course, is not a "redefinition of terms", but an entirely new taxonomy of problem formulation -- one based upon the systems of performance criteria to be accommodated.

Models of the Man/Environment Relationship

There are many design-oriented models of man/environment relationships (we use the term model to describe some formal statement of principles of relationships). Possibly the most sophisticated is Studer's[1] "behavior-contingent phsyical systems" model. Studer[2] has also suggested a formal context for environmental problem formualtion. Alexander[3,4,5,] has suggested a variety of models basic to the design of cities. Chapin and Hightower[6] have suggested a structure of "household activity systems" to describe the living patterns and attitudes of urban residents that relate to their use of city spaces. Barker[7] has described the man/environment relationship in terms of "behavior setting." Hall[8] and Sommer[9] and many others have described basic principles of man's use of space. Schowalter and Malone[10] suggest design models for lunar habitability and Nohwill[11] examines the role of stimulus control as central to design. These and many other models were examined, none of these models seemed to suit the project purpose, in that (1) none was microscopic enough to incorporate the total man/environment relationship as needed to be envisioned, (2) if it was general enough, it depended upon data and concepts not yet available, and (3) none seemed to be capable of incorporating the observations and design concepts of the literature. Very basically these models were behavior contingent models. Thus relating mans needs and use for and of space on a level of use relationships dependent in behavioral human factors. (culture, sociological implications exterterresterial, time centralizing, etc.) Whereas my model is trying to understanding the construction composition which goes into the design and organizqtion of space fitted with its elements as determined by human performance. The qualitative difference in analysis would depend on the work's organization and composition. Since in my eyes the organization model is more of a macro-analysis while some get to term it micro and the compostion model is reflective of a micro-analysis. Thus my model reflects the later.

Regardless of whether you are designing a man/environment interactive system from scratch or merely giving it a product of face lifting, the follwoing general steps are considered and noted for a successful problem solution:

Information phase: acquire sufficent information requirements of constraints, environmental conditions, and type of people who will use the design to be able to state positive and concise objectives for the applied design.

Planning phase: explore alternative approaches for stated objectives, keeping in mind such factors as economics, reliability of product, ease of maintenance.

Selection phase: select the design which seems to optimize all factors tested in Information and Planning phases. Proceed utilizing human engineering factors.

Test phase: Develop, construct and analyze models using factors to evaluate and to test the model against stated objectives.

Field Test phase: depending upon the nature of the design it may be necessary to test your final designs under actual operating conditions - using actual personnel who will eventually use the end item.

Having defined the performances to be accommodated, the next problem is that of specifying the characteristics of the correlated physical system. These variables which the designer manipulates fall into two categories: (1) those which support certain behavioral topographics through maintenance of appropriate physiological states and (2) those which don't, i.e., the requirements of the appropriate physical system explicitly specified.

If the architectural environment is to support the behavioral scheme in any effective way, it must be an integral aspect. What is required then is a system which includes the following characteristics. (Study)

Identify and Legibility	(1) Well fitting, i.e. maximally integral with and supporting, the behavioral scheme required, and in equilbrium with externally upbringing variables.
Comfort and Protection	(2) Highly adaptive, i.e. responsive to the changes in behavioral design to experimentally manipulations and to external constraints. (climatic and other uses)
Accessibility	(3) Capable of higher levels of initial adaptability, i.e. exhibiting a broader range of manipulations.

Flexibility and Adaptability	(4) Open-ended, i.e., the ability to add to, or subtract from the total system without causing serious disequilibrium.
Economy	(5) Economically feasible, i.e. in terms of both construction and maintenance.

What I have attempted to conceptualize is the general characteristics of an environment which is in constant change and capable of several important functions. There is no reason to assume that the real physical system will be "ugly". Whatever that may mean; it will be "reinforcing" because that is a requirement of its behavior - contingency.

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DEFINING THE MARKET

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Edited in cooperation with Jeffrey L. Cooper, Department of Architecture, M.I.T., The Marketing of Adaptive Housing to the Physically Handicapped, Thesis, M.I.T. 1973.

DEFINING THE MARKET

Introduction

This chapter attempts to define the size and character of the disabled market.[1] Firstly, some definitions are in order. The words "handicapped" and "disabled" are used interchangeably in this study to refer to persons with limited mobility due to the incidence of one or more chronic health impairments.

Not being able to move freely these persons are thus confined in carrying out their activities of daily living. Many are in need of special mobility aids such as wheelchairs, crutches, braces, etc.

The inability to move freely can result from any one of a number of chronic neuro-muscular or skeletal diseases, (such as Multiple Sclerosis, Cerebral Palsy, Muscular Dystrophy, Arthritis, Parkinson's Disease, Polio, Myasthenia Gravis, Spina Bifida), from heart condition, from damage due to stroke, or simply from accidental injury.

As a first step towards familiarizing the reader with the nature and prevalence of these myriad causes of mobility impairment, we shall now turn to a brief description of the most prevalent of these. Each description will be followed by a numerical estimate of the number of Americans suffering from that affliction.

A. The Nature and Prevalence of Mobility Impairing Diseases (see Figure 1A, p.40)

Paraplegia and Quadraplegia (see Figure 1B, p.42)

The term "plegia" refers to paralysis. Paraplegia is the complete or partial paralysis of the lower extremities. Quadraplegia is the complete or part paralysis of both the upper and lower extremities. The terms "paraplegia" and "quadraplegia" are generic terms, and not diseases in themselves. Paraplegia and quadraplegia may result from any number of causes, as mentioned above.

"Traumatic Paraplegia" or "Quadraplegia" refers to the onset of paralysis due to injury from a disastrous occurance. Damage in such cases (diving accident for example) is usually to the spinal cord itself - the location and severity of the lesion being directly related to the location and severity of the paralysis. Almost all traumatic paraplegics or quadraplegics are "Spinal Chord injured".

In 1965 there were an estimated 1,516,000 persons suffering from paralysis of all types, and all degrees. Approximately 116,000 of these were paraplegics and quadraplegics. Of this latter population, approximately 25% suffered their disability due to spinal chord injury. The incidence of spinal chord injury is approximately 3,000 persons per year, or 15 per million in the population. (National Health Survey No. 1000, Series 10, Number 48). (see Figure 1B, p.41).

Using this rate, it can be estimated that there are approximately 53,000 spinal chord injured persons in the U.S. at this time.

Multiple Sclerosis

Multiple Sclerosis is a disease of the central nervous system. By in large it affects people in their prime years, between 18 and 45. As the disease progresses, myelin, a cellular coating of the nerves begins to disintegrate and is replaced by scar tissue. The exact cause is unknown. No cure has been developed.

Depending on the stage of development M.S. can seriously impair the ability to move, eat or even talk. Many of the persons afflicted with M.S. are confined to wheelchairs. There are an estimated 500,000 victims of M.S. in the U.S. (Multiple Sclerosis Society, 1968).

Cerebral Palsy

Cerebral Palsy refers to the impairment of muscle and power co-ordination due to brain damage. As a rule, damage occurs before or at birth.

Many of the victims of Cerebral Palsy are wheelchair bound. There are an estimated 550,000 victims in the U.S., with 25,000 new victims being born each year. (National Institute for Neurological Diseases and Blindness, NINDB).

Muscular Dystrophy

Muscular Dystrophy is a non-contagious disease of unknown cause, in which there is a gradual but irreversible deterioration of the muscles.

There are an estimated 200,000 persons suffering from Muscual Dystrophy in the U.S. (NINDB).

Arthritis

Arthritis refers to the inflamation of the joints. Rheumatoid Arthritis, the most common variety, is a chronic disease marked by inflamation in the synovial membrane of the joint and rarefication of the bone. The disease is a progressive one, affecting primarily the elderly. Approximately 17,000,000 Americans suffer some form of Arthritis (Arthritis Foundation, AF). 250,000 of these are completely disabled as a result.

Parkinson's Disease

Parkinson's Disease is a progressive nervous disease of the later years. It is characterized by muscular tremors (especially in the hands), a general slowing of movement, partial facial paralysis and impaired motor control.

There are approximately 500,000 victims of Parkinson's Disease in the U.S. (NINDB).

Poliomyelitis

Polio is a viral infection, affecting the motor neurons of the spinal chord. It is a degenerative disease. In other words, as it progresses, it destroys live cells. Primarily polio affects children. Although there is no cure for the disease in its advanced stage, preventative vaccines have existed for some time now, and the incidence of the disease has been drastically reduced. There are an estimated 451,000 victims of polio in the U.S., a portion of whom are totally disabled.

Myasthenia Gravis

Mysathenia Gravis is a syndrone of the muscular system. Progression of the disease results in progressing severity of paralysis. At advanced stages, victims are bound to either wheelchair or bed. There are an estimated 30,000 victims of M.G. in the U.S. (NINDB).

Spina Bifida

Spina Bifida refers to a congenital defect in the spinal column which prevents normal development and growth. As the disease progresses mobility can deteriorate to eventual incapacitation. There are an estimated 30,000 victims in the U.S. (NINDB).

Stroke

"Stroke" is the degeneration of a portion of the brain resulting from clotting in or rupturing of a blood vessel. Severity of damage can range from "unnoticeable" to partial or complete paralysis and, in some cases, death.

There are presently, 2,000,000 living victims of stroke. (NINDB).

Respiratory Ailments

This is a general term referring to chronic conditions of the respiratory system. Such chronic conditions as Tuberculosis or Bronchitis can severely limit energy expenditure and thus general mobility of the individual afflicted. In 1967, 757,000 Americans suffered limitation of activity due to Respiratory Ailments.

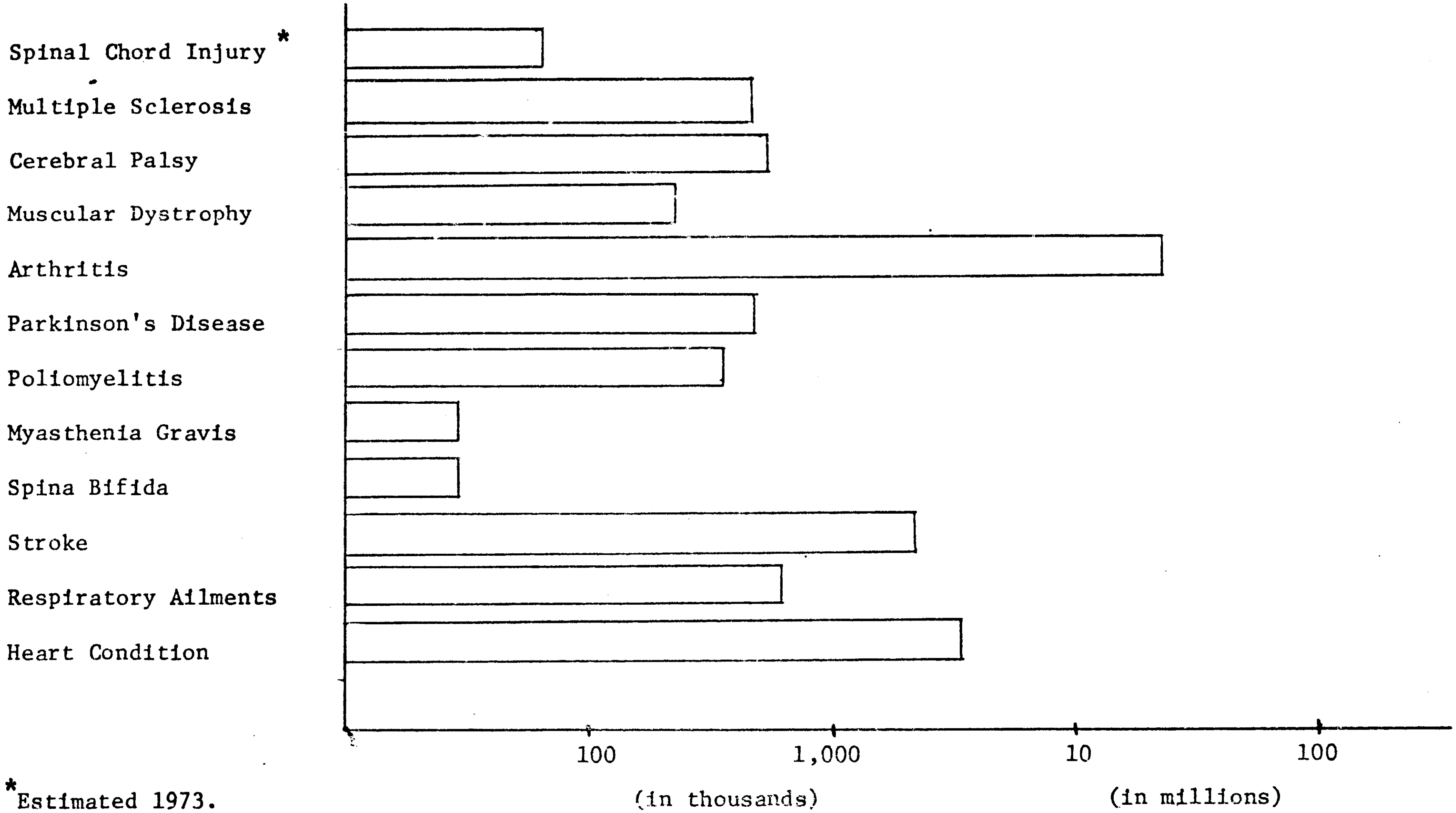
Heart Condition

"Heart condition" is a general term referring to a large number of chronic conditions that impair the functioning of the cardio-vascular system. As a result of this the c-v system is excessively vulnerable to malfunction, or heart attack. This excessive vulnerability impairs ability to expend energy and degrades freedom of mobility. Approximately 3,600,000 Americans suffer degrees of heart conditions serious enough to impair their daily activities. (National Heart Survey, Series 10, Number 61).

Now that the reader has been familiarized with the most prevalent causes of mobility impairment, we will now turn to data from the National Health Survey and attempt to explore the mobility handicapped market in greater depth.

FIGURE 1A

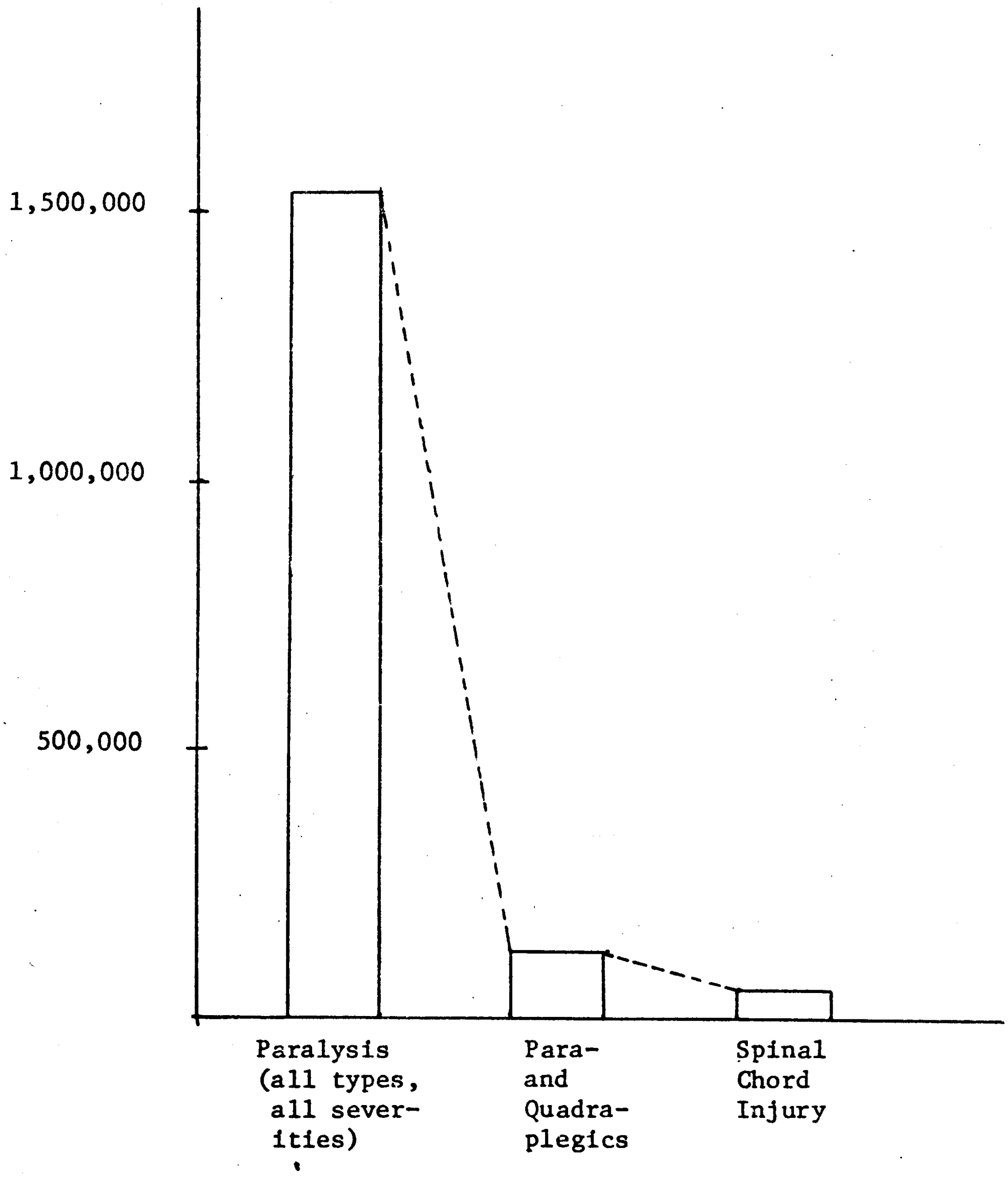
THE NATURE AND PREVALENCE OF MOBILITY IMPAIRING DISEASES
(1968)



*Estimated 1973.

FIGURE 1B

THE PREVALENCE AND NATURE OF PARALYSIS
(from all causes)
(1968)



B. The National Health Survey

The National Health survey contains statistics on persons limited in activity and mobility due to chronic health conditions. It is based on data collected in household interviews of the civilian, non-institutionalized population of the U.S. during the period July, 1965 to June, 1967.

Thus, the estimates it gives do not include those handicapped persons who are hospitalized or in the care of nursing homes or other private agencies. For this reason the numbers presented are actual underestimates of the prevalence of chronic mobility limitation in the U.S. However, for the same reason, these numbers to present a more accurate picture of the true private disabled market for adaptive household appliances.

As a first step towards analyzing the prevalence and severity of mobility limitation, we will turn to data concerning the use of special mobility aids.[2]

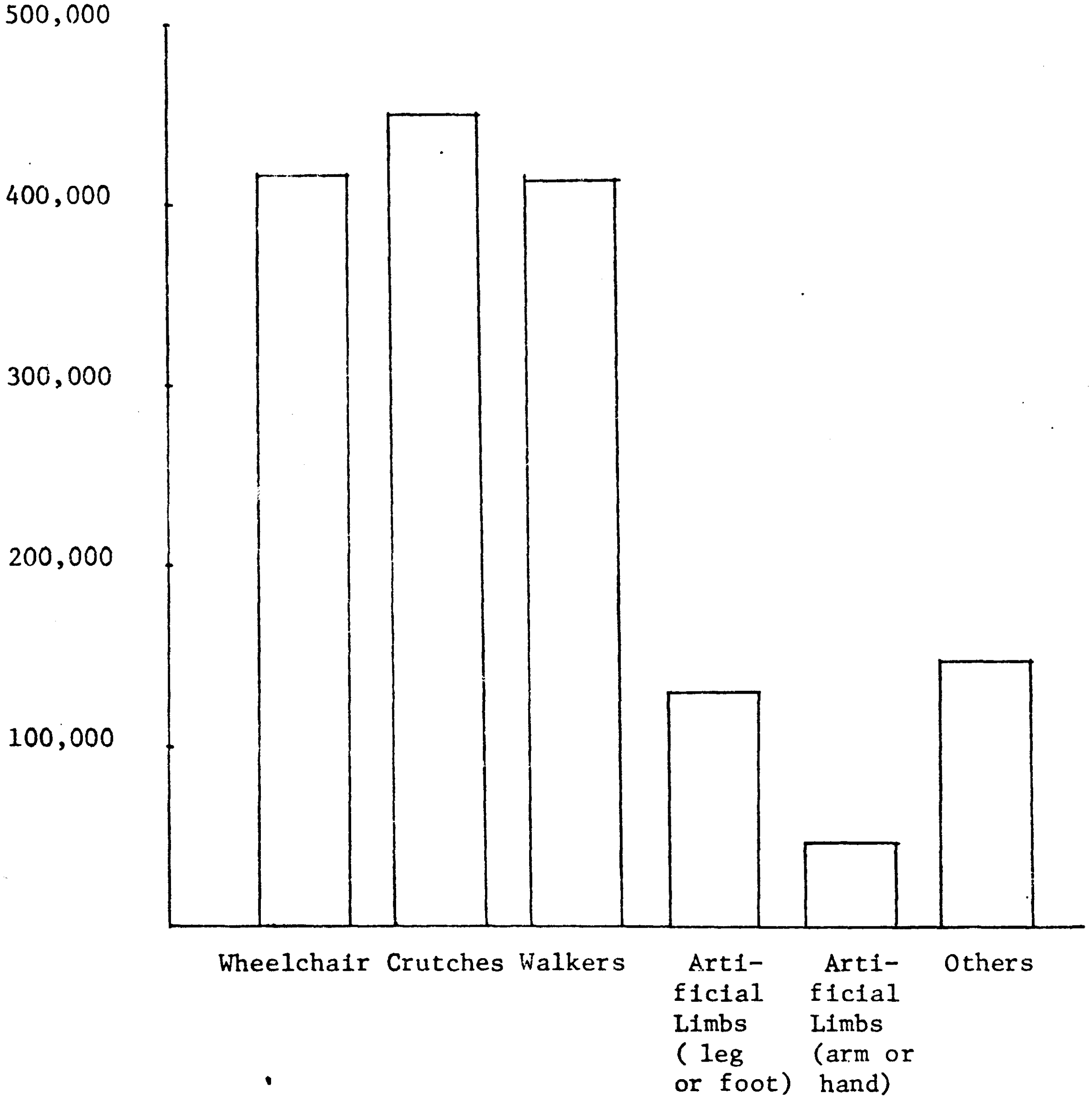
The Use of Mobility Aids (see Figure 1C, p.43)

It is estimated that a total of 6,226,000 persons are in need of "special aids" to help them move. This includes wheelchairs, crutches and walkers (four-legged supports) as well as artificial limbs.

An estimated 409,000 persons are wheelchair users, with 50% of that number being bound to their wheelchair all of the time. 443,000 depend on the use of crutches to move, while another 404,000 depend on "walkers".

FIGURE 1C

USE OF MOBILITY AIDS
(1968)



We will now analyze the Mobility Handicapped Market by the six following categories.

1. Impairment by Chronic Condition Causing Limitation
2. Impairment by Sex and Age
3. Impairment by Race and Age
4. Impairment by Family Income and Age
5. Impairment of Employment Status
6. Impairment by Geographical Distribution

1. Impairment by Chronic Condition (see Figure 1 and Table 1, pp 45 46)

Table 1 shows us the leading causes of mobility limitation in the U.S. Many of the specific causes of mobility impairments, as dealt with in the first part of this chapter, are considered together in this table under such general categories as "other diseases of muscles, bones and joints", or "impairment of back or spine". This is unfortunate as it prevents us from assessing the extent to which these various diseases impair the mobility of those afflicted. However, we can still draw some valuable conclusions from this data as it is presented.

Firstly, it is clear that arthritis and heart condition are the leading causes of severe mobility limitation, being each responsible for 20.5 per cent of the disabled population's "confinement to the house". Paralysis, complete or partial, is the next largest category, being responsible for the confinement of 13.0% of the disabled population. Thus, these three categories combined account for 54% of the population confined to the house. Impairments of the back or spine contributed more to the less severe types of mobility impairment (i.e., "Has trouble getting around alone) than conditions of the circulatory system or conditions of the genitourinary system. The reverse was true for the more severe types of mobility limitation.

TABLE 1

PREVALENCE OF IMPAIRMENT
BY
CHRONIC CONDITION CAUSING LIMITATION

Table 1. Average number and percent distribution of persons with limitation of mobility by selected chronic conditions causing limitation, according to degree of limitation: United States, July 1965-June 1967

[Data are based on household interviews of the civilian, noninstitutional population. The survey design, general qualifications, and information on the reliability of the estimates are given in appendix I. Definitions of terms are given in appendix II]

Selected chronic conditions	All degrees of mobility limitation	Has trouble getting around alone	Needs help in getting around	Confined to the house	All degrees of mobility limitation	Has trouble getting around alone	Needs help in getting around	Confined to the house
	Average number of persons in thousands[1]				Percent distribution[2]			
Persons limited in mobility----------	6,312	3,114	1,766	1,432	100.0	100.0	100.0	100.0
Tuberculosis, all forms---	*	*	*	*	*	*	*	*
Malignant neoplasms-------	95	*	*	64	1.5	*	*	4.5
Benign and unspecified neoplasms----------------	60	*	*	*	1.0	*	*	*
Asthma-hay fever----------	179	88	*	74	2.8	2.8	*	5.2
Diabetes------------------	141	54	*	63	2.2	1.7	*	4.4
Mental and nervous conditions---------------	312	129	54	129	4.9	4.1	3.1	9.0
Heart conditions----------	797	382	122	294	12.6	12.3	6.9	20.5
Hypertension without heart involvement--------------	212	96	44	72	3.4	3.1	2.5	5.0
Varicose veins------------	123	80	*	*	1.9	2.6	*	*
Hemorrhoids---------------	50	*	*	*	0.8	*	*	*
Other conditions of circulatory system-------	245	99	65	81	3.9	3.2	3.7	5.7
Chronic sinusitis and bronchitis----------------	118	55	*	59	1.9	1.8	*	4.1
Other conditions of respiratory system--------	152	84	*	60	2.4	2.7	*	4.2
Peptic ulcer--------------	60	*	*	*	1.0	*	*	*
Hernia--------------------	82	48	*	*	1.3	1.5	*	*
Other conditions of digestive system---------	146	67	*	63	2.3	2.2	*	4.4
Conditions of genitourinary system-----	175	72	*	82	2.8	2.3	*	5.7
Arthritis and rheumatism--	1,541	810	438	293	24.4	26.0	24.8	20.5
Other diseases of muscles, bones, and joints--------	208	128	47	32	3.3	4.1	2.7	2.2
Visual impairments--------	656	256	239	160	10.4	8.2	13.5	11.2
Hearing impairments-------	82	*	*	34	1.3	*	*	2.4
Paralysis, complete or partial------------------	686	202	298	186	10.9	6.5	16.9	13.0
Impairments (except paralysis) of back or spine--------------------	330	238	49	43	5.2	7.6	2.8	3.0
Impairments (except paralysis and absence) of upper extremities and shoulders----------------	42	*	*	*	0.7	*	*	*
Impairments (except paralysis and absence) of lower extremities and hips--------------------	717	350	267	99	11.4	11.2	15.1	6.9

[1] Summations of conditions causing limitation may be greater than the number of persons limited because a person can report more than one condition as a cause of his limitation; on the other hand, they may be less because only selected conditions are shown.

[2] Percentages may add to more than 100 because a person can report more than one condition as a cause of his limitation; on the other hand, they may add to less than 100 because only selected conditions are shown.

2. Impairment by Sex and Age (see Figure 2, Table 2, pp.49-50)

As age increases, the percentage of the group reporting mobility limitation increase. This is true for both sexes, in all degrees of mobility limitation. Less than 1 per cent (0.8) of all persons under 45 years had any degree of mobility limitation (The survey cites paralysis as the leading cause of mobility impairment in this age group). However, among persons aged 45-64 years 4.9 per cent had mobility limitation, and of persons aged 65 years and older, 18.7 per cent were so limited (The leading cause of limitation in this older group was reported to be arthritis and rheumatism). Interestingly enough, there seems to be little or no difference in the incidence of mobility limitation between males and females.

3. Impairment by Race and Age (see Figure 3, Table 3, pp.52-53)

The National Health Survey divides race into only two categories: "white" and "all other". Using this convention, we find that the incidence of chronic afflictions is proprotionately greater in the non-white sector of the population. 60.1 per cent of the non-whites reported some chronic condition while only 49.2 per cent of the white population reported the same. However the prevalence of Mobility Limitation within these groups is approximately the same - 3.3 per cent for "White" and 3.4 per cent for "All Other". (After age adjustment these figures become 3.1 per cent and 4.4 per cent respectively. See Summary Table 7).

FIGURE 2

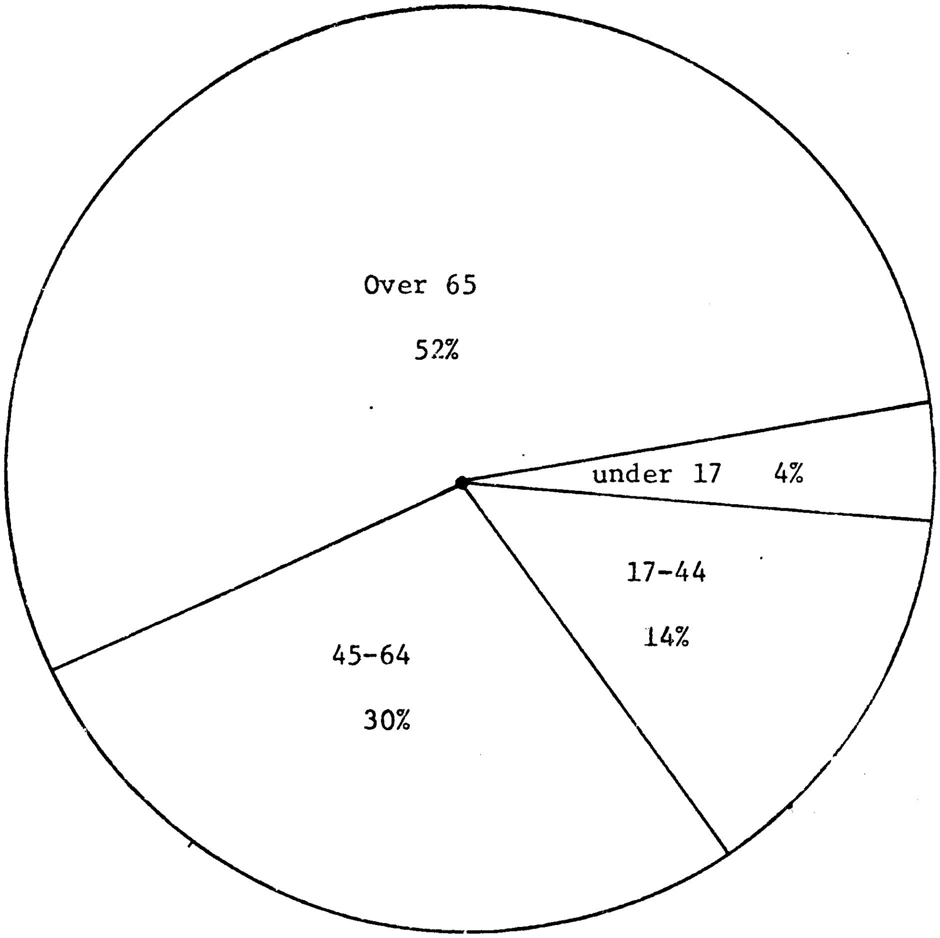
DISTRIBUTION OF MOBILITY LIMITATION BY AGE

TABLE 2

PREVALENCE OF IMPAIRMENT
BY
SEX AND AGE

FIGURE 2

DISTRIBUTION OF MOBILITY LIMITATION BY AGE
(1965-1967)



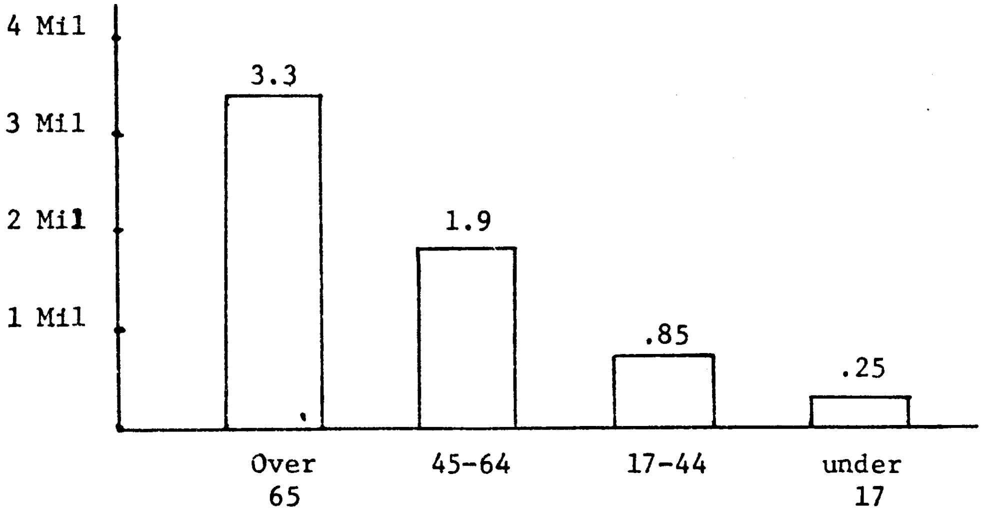


Table 2. Total population and average number and percent distribution of persons by chronic condition and mobility limitation status, according to sex and age: United States, July 1965-June 1967

[Data are based on household interviews of the civilian, noninstitutional population. The survey design, general qualifications, and information on the reliability of the estimates are given in appendix I. Definitions of terms are given in appendix II]

Sex and age	Total population	Persons with no chronic conditions	Persons with 1 chronic condition or more				
			Total	With no limitation of mobility	Has trouble getting around alone	Needs help in getting around	Confined to the house
Both sexes	Average number of persons in thousands						
All ages------	191,537	96,684	94,853	88,541	3,114	1,766	1,432
Under 17 years------	66,921	51,664	15,257	15,009	90	82	76
17-44 years---------	67,901	31,188	36,713	35,865	539	163	147
45-64 years---------	38,993	11,278	27,714	25,816	1,124	407	367
65 years and over---	17,723	2,553	15,169	11,852	1,361	1,114	843
Male							
All ages------	92,566	47,915	44,651	41,744	1,506	823	577
Under 17 years------	34,038	25,806	8,232	8,098	47	45	42
17-44 years---------	32,099	15,202	16,897	16,449	291	103	54
45-64 years---------	18,702	5,699	13,003	12,034	598	207	165
65 years and over---	7,727	1,208	6,519	5,164	570	468	317
Female							
All ages---- -	98,971	48,769	50,202	46,797	1,608	943	855
Under 17 years------	32,883	25,858	7,025	6,911	43	37	34
17-44 years---------	35,802	15,986	19,816	19,416	248	59	93
45-64 years---------	20,290	5,579	14,711	13,782	527	200	202
65 years and over---	9,996	1,345	8,651	6,688	791	646	526
Both sexes	Percent distribution						
All ages------	100.0	50.5	49.5	46.2	1.6	0.9	0.7
Under 17 years------	100.0	77.2	22.8	22.4	0.1	0.1	0.1
17-44 years---------	100.0	45.9	54.1	52.8	0.8	0.2	0.2
45-64 years---------	100.0	28.9	71.1	66.2	2.9	1.0	0.9
65 years and over---	100.0	14.4	85.6	66.9	7.7	6.3	4.8
Male							
All ages------	100.0	51.8	48.2	45.1	1.6	0.9	0.6
Under 17 years------	100.0	75.8	24.2	23.8	0.1	0.1	0.1
17-44 years---------	100.0	47.4	52.6	51.2	0.9	0.3	0.2
45-64 years---------	100.0	30.5	69.5	64.3	3.2	1.1	0.9
65 years and over---	100.0	15.6	84.4	66.8	7.4	6.1	4.1
Female							
All ages------	100.0	49.3	50.7	47.3	1.6	1.0	0.9
Under 17 years------	100.0	78.6	21.4	21.0	0.1	0.1	0.1
17-44 years---------	100.0	44.7	55.3	54.2	0.7	0.2	0.3
45-64 years---------	100.0	27.5	72.5	67.9	2.6	1.0	1.0
65 years and over---	100.0	13.5	86.5	66.9	7.9	6.5	5.3

NOTE: For official population estimates for more general use, see Bureau of the Census reports on the civilian population of the United States in Current Population Reports; Series P-20, P-25, and P-60.

FIGURE 3

DISTRIBUTION OF MOBILITY LIMITATION BY RACE

TABLE 3

PREVALENCE OF IMPAIRMENT
BY
RACE

FIGURE 3

DISTRIBUTION OF MOBILITY LIMITATION BY RACE
(1965-1967)

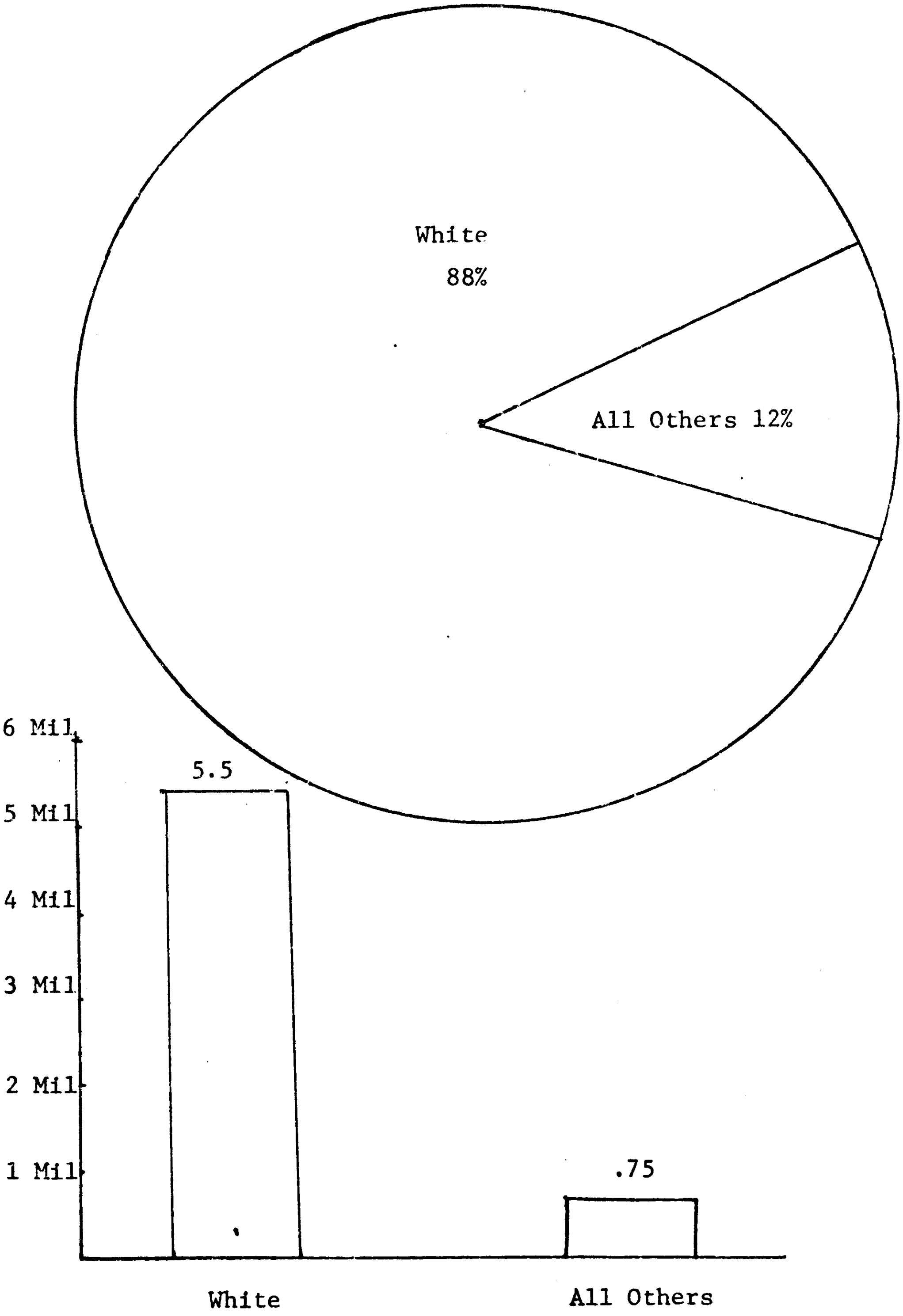


Table 3. Total population and average number and percent distribution of persons by chronic condition and mobility limitation status, according to color and age: United States, July 1965-June 1967

[Data are based on household interviews of the civilian, noninstitutional population. The survey design, general qualifications, and information on the reliability of the estimates are given in appendix I. Definitions of terms are given in appendix II]

Color and age	Total population	Persons with no chronic conditions	Persons with 1 chronic condition or more				
			Total	With no limitation of mobility	Has trouble getting around alone	Needs help in getting around	Confined to the house
	Average number of persons in thousands						
Total							
All ages------	191,537	96,684	94,853	88,541	3,114	1,766	1,432
Under 17 years------	66,921	51,664	15,257	15,009	90	82	76
17-44 years---------	67,901	31,188	36,713	35,865	539	163	147
45-64 years---------	38,993	11,278	27,714	25,816	1,124	407	367
65 years and over---	17,723	2,553	15,169	11,852	1,361	1,114	843
White							
All ages------	168,592	82,885	85,707	80,161	2,760	1,522	1,264
Under 17 years------	56,997	43,578	13,419	13,207	80	73	59
17-44 years---------	59,968	26,809	33,159	32,464	443	134	119
45-64 years---------	35,299	10,133	25,167	23,499	998	343	327
65 years and over---	16,327	2,365	13,961	10,992	1,239	972	759
All other							
All ages------	22,946	13,799	9,147	8,380	355	244	168
Under 17 years------	9,923	8,086	1,837	1,802	*	*	*
17-44 years---------	7,933	4,379	3,553	3,401	96	*	*
45-64 years---------	3,693	1,146	2,548	2,317	126	65	40
65 years and over---	1,396	188	1,208	860	122	142	84
	Percent distribution						
Total							
All ages------	100.0	50.5	49.5	46.2	1.6	0.9	0.7
Under 17 years------	100.0	77.2	22.8	22.4	0.1	0.1	0.1
17-44 years---------	100.0	45.9	54.1	52.8	0.8	0.2	0.2
45-64 years---------	100.0	28.9	71.1	66.2	2.9	1.0	0.9
65 years and over---	100.0	14.4	85.6	66.9	7.7	6.3	4.8
White							
All ages------	100.0	49.2	50.8	47.5	1.6	0.9	0.7
Under 17 years------	100.0	76.5	23.5	23.2	0.1	0.1	0.1
17-44 years---------	100.0	44.7	55.3	54.1	0.7	0.2	0.2
45-64 years---------	100.0	28.7	71.3	66.6	2.8	1.0	0.9
65 years and over---	100.0	14.5	85.5	67.3	7.6	6.0	4.6
All other							
All ages------	100.0	60.1	39.9	36.5	1.5	1.1	0.7
Under 17 years------	100.0	81.5	18.5	18.2	*	*	*
17-44 years---------	100.0	55.2	44.8	42.9	1.2	*	*
45-64 years---------	100.0	31.0	69.0	62.7	3.4	1.8	1.1
65 years and over---	100.0	13.5	86.5	61.6	8.7	10.2	6.0

NOTE: For official population estimates for more general use, see Bureau of the Census reports on the civilian population of the United States in Current Population Reports, Series P-20, P-25, and P-60.

4. Impairment by Family Income and Age (see Figure 4, Table 4, pp.55-58)

There is an inverse relationship between prevalence of mobility limitation and family income. Generally, this is true for all severities of mobility limitation. Whereas 9.4 % of those with incomes under $3,000 reported some mobility limitation, only 1.7% of those with incomes over $15,000 reported the same. Although these figures are influenced by the disproprotionate percentage of elderly people in the low income bracket, they do represent in part the limited employment opportunities open to those with mobility handicaps. (An "age-adjusted" summary table appears at the end of this section, which more accurately represents the relationship between mobility impairment and family income.)

5. Impairment by Age and Employment Status (see Fig. 5 & Tab. 5, pp.59-61)

The currently employed have the lowest proportion of persons with limitation of mobility (.1 per cent). Those not in the labor force have the highest (2.7 per cent).

Restated this means that, proportionately, 27 times as many persons outside the labor force as inside have mobility handicaps.

6. Impairment by Geographical Distribution (see Fig. 6 & Tab. 6, pp 62-64)

The South Region of the U.S. (See Figure I-3) has relatively more persons with limitation of mobility than any other region - both in crude percentages and "age-adjusted" percentages (See Summary Table 7,p68) The Northeast Region has slightly smaller percentages.

FIGURE 4

DISTRIBUTION OF MOBILITY LIMITATIONS BY FAMILY INCOME

TABLES 4A & 4B

PREVALENCE OF IMPAIRMENT
BY
FAMILY INCOME AND AGE

FIGURE 4

DISTRIBUTION OF MOBILITY LIMITATION BY FAMILY INCOME (1965-1967)

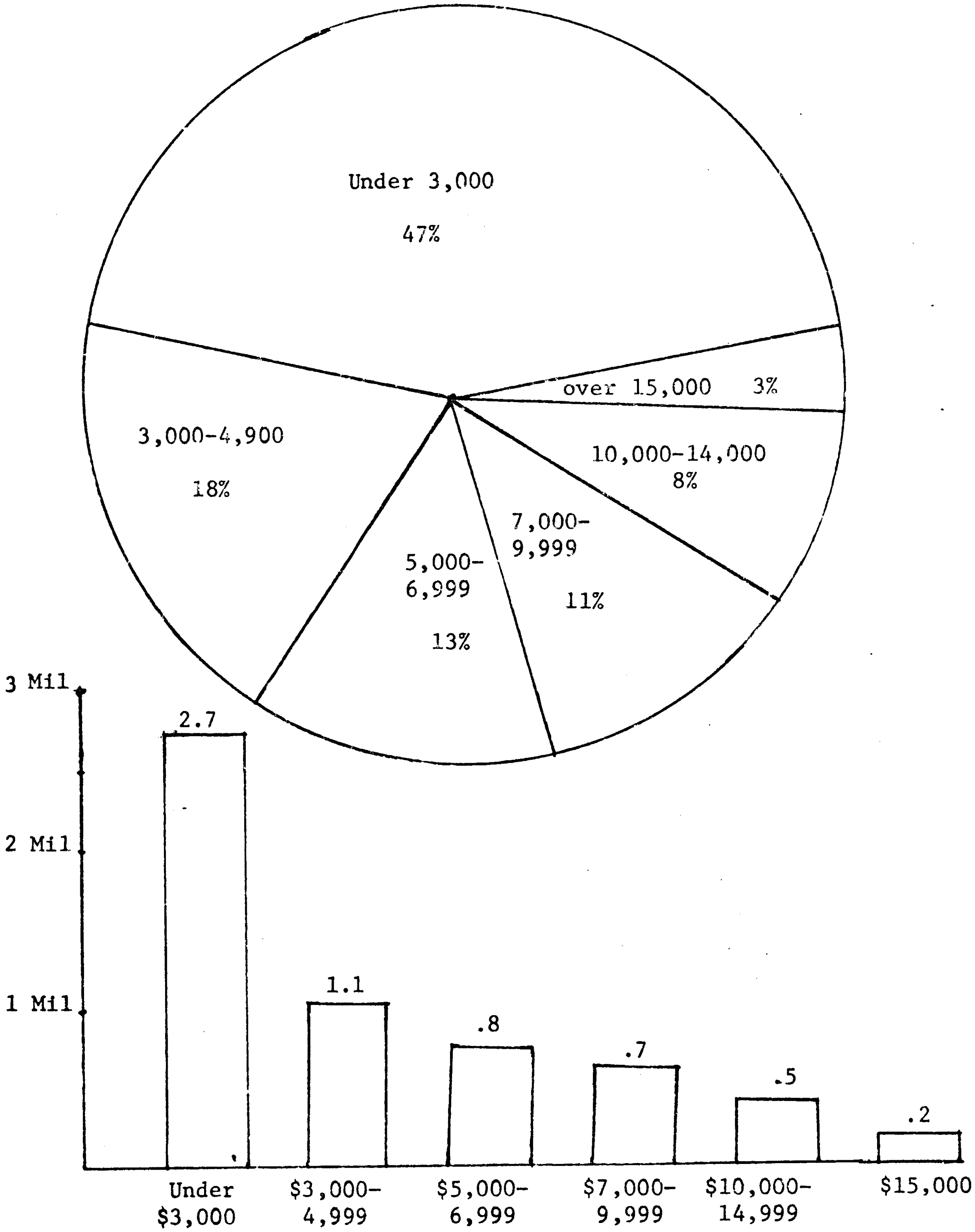


Table 4a. Total population and average number of persons by chronic condition and mobility limitation status, family income and age: United States, July 1965-June 1967

[Data are based on household interviews of the civilian, noninstitutional population. The survey design, general qualifications, and information on the reliability of the estimates are given in appendix I. Definitions of terms are given in appendix II]

Family income and age	Total population	Persons with no chronic conditions	Persons with 1 chronic condition or more: Total	Persons with 1 chronic condition or more: With no limitation of mobility	Persons with 1 chronic condition or more: Has trouble getting around alone	Persons with 1 chronic condition or more: Needs help in getting around	Persons with 1 chronic condition or more: Confined to the house
	Average number of persons in thousands						
All incomes[1]							
All ages-----	191,537	96,684	94,853	88,541	3,114	1,766	1,432
Under 45 years-----	134,822	82,852	51,970	50,874	629	245	223
45-64 years--------	38,993	11,278	27,714	25,816	1,124	407	367
65 years and over--	17,723	2,553	15,169	11,852	1,361	1,114	843
Under $3,000							
All ages-----	29,412	11,428	17,984	15,225	1,271	817	671
Under 45 years-----	15,210	9,311	5,899	5,644	130	57	69
45-64 years--------	5,922	1,167	4,755	4,042	402	158	154
65 years and over--	8,280	950	7,329	5,540	739	602	448
$3,000-$4,999							
All ages-----	31,145	15,983	15,162	14,038	586	312	227
Under 45 years-----	21,629	13,869	7,760	7,533	129	52	47
45-64 years--------	6,106	1,608	4,498	4,116	237	75	70
65 years and over--	3,410	506	2,904	2,389	221	185	110
$5,000-$6,999							
All ages-----	37,346	20,338	17,008	16,236	401	182	189
Under 45 years-----	28,558	17,905	10,653	10,445	125	45	38
45-64 years--------	6,972	2,137	4,835	4,575	154	52	55
65 years and over--	1,817	296	1,521	1,216	123	86	97
$7,000-$9,999							
All ages-----	42,001	22,335	19,666	18,984	374	186	122
Under 45 years-----	32,861	19,756	13,106	12,908	122	41	35
45-64 years--------	7,679	2,324	5,354	5,118	152	50	34
65 years and over--	1,461	255	1,206	958	101	95	52
$10,000-$14,999							
All ages-----	30,283	15,637	14,647	14,185	264	109	88
Under 45 years-----	22,896	13,497	9,399	9,265	86	*	*
45-64 years--------	6,438	1,986	4,452	4,304	94	34	*
65 years and over--	950	154	796	616	84	47	49
$15,000+							
All ages-----	13,328	6,665	6,662	6,443	108	75	37
Under 45 years-----	9,095	5,398	3,697	3,654	*	*	*
45-64 years--------	3,583	1,156	2,427	2,354	46	*	*
65 years and over--	649	111	538	435	39	41	*

[1] Includes unknown income.

NOTE: For official population estimates for more general use, see Bureau of the Census reports on the civilian population of the United States in Current Population Reports, Series P-20, P-25, and P-60.

Table 4b Percent distribution of persons by chronic condition and mobility limitation status, according to family income and age: United States, July 1965-June 1967

[Data are based on household interviews of the civilian noninstitutional population. The survey design, general qualifications, and information on the reliability of the estimates are given in appendix I. Definitions of terms are given in appendix II]

Family income and age	Total population	Persons with no chronic conditions	Persons with 1 chronic condition or more				
			Total	With no limitation of mobility	Has trouble getting around alone	Needs help in getting around	Confined to the house
All incomes[1]	Percent distribution						
All ages-----	100.0	50.5	49.5	46.2	1.6	0.9	0.7
Under 45 years-----	100.0	61.5	38.5	37.7	0.5	0.2	0.2
45-64 years--------	100.0	28.9	71.1	66.2	2.9	1.0	0.9
65 years and over--	100.0	14.4	85.6	66.9	7.7	6.3	4.8
Under $3,000							
All ages-----	100.0	38.9	61.1	51.8	4.3	2.8	2.3
Under 45 years-----	100.0	61.2	38.8	37.1	0.9	0.4	0.5
45-64 years--------	100.0	19.7	80.3	68.3	6.8	2.7	2.6
65 years and over--	100.0	11.5	88.5	66.9	8.9	7.3	5.4
$3,000-$4,999							
All ages-----	100.0	51.3	48.7	45.1	1.9	1.0	0.7
Under 45 years-----	100.0	64.1	35.9	34.8	0.6	0.2	0.2
45-64 years--------	100.0	26.3	73.7	67.4	3.9	1.2	1.1
65 years and over--	100.0	14.8	85.2	70.1	6.5	5.4	3.2
$5,000-$6,999							
All ages-----	100.0	54.5	45.5	43.5	1.1	0.5	0.5
Under 45 years-----	100.0	62.7	37.3	36.6	0.4	0.2	0.1
45-64 years--------	100.0	30.7	69.3	65.6	2.2	0.7	0.8
65 years and over--	100.0	16.3	83.7	66.9	6.8	4.7	5.3
$7,000-$9,999							
All ages-----	100.0	53.2	46.8	45.2	0.9	0.4	0.3
Under 45 years-----	100.0	60.1	39.9	39.3	0.4	0.1	0.1
45-64 years--------	100.0	30.3	69.7	66.6	2.0	0.7	0.4
65 years and over--	100.0	17.5	82.5	65.6	6.9	6.5	3.6
$10,000-$14,999							
All ages-----	100.0	51.6	48.4	46.8	0.9	0.4	0.3
Under 45 years-----	100.0	58.9	41.1	40.5	0.4	*	*
45-64 years--------	100.0	30.8	69.2	66.9	1.5	0.5	*
65 years and over--	100.0	16.2	83.8	64.8	8.8	4.9	5.2
$15,000+							
All ages-----	100.0	50.0	50.0	48.3	0.8	0.6	0.3
Under 45 years-----	100.0	59.4	40.6	40.2	*	*	*
45-64 years--------	100.0	32.3	67.7	65.7	1.3	*	*
65 years and over--	100.0	17.1	82.9	67.0	6.0	6.3	*

[1] Includes unknown income.

FIGURE 5

DISTRIBUTION OF MOBILITY LIMITATION BY EMPLOYMENT STATUS

TABLE 5

PREVALENCE OF IMPAIRMENT
BY
EMPLOYMENT STATUS

FIGURE 5

DISTRIBUTION OF MOBILITY LIMITATION BY
EMPLOYMENT STATUS (1965-1967)

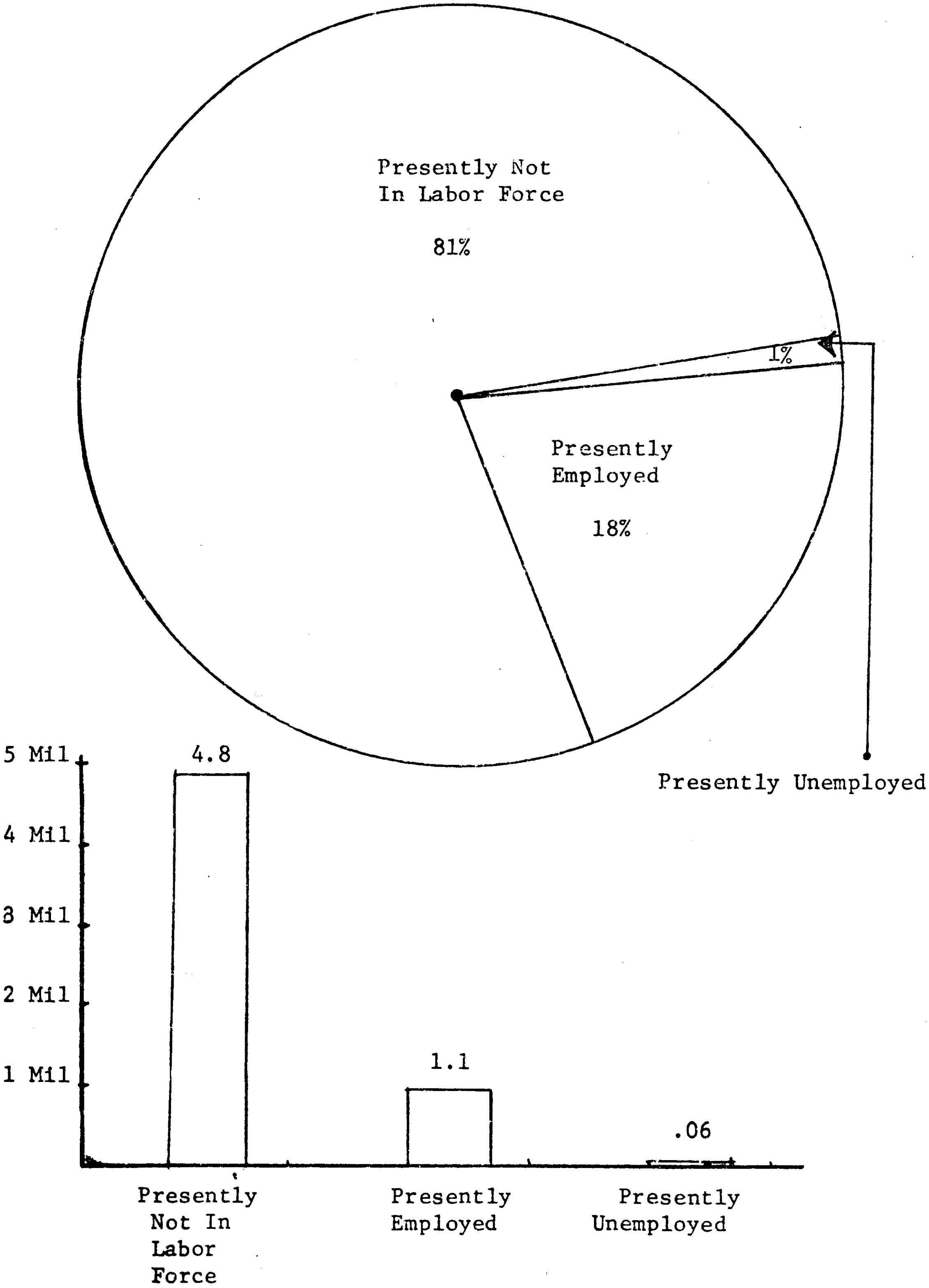


Table 5 Population 17 years and over and average number and percent distribution of persons by chronic conditions and mobility limitation status, according to employment status and age: United States, July 1965-June 1967

[Data are based on household interviews of the civilian, noninstitutional population. The survey design, general qualifications, and information on the reliability of the estimates are given in appendix I. Definitions of terms are given in appendix II]

Employment status and age	Population 17 years and over	Persons with no chronic conditions	Persons with 1 chronic condition or more				
			Total	With no limitation of mobility	Has trouble getting around alone	Needs help in getting around	Confined to the house
All statuses	Average number of persons in thousands						
All ages, 17+ years-	124,616	45,019	79,596	73,532	3,024	1,684	1,356
17-44 years-------------	67,901	31,188	36,713	35,865	539	163	147
45-64 years-------------	38,993	11,278	27,714	25,816	1,124	407	367
65+ years---------------	17,723	2,553	15,169	11,852	1,361	1,114	843
Currently employed							
All ages, 17+ years--	74,031	29,878	44,152	43,037	846	206	64
17-44 years-------------	44,355	20,790	23,565	23,208	277	60	*
45-64 years-------------	26,362	8,420	17,942	17,363	452	96	31
65+ years---------------	3,314	668	2,645	2,466	117	50	*
Currently unemployed							
All ages, 17+ years--	3,009	1,258	1,752	1,651	63	*	*
17-44 years-------------	2,160	1,053	1,107	1,062	*	*	*
45-64 years-------------	740	188	552	507	*	*	*
65+ years---------------	108	*	92	81	*	*	*
Not in labor force							
All ages, 17+ years--	47,576	13,884	33,692	28,845	2,115	1,457	1,276
17-44 years-------------	21,385	9,345	12,041	11,594	234	93	120
45-64 years-------------	11,890	2,670	9,220	7,946	643	302	328
65+ years---------------	14,301	1,869	12,432	9,304	1,238	1,062	828
All statuses	Percent distribution						
All ages, 17+ years--	100.0	36.1	63.9	59.0	2.4	1.4	1.1
17-44 years-------------	100.0	45.9	54.1	52.8	0.8	0.2	0.2
45-64 years-------------	100.0	28.9	71.1	66.2	2.9	1.0	0.9
65+ years---------------	100.0	14.4	85.6	66.9	7.7	6.3	4.8
Currently employed							
All ages, 17+ years--	100.0	40.4	59.6	58.1	1.1	0.3	0.1
17-44 years-------------	100.0	46.9	53.1	52.3	0.6	0.1	*
45-64 years-------------	100.0	31.9	68.1	65.9	1.7	0.4	0.1
65+ years---------------	100.0	20.2	79.8	74.4	3.5	1.5	*
Currently unemployed							
All ages, 17+ years--	100.0	41.8	58.2	54.9	2.1	*	*
17-44 years-------------	100.0	48.8	51.3	49.2	*	*	*
45-64 years-------------	100.0	25.4	74.6	68.5	*	*	*
65+ years---------------	100.0	*	85.2	75.0	*	*	*
Not in labor force							
All ages, 17+ years--	100.0	29.2	70.8	60.6	4.4	3.1	2.7
17-44 years-------------	100.0	43.7	56.3	54.2	1.1	0.4	0.6
45-64 years-------------	100.0	22.5	77.5	66.8	5.4	2.5	2.8
65+ years---------------	100.0	13.1	86.9	65.1	8.7	7.4	5.8

NOTE: For official population estimates for more general use, see Bureau of the Census reports on the civilian population of the United States in Current Population Reports, Series P-20, P-25, and P-60.

FIGURE 6

DISTRIBUTION OF MOBILITY LIMITATION BY GEOGRAPHICAL DISTRIBUTION

TABLE 6

PREVALENCE OF IMPAIRMENT BY GEOGRAPHICAL DISTRIBUTION

FIGURE 6

DISTRIBUTION OF MOBILITY LIMITATION BY GEOGRAPHIC DISTRIBUTION (1965-1967)

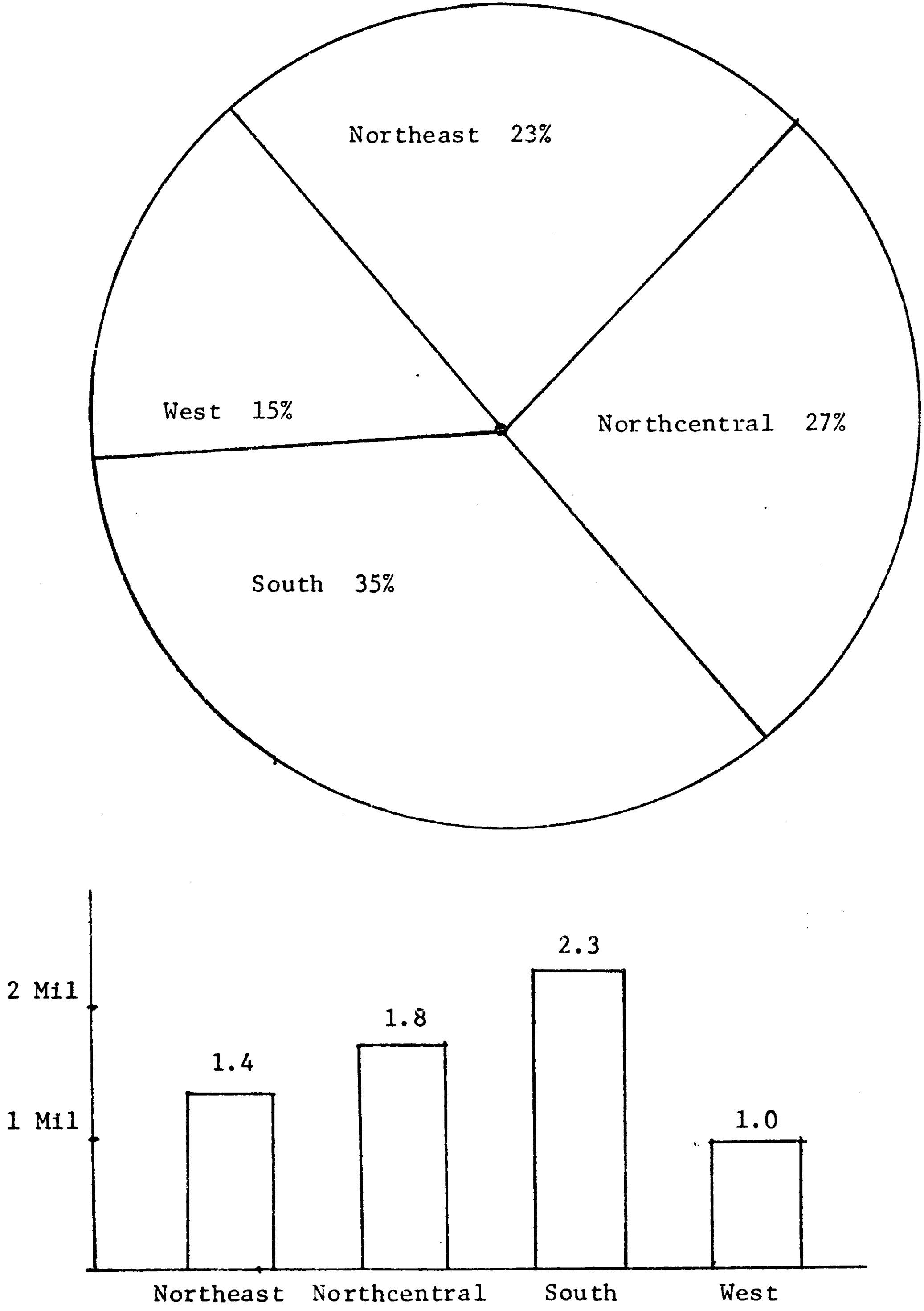


Table 6 Total population and average number of persons, by chronic condition and mobility limitation status, geographic region, and age: United States, July 1965-June 1967

[Data are based on household interviews of the civilian, noninstitutional population. The survey design, general qualifications, and information on the reliability of the estimates are given in appendix I. Definitions of terms are given in appendix II]

Region and age	Total population	Persons with no chronic conditions	Persons with 1 chronic condition or more				
			Total	With no limitation of mobility	Has trouble getting around alone	Needs help in getting around	Confined to the house
All regions	Average number of persons in thousands						
All ages-----	191,537	96,684	94,853	88,541	3,114	1,766	1,432
Under 17 years-----	66,921	51,664	15,257	15,009	90	82	76
17-44 years--------	67,901	31,188	36,713	35,865	539	163	147
45-64 years--------	38,993	11,278	27,714	25,816	1,124	407	367
65 years and over--	17,723	2,553	15,169	11,852	1,361	1,114	843
Northeast							
All ages-----	47,803	25,313	22,490	21,120	629	384	357
Under 17 years-----	15,594	12,202	3,392	3,348	*	*	*
17-44 years--------	16,866	8,443	8,423	8,260	96	35	31
45-64 years--------	10,525	3,732	6,793	6,407	201	97	88
65 years and over--	4,818	936	3,882	3,104	317	234	227
North Central							
All ages	53,471	27,100	26,371	24,614	890	513	354
Under 17 years-----	18,802	14,757	4,045	3,979	*	*	*
17-44 years--------	18,583	8,451	10,132	9,911	137	46	38
45-64 years--------	10,940	3,152	7,789	7,277	316	111	85
65 years and over--	5,145	739	4,406	3,446	413	333	214
South							
All ages-----	58,766	29,214	29,552	27,325	1,075	613	539
Under 17 years-----	21,290	16,396	4,893	4,803	*	30	31
17-44 years--------	21,004	9,478	11,527	11,219	200	54	54
45-64 years--------	11,270	2,809	8,461	7,789	400	139	134
65 years and over--	5,202	531	4,671	3,513	447	390	320
West							
All ages-----	31,497	15,057	16,440	15,483	520	256	182
Under 17 years-----	11,235	8,308	2,927	2,878	*	*	*
17-44 years--------	11,448	4,816	6,632	6,474	107	*	*
45-64 years--------	6,257	1,586	4,671	4,343	208	60	61
65 years and over--	2,558	347	2,210	1,788	184	156	82

NOTE: For official population estimates for more general use, see Bureau of the Census reports on the civilian population of the United States in Current Population Reports, Series P-20, P-25, and P-60.

The National Health Survey "Age-Adjusted" Summary

Unfortunately several of the preceding tables contain slight statistical biases owing to the differing age distribution in the various categorical populations. For example, the category of "persons earning under $3,000" contains a disproportionate number of elderly. Yet the elderly also tend to be the major victims of mobility handicaps. For this reason the statistics overstate the relationship between disability and low income.

To present a slightly more accurate picture of the various relationships between disability and sex, income, etc., I have included an "age adjusted" summary table of the preceding data. (see Fig. 7 & Tab. 7, pp. 66-68

C. Other Estimates

As noted, the figures in the Public Health Survey do not account for the non-civilian or institutionalized sector of the handicapped population. Although these persons are not expected to appreciably augment the size of the private market for adaptive housing, it can be predicted that a limited number of those presently institutionalized might be able to leave the institutions and function on their own, or with families, were satisfactory adaptive housing to be made available. For this reason it is instructive to look at the various estimates made of these institutionalized populations.

The 1967 National Health Survey estimated that there were 554,000 persons in nursing homes throughout the country, of whom 26,000 were suffering from paralysis due to all causes except stroke. It was further

FIGURE 7

CHARACTERISTICS OF THE MOBILITY HANDICAPPED MARKET: SUMMARY

TABLE 7

CHARACTERISTICS OF THE MOBILITY HANDICAPPED MARKET: AGE-ADJUSTED SUMMARY

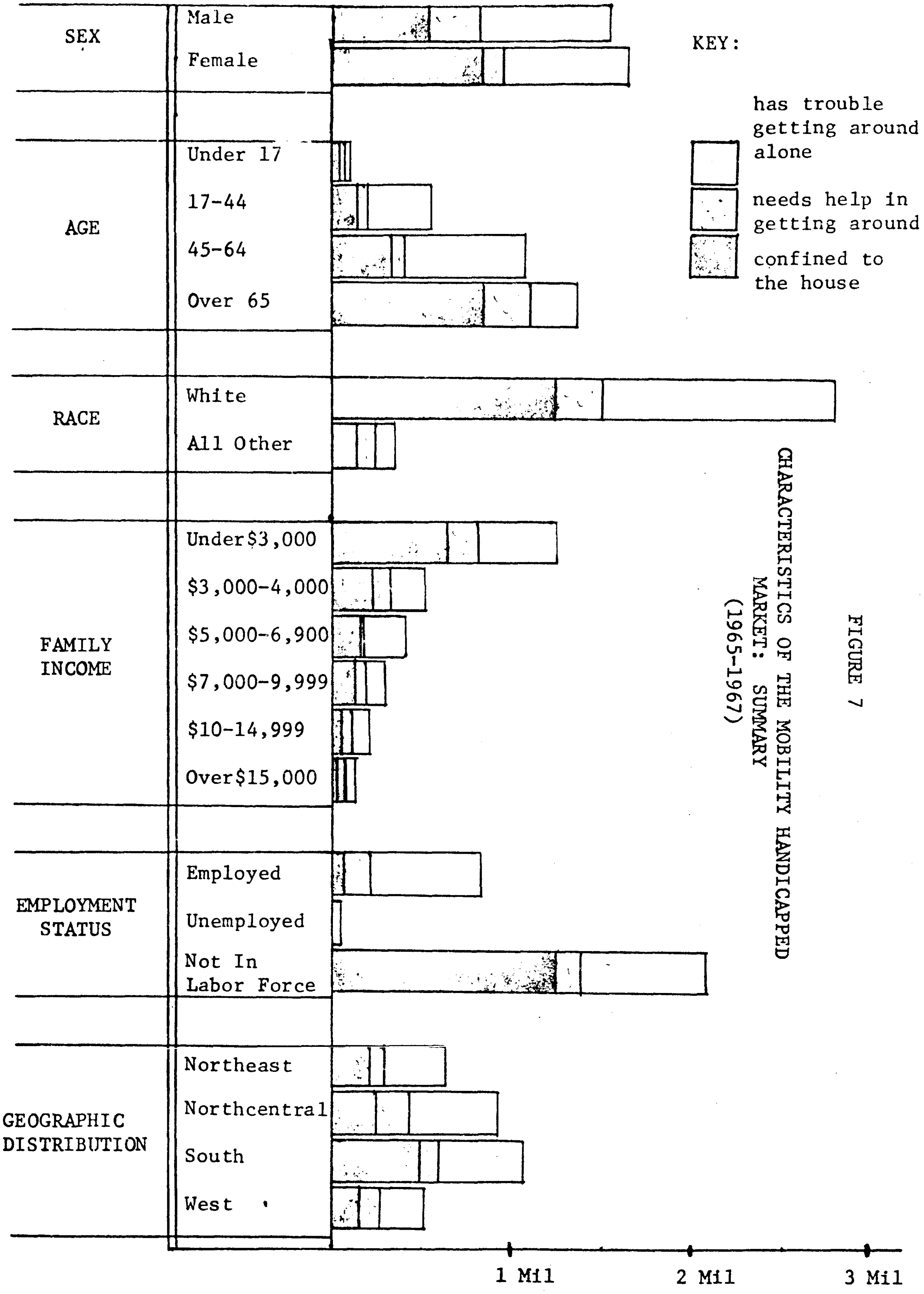


FIGURE 7

CHARACTERISTICS OF THE MOBILITY HANDICAPPED MARKET: SUMMARY (1965-1967)

Table 7. Age-adjusted[1] percent distribution of persons by degree of chronic mobility limitation, according to selected characteristics: United States, July 1965-June 1967

Selected characteristic	All persons	Persons with no chronic conditions	Persons with 1 chronic condition or more				
			Total	With no limitation of mobility	Has trouble getting around alone	Needs help in getting around	Confined to the house
	Percent distribution						
Population, all ages	100.0	50.5	49.5	46.2	1.6	0.9	0.7
Sex							
Male	100.0	50.9	49.1	45.7	1.7	0.9	0.7
Female	100.0	50.2	49.8	46.6	1.5	0.9	0.8
Color							
White	100.0	49.8	50.2	47.1	1.6	0.9	0.7
All other	100.0	55.6	44.4	40.0	2.0	1.5	1.0
Family income							
Under $3,000	100.0	48.2	51.8	46.2	2.8	1.5	1.4
$3,000-$4,999	100.0	51.8	48.2	44.7	1.8	0.9	0.7
$5,000-$6,999	100.0	51.9	48.1	45.3	1.4	0.7	0.7
$7,000-$9,999	100.0	50.1	49.9	47.3	1.3	0.8	0.5
$10,000-$14,999	100.0	49.2	50.8	48.1	1.4	0.6	0.6
$15,000 and over	100.0	50.0	50.0	47.9	1.0	0.8	0.4
Geographic region							
Northeast	100.0	54.1	45.9	43.2	1.2	0.7	0.7
North Central	100.0	50.8	49.2	46.0	1.6	0.9	0.7
South	100.0	48.9	51.1	47.1	1.9	1.1	1.0
West	100.0	47.2	52.8	49.6	1.7	0.9	0.6

---

[1] Adjusted to the age distribution of the civilian, noninstitutional population of the United States.

estimated in the 1970 report "Spinal Chord Injury"[3] that at least 1,800 of these persons along in 1965 were paraplegics or quadraplegics. This report also estimates that there existed in 1965 an additional 1,200 paraplegics in State Chronic Disease Hospitals and another 2,100 in Veteran Administration Hospitals.[4]

It should be furter noted that the Veterans Administration reported an average of 84,000 patients receiving hospital care in V.A. Hospitals in February, 1973.[5]

FOOTNOTES AND REFERENCES

[1] For a variety of convenience reasons, the true market for adaptive housing products is expected to be larger than the disabled market alone.

[2] Use of Special Aids, Rockville, Maryland: Public Health Service, Vital and Health Statistics, Series 10, No. 78, December, 1972.

[3] Sharmon, Graham J. and Kenneth A. Owens, Jr., Spinal Cord Injury: Report to the National Paraplegia Foundation, Bedford, Massachusetts: The Massachusetts Association of Paraplegics, Inc., September, 1970.

[4] Vertans Administration statistics.

[5] Veterans Administration statistics.

[6] American Nursing Home Association (ANHA) statistics.

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MOBILITY: ITS HUMAN COSTS EXAMINED

ENERGY EXPENDITURE DURING AMBULATION

Introduction

Since the concept of getting around usually requires work on the part of the human we are concerned here with (1) how to increase the amount of work the human can do with the residual functional parts of his body and (2) how to decrease the amount of work required by the use of adaptive devices and environmental manipulation.

In order to set realistic goals when structuring environments, we must know how much work normal persons do in the course of everyday activities, how much these work requirements increase for the disabled person and how much this increaae can be lessened by exercise, training and assistive devices.

Terminology

Work is equal to force times distance (Table 1-1). In walking, the force is primarily gravity and friction plus the inertia of acceleration and deceleration. The distance is the up-and-down motion of the body and its separate parts. To diminish the work required for a task such as walking, the force needed is decreased (e.g., by using lighter weight materials for prosthetics), or the distance lifted is shortened (e.g., by providing knee flexion in a prosthesis to decrease the vertical exercusion of the center of gravity). If the person has the energy ro capacity for doing the work required, he may succeed in walking.

Table 1-1 Equivalent Units of Speed, Work and Power

Equivalent Units of Speed

1 mi/hr
= 88 ft/min
= 26.822 m/min
= 1.609 Km/hr
= 1.467 ft/sec
= 0.447 m/sec

Equivalent Units of Work

1 Kcal Cal (kilocalorie or "large calorie")
= 4184 watt-sec (joules)
= 3086 ft-lbs
= 1000 cal (gram calorie or "small calorie")
= 427 Kg-m
= 3.968 BTU (British thermal units)
= 0.00156 hp-hr
= 0.00116 Kw-hr

Equivalent Units of Power

1 Kcal/min (Cal/min)
= 3086 ft-lbs/min
= 1000 cal/min
= 427 Kg-m/min
= 69.733 watts (joules/sec)
= 3.968 BTU/min
= 0.0935 hp
= 0.0697 Kw

<u>Power</u> is the rate of doing work:

$$\text{Power} = \frac{\text{Force x Distance}}{\text{Time}} \qquad (1)$$

The power available, i.e., the rate at which a patient can expend energy for the work of walking, usually limits walking speed. Thus, the rate of energy expenditure in handicapped (and normal) persons is kept at a tolerable level by decreasing the force or distance, or both (the numerator of

Equation 1), or by increasing the time spent on the task (the denominator).

The only source of energy that the human body can use is the chemcial energy contained in complex food molecules.[6] The oxidation of these to simpler substances such as water and carbon dioxide is an exothermic reaction:

$$C_6H_{12}0_6 + 6\ 0_2 = 6\ CO_2 + 6\ H_20 + 686\ \text{Keal/mole} \qquad (2)$$

Glucose + Oxygen = Carbon dioxide + Water + Energy

This overall chemical reactionis in fact the sum of a multitude of individual steps in the reaction, some of which are coupled in the body to other reactions that produce chemical or physical work. The upper limit of possible efficiency is determined by the proportion of these steps that can be usefully coupled. The actual efficiency is always much less than this since a proportion of the work produced is non-useful work, and is thence converted to heat. At rest the available work energy is spent to purchase the displacements from equilibrium that are necessary for life: the maintenance of a pressure gradient in the arterial system, the intra-thoracic pressure viations, which move air in and out, and the ionic gradients across cell membranes, which permit their survival and chemical functioning. The efficiency of muscle action rarely exceeds 25 percent and averages closer to 10 percent, so most of the energy expended during physical exertion is lost as heat; the rest is used to do external work on the environment, which is the object of the exercise.

Units of Measurement

The following units of measurement are used in this chapter: Miles per hour is used as the unit for speed because it is the unit most familiar in the English speaking world. Conversion factors are given in Table 1-1 for other units. The kilocalorie (Calorie, kilogram calorie or "large calorie") is used to express work or energy. Only one kilocalorie is required to lift 3086 lbs 1 foot, or 1 lb 3086 feet, a rather formidable amount of work. Assuming 20 percent to 10 percent muscle efficiency, it would require 5 to 10 Kcal to do this much work, the amount in half a sugar lump.

The rate of work, which is power (Eq. 1), is expressed in kilocalories per minute. One Kcal per min is approximately the basal metabolic rate for an average sized adult. This unitary value is convenient in comparing values during work, which are read directly as multiples of the basal rate. Conversion factors are given in Table 1-1 for some other units of energy that are frequently encountered in the literature on "work physiology" or "ergonomics."

In many people a work rate greater than 5 times the BMR, or 5 Keal per min. usually results in the accumulation of an oxygen debt, with a rise in the serum lactic acid level. Five Kcal per min is about the maximum that one can maintain for several hours. It is this physiological fact that probably sets the limit on "light" industrial work or "comfortable" walking speed (Table 1-2). Brown and Brengelmann[6] have written an excellent, more general discussion of energy metabolism and units.

Table 1-2 Energy Cost of Light Activities in Adults

Activity	Average Energy Cost (Kcal/min/70 Kg)
Sleeping	0.9
Lying quietly	1.0
Lying quietly doing mental arithmetic	1.04
Sitting at ease	1.2 -1.6
Sitting, writing	1.9 -2.2
Sitting, playing cards	1.9 -2.1
Sitting, playing musical instrument	2.0 -3.2
Standing at ease	1.4 -2.0
Walking, 1 mph	2.3
Standing, washing and shaving	2.5 -2.6
Standing, dressing and undressing	2.3 -3.3
Light housework	1.7 -3.0
Heavy housework	3.0 -6.0
Office work	1.3 -2.5
Typing, mechanical typewriter	1.26-1.57
Typing, electric typewriter	1.13-1.39
Walking, 2 mph	3.1
Light industrial work	2.0 -5.0
Walking, 3 mph (average comfortable walking speed)	4.3

Methods of Measurement of Energy Expenditure

The most obvious way to study energy expenditure is to measure the actual work performed, i.e., the force produced and the distance through which it moves. Although this would be difficult for most daily activities, a number of ergometers have been devised to measure human work in such units as foot-pounds. These measure the physical work done but do not indicate the energy cost because of the unknown variable of efficiency. It is these human energy demands during adaptation to physical impairments that are the primary concern in rehabilitation.

Actual energy expenditure during ordinary activities could be determined by measuring any of the elements of Equation 2. For example, the amount of food consumed and metabolized correlates with daily work levels but cannot be measured on a minute-by-minute basis. Variations in eating habits further complicate this method.

Direct Calorimetry

If no external work is done on the environment, the energy produced (Eq. 2) is dissipated as heat and can be measured accurately in a human calorimeter. This is a large, sealed, insulated chamber within which the subject rests or works on an ergometer. The total energy he expends is measured as the calories of heat which must be removed from the chamber to maintain a constant temperature. This technique is impractical for day-to-day clinical studies because of the technical difficulties involved.

Indirect Calorimetry

The estimations of energy expenditure by measurement of the oxygen consumed in Equation 2 was introduced by Atwater at the end of the nineteenth century. An average of 4.83 Kcal of energy are released when 1 liter of oxygen is consumed to oxidize an ordinary diet. This "caloric equivalent" value varies slightly and depends on the specific food molecule in question, averaging 5.05 for carbohydrates, 4.74 Kcal for fats, 4.46 Kcal for proteins and 4.86 Kcal for ethyl alcohol. The use of the standard average value of 4.83 Kcal per liter for the caloric equivalent of oxygen causes inaccuracies no greater than a few percent in a subject having a mixed diet.

Measurement of the oxygen consumption rate under specified resting conditions constitutes the familiar basal metabolism rate test. At rest, body surface area is the body size dimension that provides the most accurate correlation with energy expenditure. Surface area can be predicted from tables or nomograms of height and weight. However, most activities in the environment involve moving all or parts of the body against gravity. During exercise, the total weight of the subject, plus clothing and equipment carried, correlates better than surface area with the energy costs of the activity. Therefore, values used in this chapter for energy costs will be expressed per unit of body weight rather than per unit of surface area.

In most systems used to measure human oxygen consumption the expired air is collected, its volume measured, the expired 0_2 concentration determined and the expired volume of 0_2 subtracted from the 0_2 in the inspired ambient air (20.93 per cent of inspired volume, unless altered by conditions of the experiment). The volume is corrected to conditions of standard temperature (37°C), pressure (760 mm Hg) and relative humidity (zero or dry)-STOD-and expressed per unit of body weight.

The simplest method of collecting expired air is in a large floating bell spirometer if the subject is working in one place, or in a rubber-impregnated canbas "Douglas bag" or neoprene bag if the subject is moving. The bell spirometer provides a direct reading of gas volume; if a bag is used, its contents are later squeezed out through a gas meter to determine expired volume.

Kofranyi and Michaelis (1940) described a small portable respirometer that could be carried on the subject's back like a knapsack. It stored an aliquot of the total expired air in a rubber bladder. This "Max Planck respirometer" has permitted many studies of energy expenditure in actual field situations in industry, athletics and the home. With improvements in the meter and with careful calibration, variability is about ± 4 percent; breathing resistance increases the inaccuracy at ventilation rates above 30 to 40 liters per min.[23] A similar device with lower breathing resistance and higher accuracy has been reported by Wolff.[35] The expired air is analyzed for oxygen content by chemical or physical means.

Carbon dioxide production (Eq. 2) also correlates with energy expenditure, but the relationship varies more with dietary differences. In addition, the body's bicarbonate buffer system allows significant amounts of the gas to be stored during exercise or hypoventilation, causing variations in carbon dioxide output that are unrelated to the instantaneous metabolic level. For these reasons, oxygen consumption is simpler to use as an indirect measure of energy expenditure.

Heart Rate

Although studies of oxygen consumption provide the most accurate estimation of human energy expenditure, it can be measured only a limited number of times on one subject in one day. In studies in which a large number of observations are more important than accuracy, heart rate has often been used as an index of energy expenditure.[21] For a given subject at a given time, heart rate bears a linear relationship to oxygen consumption and correlates with work measurements such as speed of walking or running, work on a bicycle ergometer and rate of stepping up and down (the basis for the Master two-step exercise test[21]). The measurement of heart rate is simple and no special equipment is necessary. It has been suggested as a routine measurement whenever elderly, debilitated or cardiac patients are given therapeutic exercise[1]. The method is also suitable in field situations in which oxygen uptake studies might be impractical. In long-term studies in a remote location, small heart rate counters can be worn by the subject.[3]

The usefulness of heart rate as an index of work level in environmental design is limited because the data on which the norms are based were derived from studies of high work rates in healthy young people, trained athletes or physical laborers. These results are not necessarily applicable to sedentary, elderly or physically handicapped subjects. Indeed, the heart rates of subjects during standardized work are used as an index of physical fitness. The heart rate nomogram of Astrand, which relates O_2 consumption in submaximal exercise to an extrapolated maximum O_2, underestimated actual maximum oxygen consumption by 27 percent in a group of sedentary adults.[31] The inaccuracy increases at the lower work loads characteristic of handicapped persons. At low work levels, heart rate can vary independently of energy expenditure, under the influence of such factors as cardiac disease, drugs, fatigue, emotion, time since last meal, total circulating hemoglobin, hydration, ambient temperature, posture, body build and per cent body fat.[31]

Heart rate, as well as blood pressure, rises more when a given rate of work is being done by the upper extremities (e.g., crutch walking) than by the lower extremities (e.g. normal walking). This is probably due to the fact that when a muscle contracts with a given percentage of its maximum force, the effect on blood pressure is approximately the same as during the same percentage contraction of any other muscle.[19] Thus the smaller arm muscles contract more markedly and have a greater stimulating effect on the cardiovascular system than do the larger leg muscles doing the same work. This should be borne in mind when persons having cardiovascular disease are being considered for an environmental design because of their hand-held ambulation aids, wheelchairs[16] or any forceful arm and hand exercises. Just as isometric exercises also produce more cardiovascular effects than isotonic exercises and may be dangerous in certain conditions in which cardiovascular stress must be minimized.

Pulmonary Ventilation

Pulmonary ventilation rate correlates fairly closely with energy expenditure at medium work rates, if a predetermined regression line for each subject is used.[13] A simple flow meter mounted on a face mask has been described for long-term recording of pulmonary ventilation to estimate caloric expenditure.[5] However, as with heart rate, ventilation rate is mainly useful when the need for simplicity outweights the need for accuracy.

Control of Speed

Energy expenditure varies directly with the rate or speed of performance of an activity. Therefore, data on energy costs mean littlewithout a known, constant rate of work. A metronome may be used to control the speed of a repetitive activity such as stair climbing, weight lifting, or shoveling.

For work on an ergometer, speedometers or resistance guages indicate the work rate. In walking, the rate may be controlled by a motor driven treadmill.[12] However, many persons cannot use the treadmill because of locomotor handicaps. Most studies of the energy cost of handicapped ambulation have been done on smooth level floors, and the average speed determined by dividing distance walked by elapsed time. Fatigue toward the end of such a test is likely to decrease the speed of the subjects. Since the relation between energy cost and walking speed is not linear, energy cost determined under conditions of varying speed does not truly correspond to the average speed. In studies in which two different modes of ambulation are compared, any improvement in walking skill, as with a better prosthesis, may allow the subject to increase his walking speed, but the energy expenditure at the higher speed may be the same or even higher when utilizing the improvement. To avoid this and to control the variable of speed, a velocity-controlled cart has been developed which accurately controls walking speed at preset rates over any type of terrain while measuring oxygen consumption.[8] This system has been used to evaluate the energy advantage of brace modifications in hemiplegia, to compare paraplegic crutch-walking with wheelchair ambulation at the same speed, and to study prosthetic modifications, crutch and wheelchair ambulation in amputees.[9,10,34]

Energy Expenditure By Normal Persons

Rest

The basal or resting metabolism per unit of body size is low at birth.

reaches its peak around age two, declines by 30 percent during the growing years and by another 10 percent during adulthood. At every age females tend to have about a 10 percent lower metabolic rate, whether at rest or during work. This probably results from the female's higher proportion of body fat, which has a lower metabolic rate than most other tissues. The metabolic rate increases about 10 percent for every degree centigrade rise in body temperature above normal. Cooling of the body initiates shivering and thereby an increased metabolic rate as the body attempts to restore or maintain normal temperature. Extreme shivering can increase the metabolic rate to as much as 6 Kcal per min for short periods.

During sleep the metabolic rate is 5 to 10 percent lower than basal, while energy expenditure during sitting or standing is somewhat higher (Table 1-2).

The metabolic rate increases after eating owing to the "specific dynamic action" (SDA) of foods. Proteins have an SDA of about 30 percent of their caloric value; for fats and carbohydrates, the effect is transient and only about 5 per cent of their caloric values. The SDA is unrelated to digestion or absorption of the foods and is probably associated with their intermediary metabolism.[6] To avoid variations caused by SDA, metabolic studies are customarily performed on fasting subjects.

Ambulation

In the past half-century, studies of the energy cost of walking have produced surprisinly similar data. McDonald[22] has tabulated and analyzed data on the energy cost of walking in 8600 subjects from the world literature between 1912 and 1958. Heavy persons use more energy at a given walking speed, but when corrected for the weight of the subjects plus clothing and any equipment carried, the metabolic cost of walking is similar to lighter, normal subjects. Age and height have no effect, but female subjects usually show about 10 percent lower energy expenditures at a given speed.

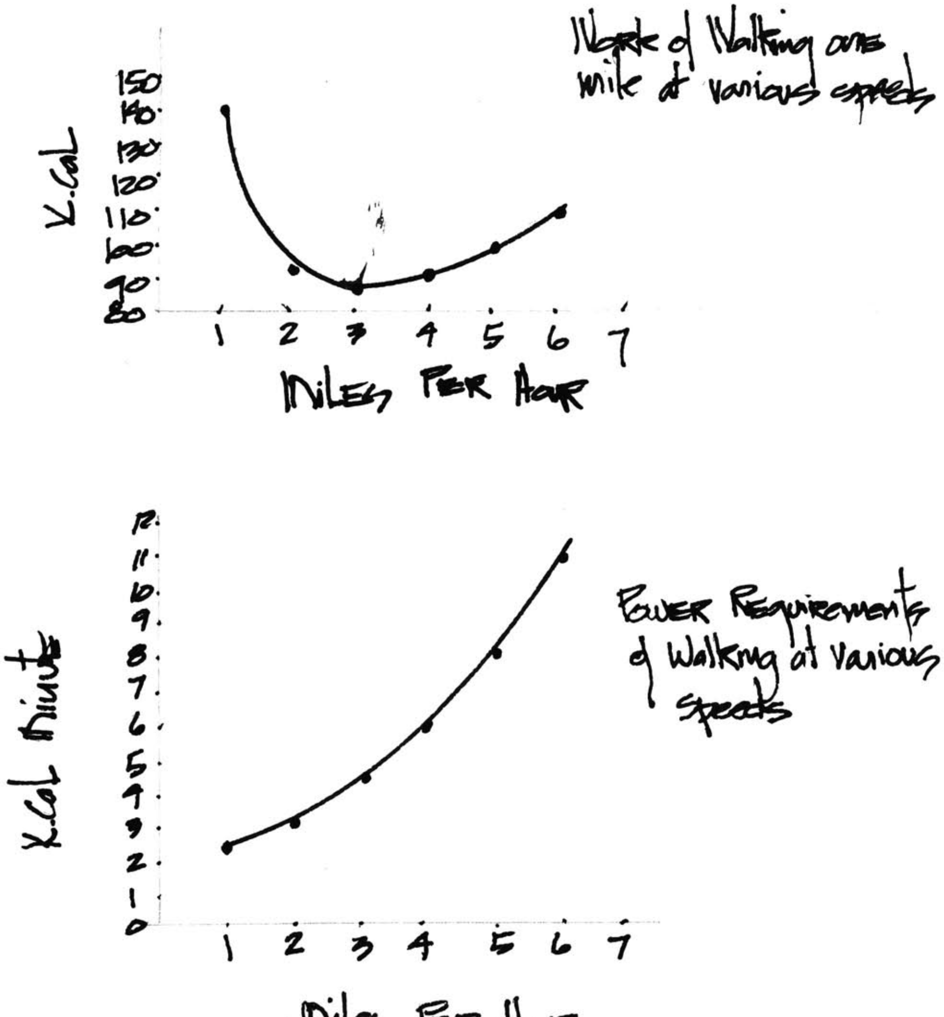

Figure 1-1 The work of walking (upper curve) decreases to a minimum around 3 mi/hr, the average walking speed of normal subjects. However, the power, or work <u>per unit of time</u> (lower curve), increases steadily as walking speed increases. Values given are for a 70-kg man.

The energy demands of walking increase as walking speed increases. This relationship is curvilinear; at faster walking speeds a further increment in speed will necessitate a greater increase in oxygen consumption than at lower speed.[8,28]

$$E = W(.03 + .0035V^2) \qquad (3)$$

where E = energy cost in Kcal per min, W = body weight in Kg and V = walking speed in mi per hr. For each sex McDonald[22] has published other equations which are more cumbersome, but provide greater accuracy at speeds above normal walking speed.

The amount of work done in walking a given distance is greater at very slow speeds than at ordinary walking speeds. The curves in Figure 1-1 are derived from Equation 3 and show that the caloric cost of walking a given distance is lowest at a walking speed of around 3 mi per hr. Several studies show that people spontaneously select this walking speed, presumably because it is

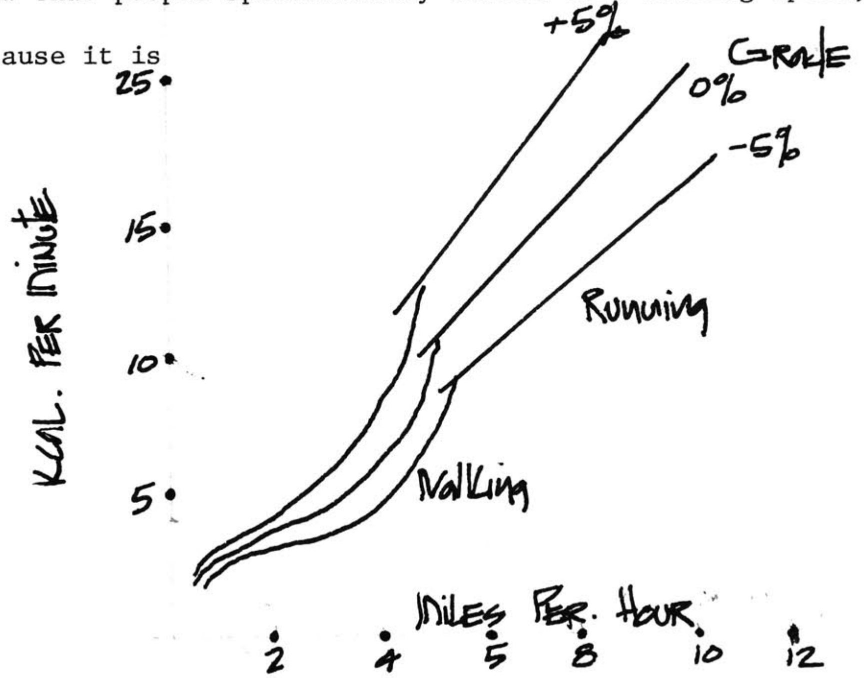

Figure 1-2 The power required for ordinary walking rises sharply at speeds 5 mi/hr, and running becomes less demanding than walking. Note that the relationship is nearly linear for running. The limit to running speed is set by the maximum rate of energy conversion which the subject can attain. (After Margaria, et al.: Energy cost of running. J. Appl. Physiol., 18:367,1963.)

the most economical in caloric cost and does not exceed the 5 Kcal per min limit for sustained work without accumulating an oxygen debt.

Persons with abnormal ambulation also tend to select the walking speeds at which the work of walking the desired distance is minimal.[4] This optimal speed may not be possible if the energy cost exceeds 5 Kcal per min, or if the cardiovascular or respiratory capacity is diminished.[9]

The upper limit of normal walking speed is 5 to 6 mi per hr; beyond this speed one breaks into a run. The energy cost of running is lower than that of walking at speeds above 5 mi per hr. At speeds under 5 mi per hr walking requires less energy than running. The curve of the energy cost of running at various speeds, if superimposed on the non-linear curve for walking in Figure 1-1, intersects the walking curve near the speed of 5 mi per hr[20] (Fig. 1-2). Running on a speed-controlled treadmill provides a way to administer precise doses of work to persons on a cardiovascular reconditioning program.

The energy cost of walking on a 10 to 12 per cent grade is approximately double the energy cost of walking on the level; on a 20 to 25 percent upgrade the rate is tripled. On downgrades the energy cost is lowest at a 10 percent grade and rises again on steeper downgrades. Comparable data for handicapped persons are unavailable except for wheelchair use.[16]

Adding weight to the subject-either extra body weight or clothing and equipment-causes a linear increase in the energy cost of walking. Added loads are carried most efficiently on the head, somewhat less efficiently on the back, still less in the hands, and least efficiently on the feet.

The addition of 2-1/2 lbs to shoe weight can increase the energy cost of walking by 5 to 10 percent. This may be due to the greater gravitational force exerted during the up-and-down excursions of the feet during the gait cycle, as well as to the greater mass that must be accelerated and decelerated at the end of the limb. The implications for prosthetic and orthotic design are obvious.

Soft or uneven ground can increase the energy demands by 40 percent or more; the wearing of high heels (3 inches) can cause a 10 to 15 percent increase. A tight skirt will cause greater work. Handicapped persons usually learn ot avoid these unnecessary sources of additional work. Climbing stairs requires from 6 to 12 Kcal per min, depending on body weight and speed. Descending stairs requires only one-third as much energy.

Differences Between Upper and Lower Extremity Work

Physically handicapped persons are frequently trained to adapt to lower limb impairments by using upper limb muscles with aids such as canes and crutches. Assuming equal efficiency, a given amount of mechanical work requires the same oxygen uptake whether performed by the upper or the lower extremities. Nevertheless, upper extremity work is more stressful in several respects. The smaller muscles of the arm must exert a larger percentage of their maximum contractile force, resulting in anaerobic metabolism at lower work loads and a greater blood pressure response.[19] Hard work with the upper limbs may also require forced breathing against a closed glottis and other interruptions of normal breathing patterns.

In a comparison of work performed on a hand-cranked ergometer with that done on a bicycle ergometer, the work and recovery pulse was significantly higher on the hand-cranked ergometer, althoug the work loads and mechanical efficiencies were the same for both.[2] Similar increases in heart rate were found in crutch-walking versus prosthetic ambulation (39 per cent),[11] and in wheelchair propulsion versus normal ambulation (33 per cent),[16] although the energy expenditures were about the same.

All these factors are compounded when the upper extremities are weakened by disuse or disease, which underscores the importance of maintaining and increasing upper extremity strength during the acute stages of such lower extremities diseases as amputations or fractures.

Energy Expenditure in Handicapped Ambulation

Immobilization of Body Segments

Immobilization and deformity of the joints of the trunk and lower extremities interferes with the harmonious movements of gait.[32] The effects of these deformities are summarized in Table 1-3. The extra energy cost is reduced only slightly by use of lifts to equalize leg length. The angle of a joint fixation is important, and the optimum angles should be sought whenever hip or knee immobilization is unavoidable.[30]

Lower Extremity Amputation

Below-knee amputees have about the same increase in the energy cost of walking as persons with ankle immobilization (about 10 per cent). Little data is available for bilateral below-knee prosthetic users.

The energy cost of walking with above-knee prostheses is 10 to 15 percent above normal in younger and 25 to 100 per cent above normal in older amputees. The energy cost is increased by heavier prostheses, by a more distal placement of the center of gravity and by decreases in alignment stability ("trigger setting" of the knee joint, requiring greater muscular effort to prevent knee flexion in the stance phase of gait).[26] The energy cost of walking with the prosthetic knee locked is about the same as with a free knee in a group of older above-knee amputees at slower speeds.[34]

Table 1-3 Increased Energy Costs Caused by Immobilization and Deformity

Immobilization or Deformity	Approximate % Increase in Energy Cost
Arms taped to sides	N.S.
Body cast	10
Hip spica cast -180°	20
-150°	0-10
-120°	30
Hip arthrodesis (140-160°)	
slow walking speed	0-10
fast walking speed	25
Knee immobilized in cast	
180°, 165°, or 150°	5-10
135°	25-35
One ankle immobilized in cast	6
Both ankles immobilized in cast	9

The alternatives to prosthetic ambulation are crutch-walking and wheelchair use. Crutch-walking requires nearly as much energy as prosthetic use, while wheelchair ambulation by amputees requires no more energy than normal walking at the same speeds.[11,34] The above-knee amputees who succeed in walking usually select lower speeds (average 1.86 mi per hr). but their energy expenditure (3.5 to 4.0 Kcal per min) is about the same as for normal walking at the usual 2.5 to 3.0 mi per hr.[29]

A hydraulic knee unit requires the same energy as a constant friction knee joint at comfortable walking speeds (2.1 mi per hr). but about 10 percent less energy at 2.7 mi per hr, and permits a higher maximum walking speed (3.3 mi per hr) than is possible with the constant friction (2.7 mi per hr).[27] The speed of an above-knee amputee is limited by the resonance frequency of the prosthesis. Persons automatically select the step length at which the energy cost is minimal.[24]

Paraplegia

The energy cost of paraplegic ambulation using crutches is two to four times greater than that of a normal person walking at the same speed and increases rapidly with small increases in speed.[7,10,15] Top speed for most paraplegics is 1 to 2 mi per hr. At a given speed, energy cost of ambulation is greater for paraplegics with higher neurologic levels. The minimum energy requirement is reached after four to six weeks of training, and again rises significantly after a few months' lack of practice.[7] By contrast, wheelchair ambulation requires no more energy than normal walking and allows the paraplegic to maintain the normal speed of other pedestrians.[10,16]

Modification of braces can influence the energy cost of walking. The use of a rigid ankle brace with a firm sole plate lowers energy costs appreciably when compared with a brace allowing free dorsiflexion. The rigid brace lifts the center of gravity passively at the end of the stance phase, so that 1 to 1-1/2 inches less lifting is required by the arms during the swing phase.[18] In another study one patient was found to expend 20 percent more energy when the spinal extension of his pelvic band was removed.[15] In the laboratory, preliminary studies of removal of the pelvic band showed little effect on energy expenditure. Paraplegics seem to select the gait pattern (4-point or swing-through) that for them requires the least energy expenditure.[16]

Hemiplegia

In one series, the energy cost of hemiplegic ambulation averaged 64 percent greater than normal for a given speed, but this could be reduced to 51 per cent above normal by use of a short leg brace.[9] The net effect of hemiplegia is to decrease the walking speed to a point at which the energy demands are tolerable. At comfortable walking speeds, which varied from 1 to 2 mi per hr (average 1.8 mi per hr), the hemiplegics expended almost the same amount of energy as normal subjects at 3 mi per hr. On stairs, hemiplegic subjects use 18 to 35 percent more energy *per step* than normals, but expend approximately the same energy *per minute* because they select slower rates of climbing.[17]

Wheelchair Ambulation

The finding that wheelchair use on a smooth, level surface requires the same or slightly less energy than normal walking explains why "wheelchair independence" is a desirable reality for many persons who are too handicapped to walk.

Slight inclines cause marked increases in the energy requirements. Placement of the large wheel in the rear results in greater steering accuracy, higher efficiency, lower energy expenditure and a smaller rise in heart rate. The average heart rate rises from 90 to 130 veats/min as speed increases to 2.5 mi per hr; this rise is even greater in those patients with involvement of upper extremity or should girdle muscles.[16] Thus upper extremity strengthening is an important part of wheelchair mobility.

Discussion

A large body of data is available on the energy costs of many everyday activities, occupations and sports in normal persons.[14,25,33] Use of this information allows the prescription of known amounts of work, either to increase physical fitness in the healthy or to restore it to normal after illness.

Much less information can be found to guide the rehabilitation practitioner in the management of physical disabilities. When the person also suffers from cardiovascular or pulmonary disease, the need for objective energy cost data is even more acutely felt.

It is hoped that the guidelines given in this chapter will encourage the acquisition of more of this needed information.

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MOBILITY: ITS HUMAN COSTS EXPLAINED

HUMAN FACTORS CONSIDERATIONS

Section I Physiological Characteristics
Subjective Measures

Section II Human Performance Measures

Pedestrian Issues

To accommodate this environmental user - the disabled pedestrian, we must first understand the characteristics of the physiological and psychological market;which in turn, determines the models application. The intent is to help fill the broad gap that exists in the planning and design of building and structuring spaces for comfortable and convenient human use by the disabled. That qualitative design of a pedestrian environment require that basic understanding of related human characteristics and capabilities and limitations. The physical dimension of the body and mobility aid determine working widths and passageways. Psychological preference is a determinant of inter-person spacing zones and other crowded pedestrian environments. The concept of locomotion involves many complex characteristics of balance, timing, and even human sight which are often taken for granted by all but the disabled. Natural free speed locomotion requires special spacial components for pacing and for human sensing and reaction. This locomotion exhibits difficult characteristics on level surfaces and on stairs with the latter requiring much more attention to design because of safety and energy expenditure. The perception of urban spaces is related to its coherence of expression. Confused spacial designs lowers human receptivity to aesthetics and other secondary visual inputs.[1,5]

This process of identifying the human performance characteristics of a disabled user group will identify the human requirements necessary to maintain a sense of human equilibrium; which in turn can be measured against environmental relationships to determine the proper environmental setting. The coordinating process of this man/environment interaction will focus on 4 major pedestrian states: Phsysiological, Subjective, Accidental, Human Performance.

Graphics, Signing, Mapping as Orientation, expression of city function.

Much of the environment goes unused by the physically disabled simply because of ignorance and poor organizational frameworks of the services available. The need for communication networks seems to be a prime modal factor in increasing the mobility needs of the physically disabled. While communications alone will not solve all of the mobility problems of the physical needs, it can be a method of guiding people to the delivery of goods and services.

Mapping as a system of identifying networks

(Communication networks, which we will call "information systems") can widely affect the social, psychological, physiological and cultural latitudes of a physically disabled person. Maps as information systems have the potentiality of operation and performance for substantially improving the environment's responsiveness to user needs by pinpointing, identifying and directing efficiency and delivery processes. An important innovative aspect of an action-oriented map as information system is its close relationship and coordinationto the social needs which include rehabilitative services, as well as to medical and technical, governmental and private groups.

Since past innovations towards design of maps have been limited to relatively minor improvements of selected functions of the existing production and delivery process, the proposed will be an effort to develop strategy with a substantial perspective on user needs which will enable responsible sources to exploit fully their potential for improving responsiveness, efficiency, and performance. One must realize that the implementing of action would include making structural and operational changes in our socio-economic-political environment to create the necessary setting for stimulating radical organizational and technological innovation. There is a deficit of motivation among planners, architects and environmental specialists to obtain an environmental policy which will provide for the independence and mobility of the total population. There is a strong need to advance beyond the minimum standards and approach optimum standards and produce a world which is psychologically, physically and socially a better world for all.

The implications involved in the issue of psychological reaction of the physically disabled to the environment are:

1. The physically disabled individual exists in a social environment whose expectations and evaluations affect him profoundly.
2. The environment relegates him to inferior status and limits his rewards because of his physical condition.
3. In order to understand society's attitude toward him and his limitations, the disabled person may accept or reject the stigma according to his opportunity and intentions.

4. Consequently, the behavior of the physically disabled individual is due not only to society's restrictions on his opportunities, but also his integration of society's values and attitudes into his self-concept.
5. Based on the previous suppositions, changing the physically disabled opportunities will alter not only society's attitude toward his capabilities, but also his own self-concept.

Mobility, as new identity, is qualified by the previous orientation of the psychological meaning of social interaction. It becomes obvious that changes in the physical environment will produce outreaching effects on the social environment. Environmental changes that would allow the physically disabled individual to function in a normal way and to participate more fully in the usual activities of daily living would necessarily affect the number and kind of associations these individuals have with other members of society. The more satisfaction that can be gained from environmental participations, the closer one will approximate a normal life style. The extent to which the environment is maximized to meet these needs depends upon our architects, planners, environmental specialists' work with psychologists, sociologists, elected officials, and all other members of society.[31]

One may infer from this text that while energy as the theme is an important factor in increasing the mobility of the disabled pedestrian. Other factors may outweigh this physical restraint. The psychological stresses, time factors, nature of the trip, public attitudes and environmental setting - weather, supports, orientational topography will have a great affect on the disabled persons considerations of his competince at attacking his setting or trip to new setting.

Elements of Visual Communication by Signs

The following sheets demonstrate the types of matrix analysis that can be used to analyze other components of the environmental framework such as for incidental activities (street furniture, newstands, etc.)

The person - physiological characteristics; sight impairments, color blindness, etc., mental capabilities, education level, memory recall, familiarity, complexity of message content, language difficulties, psychological attitudes, nervousness, uncertainity,

The display - overall sign and type of display, lighted, unlighted, character eye and type, symbolic, geometry, brightness/ contrast resolutes, visual phenomena, habits, coding by color or symbol, number of bits of information esthetic values, letter style, materials, colors,

The location - viewing distance and angle interruptions of level of sight , compacting display, display background relationship, illumination, colors, physical configurations, statement of direction.

These guidelines can be used as ground working policy to establish operational criteria as a process for analyzing, planning, implementation, and as an organizational framework to develop more basic systems criteria. An environmental informat for the physically disabled can be as basic as public education--efficient and critical in orientation, aimed at achieving a sense of security.

To correctly evaluate and further refine these operational criteria into performance standards by which information planners can evaluate alternative actions, a methodological framework must be developed within which operational criteria can have a functional role. For the physically disabled, this means determining the stress points in theprocess of system survival. Further, we have to analyxe the nature of physical disability, its strong points, its idiosyncracies, its needs in physical movement through the environmental system, its psychological aspects in terms of development and understanding of the physiological traits, and of course the many deficiencies due to the social, physical, and psychological structure of our multifaceted environmental system.

Establishing priorities to interpret and define the correlation of information analysis functionally lacked a strong framework for visibility of presentation. To mediate conflicts of interest, environmental information policy must set priorities among various types of information, provide nonoverlapping channels where possible, and establish controls for the access to these channels.

Information as an informant can be most responsive since it can shape answers to the needs and abilities of questioners as well as record their reactions and responses for future reference. The system should be adaptive, growing, and changing in direct response to issues and values defined by people who use it. Beyond this, it may be able to educate the people about culture, variety, economics, and social diversities and adversities. Relations between people and their natural environment can also be described.

Developmental processes, as stated by Ashley, et. al. in City Signs and Lights[3], is the process by which environmental information can be deemed to meet the needs of all interest groups. It must be more politically accountable to public needs and less a function of conventional bureaucratic procedures. Within this context and under the controls of previous operational criterion, they developed a framework tht will allow the best possible analysis of environmental perception for the physically disabled.

Development policy will coordinate a process which looks at levels of statistical interaction. It was found that the necessary functional steps can be seen in terms of:

1. people to people relationships
2. activity to activity relationships
3. people to activity relationships

Within these strata, information can be an effective media in three perceivable states--reflexive information, responsive information and experienced information.

Reflexive information is the non judgmental type which one interprets because of his awareness of his situation. It can be immediately grasped and followed, usually without the need for hesitation, thought, or concentration. Imagery and symbolization are the prime techniques in reflexive information. Its effectiveness as a media is usually displayed in a one-dimensional form.

Responsive information is more perceptive information which gives detailing for scanning and analysis. Interpretation is based on the depth one wishes to scan and the degree to which one seeks some aspect of information. Response may be in audio or visual directions, readings, instructions, posters or pictures. One- or two-dimensional representations are chiefly used to designate this kind of information.

Experienced information becomes a vital resource for the physically disabled because this information is for personal processing. It usually is used as a reference resource to improve one's understanding of issues. It is a clarification media--such as library service, movies, tapes; something that is multi-dimensional in impact and scope which can be stored, viewed, listened to or read, as well as talked about. While this kind of information is more penetrating, it is less confusing becuase there is no time lapes, pressure, or scheduling problems.

While these perception indices may be categorical as to formal language, they posses a harmonic quality, their disposition being the extension of the same system. This implies that environmentally and psychologically the imagery and symbolism of these should be as perceptible and understandable as their message-transfer indications. The function of mode has its implicit degree of interpretation and responsibility to the user. Needs can then be developed on a wide scale of bases and attitudes. Obviously complexity is not inherent in a system of easy and rapid transfer where the greatest impact must be made with the quickest documentation and representation.

Perception limitations will be evolved by the translation of application to decision processes and analysis is in terms of associations, clarity, intensity to functional response, and individual meaning.

INFORMATION HIERARCHY PROCESS

Map Development
Signs Development
Graphics Development

end node
beginning node

Circulation Planning
- Home Range
  - Vehicular Elements
    - Community Network Streets
    - Highway Network (Routes)
    - Interstate (turnpike)
    - City Composition (streets)
- City Range
  - Vehicular Elements
    - Movement Patterns (streets,etc.)
    - Distribution of Generators (rotaries, intersections)
    - Modal Elements (parks, plazas, public transit)
    - Vehicular, Storage (open, closed)
- Street Range
  - Pedestrian Elements
    - Movement Pattern (streets, sidewalks)
    - Distribution of Generators (intersections)
    - Modal Elements (parks, plazas, squares)
    - Storage (bicycles)
- Complex Range
  - Pedestrian Elements
    - Movement Pattern (plazas, corridors)
    - Distribution of Generators (plaza, park)
    - Modal Elements (courts, intrus., etc.)
    - Vehicle Storage
- Building Range
  - Pedestrian Element
    - Movement Pattern (elevators, corridors)
    - Distribution of Generators (Organization/Framework)Offices
    - Modal Elements (Activity Framework (bathroom))
    - Vehicle Storage

end node
beginning node

(this should be cross-tabulated against the type, the display, the location.)

Notes: 1. Hierarchy process/or, the distribution of information whether its signs, maps, guidebooks - overall concept is immediate environment efficiency.
2. The system should feed two ways   no beginning - no end
3. Controlled within this framework is the level of information framework
   1. people to people
   2. people to activity
   3. activity to activity

Section I Physiological Characteristics
Subjective Measures

Aging Symptons

The physiological analysis of what may be termed aged induced phenomena ranges from sensory deterioration, health dificiencies, such as heart condition or lung ailments and changes in physical and perceptual motor capabilities which will affect and effect the activities of daily living. There are a whole series of losses that occur as a person begins to age. These losses can be subsumed under the human development continium and characterized as a loss of continium.[14] These losses increase in severity with each decade of age so that essentially the sensory deterioriation occurs rather serious. Hearing and vision become problems. One's other sensory mobilities deteriorate as well. There are other losses that occur such as deterioration of coordination of muscular skill resulting in a diminished level of independence. So that these factors of deterioration manifest themselves with increasing severity over time. There is a reduction in one's life space (mobility). Qualitatively this means the physiogomy of THE aged individual is subject to a narrowing of the visual field, sensitivity (neurological), sensitivity to brightness, sensitivity to motion, poor night vision and lower tolerance to glare, decreased hearing, reduction of muscular coordination, and normal dexterity, lengthened reaction time, diminished nervous system functioning (especially with respect to balance mechanism), changes in walking gait, relaxed walking speed, increased tendency for dizyiness and faintness, thinning and weakening of the bones (especially females), and greater susceptibility to infection, heart failure and pneumonia and greater tendency to become disoriented.[10,14,15,19,21,22,32(A-F),59]

Behavior responses are brought about by physical changes. The elderly person depends upon his living environment - space and its furnishings to assist him in adjustment to incoming physical limitations. He actually leans on his environment as does a disabled person. If it functions well for him he gains a feeling of security. It may be limited security, but none the less it is a security.

Older Pedestrians

Subjective and Accident Factors

There are some specific and very important reasons for viewing age and pedestrianism within a broad context and for offering the opinion that the subject has implications beyond accident prevention and safety program planning.

Of the aged population more than 24% are below the poverty line and less than 14% are licensed drivers; yet 30% are limited in activity because of chronic conditions. While 80% of the aged population are retired, 95% live in what can be termed the community - not in institutions. Of this group 67% have chronic conditions that do not interfere in mobility and 81% have no limitations in mobility. Only 6% need help of another person, 5% are homebound and 4% are in institutions. These statistics reveal that the elderly are although a poor group very visable, active and mobile sector in our society given the structure of the built environment.[21,32(A-F)]

Although definitive studies are not available, all the evidence currently indicates that persons over 65 constitutes a signficant proportion of all pedestrian traffic fatalities.(Safety Council) Older people constitue approximately 10% of the population but fully 25% of the nation's pedestrian traffic fatalities. There is further evidence increased fatality risk is age rather than exposure associated.[46,57]

The aged-reduced phenomena such as narrowing of the visual field, sensitive to motion and brightness, poor night vision, lowered tolerance of glare, decreased hearing, reduction of muscular skill, endurance, coordination, lengthened reaction time, diminished nervous system functioning and especially with respect to the balance mechanism and accompaning changes in gait may result in reduced walking speed; an increased tendency for dizyness and faintness and other chronic conditions induced by aging.[53,54,56,57]

Yet because the older population is restricted from driving either because of age-induced phenomena, financial status or fixing situation are a trapped group in pedestrianism. Thus if walking is the main mode of transport for elderly, that includes walking to public transport what are the apprehensions.[33,35,37] Most elderly have many environmental fears which are both design and people orientated. These fears range from the fear of falling, being hit by a car, being attacked, becoming lost. Thus there is the fear of the helpless pedestrian.

What can be done? The conditions of walking -- the sidewalks, the pedestrian traffic zones and regulations, the complexity and speed of vehicular traffic and of vehicular and control signals - may further increase the negative reliance of pedestrianism.[33,35,37] We have scores of able engineers and planners who can translate findings on the elderly's physical capacities into sound plans for street design, traffic signal control, pedestrian walkways and the like.[14,19]

The older pedestrian's pedestrianism usually occurs during the daylight hours.[32C] His major trip purpose is not orientated to a place of employment. While many generated trips are centered in the neighborhood residences, many leisurely hours are focused on trips generated to the CBD. More over he may walk with some apprehension regarding his ability to negotiate the physical barrier, lying in his path and his safety.[32B]

Therefore what of pedestrian territory? First it has a significant bearing on the extent to which the older pedestrian will emerge from his role as a "forgotten man." Pedestrianism would give impetus to the debate of the issue of whether it will be recognized as an important short distance transport mode. Secondly, how and in what will the elderly's ease of access to community facilities and services depend. Third, the older person's captivity in pedestrianism, whether accidental or designed, raises a variety of questions about the direction of or for public policies.[33,34,35,37,38]

With this as a focus, then the issue arises of the concept of spatial orgainzation for access and service delivery orientated environments. The development and deterioration of the sensory mobilities is directly related to the concept of viewing the environment as a language and one's ability to perceive and respond to environmental cues.[32A,B] What is the message, The problem is to get the visual, audible, thermal and olfactory messages through to the receiver. What is suggested here is a design concept called redundant cuing. The idea is that in general, a space should have a singular and unambiguous definition and user. Again, the purpose is to compensate with environmental arrangements for lessened sensory activity. The concept has several important dimensions. The first has to do with designing spaces which facilitate individuals with reduced abilities to claim and defend such spaces as their own inviolate spheres.[32B] Thus the environmental framework subsidizes the sensory deterioration, loss continium and deficient modalities which bring us to the concept of therapeutic or service supported environment.

It has been recognized that the elderly are a heterogeneous group varying widely in age, health, functional capacities, socio-economic circumstances, life experiences and life styles, family composition, personality and a host of other dimensions.[32D] Consequently, their needs for success vary. Paralleling these developments has been a growing awareness of the impact of environmental factors on functioning of all human beings. Older people as a group are more vulnerable to environmental barriers, stress, and hazards and have fewer resources with which to cope with them. there is an intimate relationship between the provision of services and the physical environment. Expressed thusly:[32D]

(1) A successful environment may be measured by: (a) the extent to which it aliviates or minimizes the need for services, (b) facilitates the development, maintenance, and delivery of those that are required, and (c) can be flexible in accommodating to the changing service needs of changing elderly individuals and populations.

alleviates ?

(2) Conversely, a criterion of effective services is the extent to which they take note of environmental factors.

(3) Policy (social) is of major consequence as it affect and interfaces with both services and environment.

The task then is to identify and measure the needs quantitatively and qualitively, to find out what works via innovation and systematic experimentation; to evaluate and to implement the knowledge through policy and practice.

The Disabled User

"Handicap"is a broad term describing a wide range of disabilities which means a diminished ability to perform. The term - physically. disabled describes a physical state. We prefer to use this term because it has no environmental connotation,as does the word "handicap." If our environmental obstacles are indicated the term handicap would not apply to this group of people who could then be mobile and independent.

Unlike age-induced psychological phenomena, it is difficult to obtain an accurate picture of the extent and affects of physical disability. Each disorder presents particular symptoms and consequences,and difficulties. These are concerned with mobility, balance, reaching and bending, lifting and carrying, gripping and handling, and general stamina. However, the following section will attempt to give an overall picture of the effect of disability due to disability due to disease on physical mobility.

The Disabling Diseases

It is difficult to obtain an accurate picture of the extent of physical disability in this country due to disease. However, the following section will attempt to give an overall picture of the effect of disability due to disease on physical mobility. The following is based on information obtained from Cofield and Wooten[31]. Only the most common diseases will be discussed.

Arthritis

Characteristics - Painful inflammation of the joints, with some destruction of the joints and adjacent bones, and resulting deformaties. The disease may start at any age, but most often between 25 and 55 years of age. Known causes include infection, injury and degenerative joint disease.

Effect on Mobility - People with arthritis have an impairment of ability to walk or use arms, hands, fingers, with consequent limitation of activities. They have very stiff joints and move slowly, painfully and unsteadily. They have difficulty in climbing high steps and curbs, and in negotiating steep gradients.

Prognosis - Generally the various forms of the disease cause continuing deterioration. Drugs, physical and occupational therapy, and mechanical devices may make the patient more comfortable.

Long-Term Care Needs- Continuing medical care and supervision, physical and occupational therapy, bracing and orthopedic surgery, training in activities of daily living and use of special equipment, help with housekeeping and personal care, transportation, etc.

Cerebral Palsy

Characteristics - Impaired control of movement with lack of control of some or all extremities, involuntary movements, lack of balance and body control; usually associated with injury or illness at birth.

Effect on Mobility - The different types of cerebral palsy may result in weakness, poor balance, wild uncoordinated movement; impairment may also include speech, vision, and hearing problems. Walking and self-care may not be possible.

Prognosis - The condition itself is usually static, but handicaps may impair normal physical growth and development. Life expectancy may be near normal.

Long-Term Care Needs - Continuing medical supervision, with necessary physical and occupational therapy, orthropedic surgery, bracing, counseling,help with personal care, etc.

Multiple Sclerosis

Characteristics - Progressive destruction of the central nervous system from unknown cause, with loss of motor and sensory functions. The disease is characterized by early periods of partial recovery between increasingly severe attacks.

Effect on Mobility - Sclerosis causes paralysis of muscles and disorders of balance and vision, impaired coordination, easy fatiguability, numbness, and some tremor or paralysis. A wheelchair may eventually become necessary.

Prognosis - Attacks may be frequent or infrequent, with years of relatively normal functioning between early attacks. Disability increases after each attack, although life span may be considerable. In rapidly developing cases the sufferer may be permanently confined to a wheelchair within months.

Long-Term Care Needs - Hospitalization may be required during severe attacks; at other times, individual may need medical and rehabilitation care, psychological and social support, help with housekeeping and personal care needs.

Muscular Dystrophy

Characteristics - Progressive degeneration of muscles, with resulting weakness, usually occurring first in childhood or youth. It is more common among males than females. The cause of the disease is unknown, but there is an hereditary component.

Effect on Mobility - Increasing weakness with eventual loss of function in arms, legs, face and/or body, depending upon the particular form of the disease. A wheelchair eventually becomes essential.

Prognosis - There is usually increasing disability and eventual death after five or more years. There is no effective medical treatment.

Long-Term Care Needs - Medical, psychological, and social support for patient and family. Physical therapy, special braces, mechanical aids and help with personal care are usually needed.

Paralytic Poliomyelitis

Characteristics - Paralysis of arms, legs, and/or chest and trunk resulting from infection of the spinal cord.

Effect on Mobility - Loss of functional use of any voluntary muscles of extremities, neck, and /or trunk. Normal physical growth and development may be affected if paralysis occurs during childhood. Wasting and paralysis of the limbs may result in unsteadiness especially on gradients and difficulty in climbing steps. Many people with polio are confined to wheelchairs.

Prognosis - Impairments are usually permanent althoughsome functioning can be improved through early treatment and rehabilitation. With proper care and treatment life expectancy may be near normal.

Long-Term Care Needs - Continuing medical care and rehabilitation; physical therapy; mechanical breathing devices, braces, and other assistive equipment are often required; attendant care and help with activities of daily living and social support are needed.

Disability Through Trauma

Impairment due to unnatural causes accounts for the fastest growing number of physical disabilities. Injury due to trauma may be the result of sporting accidents, automobile accidents, or war. Adding to those permanently injured in WWII or the Korean War, are the large number of returning veterans of the costly Vietnam War.

Paraplegia

Characteristics - Condition that results from injury to the spinal cord at the thoracic or lumbar level (see Fig. 1), depending upon where the injury occurs in the spine (it may also be caused by disease such as cerebral palsy, poliomyelitis, spina bifida, multiple sclerosis and other diseases). It is a paralysis of the legs and lower part of the body, both motion and sensation being affected. The individual has sound use of his upper extremities.

Effect on Mobility - Extent of disability varies, depending on the part of the spinal cord that is damaged and on the attitude and retraining of the patient. Eventually, most paraplegics can be independent with the use of braces and crutches or in wheelchairs.

Prognosis - Impairments are permanent. Life expectancy is near normal with proper care and treatment.

Long-Term Care Needs - Continuing medical and nursing supervision;

training or retraining for patient and family in the prevention of respiratory and urinary infections, bed sores, and further disability from contractures or disuse of limbs.

Quadriplegia

Characteristics - Condition that results from injury to the spinal cord at the cervical level. The upper extremities are affected as well as the lower extremities.

Effect on Mobility - Extent and degree of disability varies, depending on the part of the spinal cord that is damaged and on the attitude and retraining of the patient. Some individuals may be able to use a wheelchair or walk with the help of crutches and attendants.

Prognosis - Impairments are permanent. Life expectancy may be near normal with proper cqre and treatment.

Long-Term Care Needs - Continuing medical and nursing supervision; training or retraining for patient and family in the prevention of respiratory and urinary infections, bed sores, and further disability from contractures or disuse of limbs. Ramps, lifts, and assistance with housekeeping, personal care,social, psychological, and financial problems are often needed.

Hemiplegia

Paralysis of one side of the body. Extent and degree of disability depends on amount of paralysis to affected side. In severe cases both arm and legs are affected and are non-functional. Usually the leg is functional for support with varying degrees of function in the upper extremity.

Amputation

Surgical removal of limb or limbs due to injury or disease. In the case of amputation of the leg, some unsteadiness results, especially on gradients.

The Physically Disabled

Subjective and Physiological Measures

There can be no question of the fact tht the man-made environment has been designed for the young and healthy. By using the ideal human body as a model for the design of built form, architects have excluded many real people -- the short, tall, elderly, those with ambulatory impairments (th wheelchair user, those needing crutches, canes, leg braces), respiratory ailments, etc. from making full use of their environment. In the case of wheelchair users, the exclusion is much more serious, as this group of people are kept from leading what could be a normal life of activity and independence.

An architectural barrier is defined as any man-made or natural obstacke that prevents people from leading normal, active lives. A physically disabled person only becomes physically "handicapped" when he cannot function in our environment because of architectural barriers. Architects and planners have long been unaware and neglient with regard to the large numbers of the physically disabled population and their needs. They have and are continuing to build into their structures elements which have partially, and in many cases, totally barred use of their buildings by those needing to use them. Architectural barriers are not only flights of stairs or too narrow doorways. Curbs, uneven sidewalks, narrow passageways, too heavy doors, out of reach telephones or drinking fountains also fall into this category.[31]

How widespread is the awareness of this problem? In a report by the National Commission on Architectural Barriers to Rehabilitation of the Handicapped, a public opinion poll revealed that 64% of the American people had not thought enough about how the physically disabled manage to get around in their communities to realize that a serious problem even exists.

They were also unaware that the greatest single obstacle to employment for the physically disabled is the physical design of the buildings and facilities they must use. Besides being barred from earning a living, the non ambulatory are excluded from educational facilities, government buildings, commercial activities and so forth. Not many realize that one out of ten persons has some disability which prevents him from using buildings and facilities designed only for the physically fit, and when one adds to this number those who are temporarily confined to a wheelchair or use of crutches due to a fall or skiing accident, it brings the number up to almost everyone having this problem at one time in his life. Even those who are fortunate enough to escape disabling illnesses, will ultimately be caught up to the aging process with accompaning stiffened joints, failing strength, and perhaps respiratory or heart ailments. The elderly are constantly faced with many of the same architectural barriers encountered by the young non ambulatory.

If the disabled population had enough money, they could surmount the architectural barrier problem by having a home, furnishings, and car especially designed to meet their individual needs. However, the vast majority of the disabled are poor. Over half of the families of employable but disabled adults have incomes of less than $4000 a year which is well under the national average. The medical expenses are astronomical, and because the environment and society, in many cases, does not allow a disabled person to hold a job which reflects the individual's educational or intellectual capacities, life becomes a vicious circle. He needs money for the elimination of architectural barriers and resulting mobility; needs a job for money; cannot get a job because barriers make him immobile in the environment.

One point which we feel needs emphasis: <u>everyone</u> will benefit from an elimination of architectural barriers. No one enjoys climbing a flight of stairs, opening heavy doors, tripping up curbs.

The politics, planning and physical evolution of "Environmental Development has failed to recognize, even to consider programming and planning for our physically disabled--the wheelchair users in particular. This has jeopardized their existence in environmental use and the disabled's potential as a productive and contributive force in environmental policy, i.e. design, planning, local and regional organization and politics. This prejudice has left them outside of their own lives dependent on society for their needs, without any claim to their rights. It is observed, compounded and reflected in the attitudes of individuals, in the institutions that house disabled children and adults, in the inaccessible transportation system we build, in the unusable supply of housing stimulated by the public and private sectors of the market, in the physical community design of streets and parks, in the social community design of services and delivery systems, even in the family unit--the home. Daily life for the physically disabled is a continuing process of confrontation, discrimination and segregation.[31]

What design andplanning that is done is rarely implemented to alleviate or prevent physical and emotional hardship (stress), unless of course it is done in light of pregnancy, heart patients, vertigo sufferers, garbage services, or maybe the elderly; but what if you're in a wheelchair or ambulate on crutches or braces? What happens is that you become a loner, a homebody, forced into seclusion, isolated and stranded from your unaccommodating environment--be it your two step, two story townhouse, walkin second floor apartment, in the bedroom of your too-narrow door suburban residence. The logical question would be, why? The response would be performance--no consideration has been given to the environment as a performing agent. Environmental considerations have not been made to the incidence of accidents and tragedies, varieties of body compositions and physical capacities or the aging process so that all persons can perform efficiently and effectively in the environment.

Performance can be measured in terms of energies required to negotiate fluently in the environment. The wheelchair use is constantly confronted by performance codes: in the bathroom too small to permit the wheelchair to enter; in the corridor too narrow to allow wheelchair passage; in the kitchen with cabinets too high to reach, counters too high to use, floor area too small for leg space. While the confrontation begins here in thehome, it is multiplied by the implications of larger environmental strategy and structure. People climb up and down all day, everyday and think nothing of it, but for the physically disabled, the wheelchair user, this means a dramatic difference in getting around. What is implied is a look at the wholistic environmental structure.

Use of and access to this implicitly vertical world promotes an entity--irregular, costly, complicated and confusing for those in wheelchairs whose movement is inherently horizontal. The concept of "getting around" becomes dependent on "good" information as a kinetic force to shape answers to the abilities and needs of questioners and/or on luck for having previous experience of negotiation in the environment--up the curb, up the public steps, up the lobby steps to the elevators; down all again and over to the stores; up the parking lot rim, up the entrance stairs and home, up the garage steps, up the home step. Every trip becomes a task; it decreases the likelihood of independent performance of the physically disabled trip makers, as well as straining their physical and psychological energies. Architectural barriers, transportation barriers, and information barriers mean independent planning, mapping and surveying for procedural encounters for each and every trip of each and every disabled person. Thus this planning eliminates any casual or even social trips to ones of high utility--survival activities. But overall mapping for barriers does not guarantee a successful trip completion. There are service levels to be considered and the support derived from this environmental encounter,i.e. general physical accessibility for wheelchairs, accommodating facilities for biological needs, information of destination, standards of structure and furniture. Environment must fo beyond traditional proviso of environmental knowledge for environmental use, but structure, support and reinforce attitudes toward negotiation of environmental processes. This process as a communication transmittal process is a coordination of a sense of efficiency in environmental use.

These living and travel barriers have broader implications in the context of living in and at a standard of decency. Barriers in the home have the disabled person dependent on family; barriers in the community have the disabled not only dependent on persons outside their community, but stranded or isolated from his living needs--shopping, bank, church, recreation, as well as survival needs--employment, education, medical, legal, and social spheres. The mediating function between citizen participation of the wheelchair user and development process is lack of translation of means, upward and downward flow of information. Communication diverse forces demand analysis and examination of this complex organism, the function of communication, its effectiveness and responsiveness, agency plethora, advocates of public interest and city structure.

Social structuring has strategically aided the barrier concept through its continuing process in environmental design and planning by discriminating against and segregating the disabled in old back rooms, upper floor apartments, nursing homes, institutions, special schools and colonies, thus not having to consider, prepare, plan or design for their physical and social needs. While more often than not, they prepare the disabled in these closed environments for a society that outwardly discriminated against them in the building policy, employment opportunities and living practices, and social integration practices through non governmental action. Socially the disabled chairbound person is thus deprived of fulfilling educational goals, seeking cultural refinement and entertainment and fulfilling the need for human interaction--plagued by the misconception that an injury to the body is an injury to the mind.

People tied to wheelchairs are not satisfied with this mere compensation for disability of life in a wheelchair, but biological cure is not evident for lack of and part of this social strategy to avoid and segregate these problems as part of the discrimination policy. Thus, this segregation has been structured and interlaced such that it reinforces the relationship that promotes these environmental barriers for the physically disabled. Yet they increase the dependency factor of the physically disabled, emotionally stressing and stagnating them. The idea that they need someone to do and to carry them around schools and homes and cities is socially impeding their independence; it is psychologically exhausting, demeaning and physically strenuous.

Approaches to an environment for mobility and independence must presuppose the environment as being a network of the ecological (the relationship of individuals to their physical environment), social, psychological and biological environmental frameworks, the way they interact and function so as to provide for effective and efficient planning which promotes an optimum environment with all men as the measure. This present work will approach the evolution of new design standards, organizational concepts for architects and planners, a useful manual for ambitious physically disabled groups and a social process to amend the nearly irreversible damage of public, social and rehabilitative services. The concept is that as through rational processes, we can approach the technical aspects of the physically disabled person's needs ranging from macro (public) to micro(individual) scales of need.

In order to obtain the needed information, we incorporated the assistance of the system's users, the physically disabled, the wheelchair user, to gain the philosophical and inert knowledge of their user experience. User input is difficult to collect because of themany dissimilarities of our group and given our time, spatial and density concerns. This cross flow of information would establish the criteria and the impetus to propose design solutions and recommendations which should lead to new environmental controls to make our environment more compatible with the physically disabled's psychological and physical capacities and limitations.

Section II Human Performance Measures

Human Performance Measures

The pedestrian system is that of an elaborate, integrated assemblage, consisting of complex physical components and personnel involved in its use, interaction and in its operation. It is proposed that many of the less complex types of systems and types of equipment and situations mentioned above can be also viewed in the systems context. It is obvious that the type of system - the pedestrian system - and its complexity would determine the nature and scopes of the human factors problems associated with it and should therefore influence the nature and scope of the solutions there to. The variations would be expected in the various facets of the pedestrian system development, such as the establishment of goals, the determination of requirements. The allocation of functions to man/versus environment components, the design phases, the evaluation and testing of the system. The variations in these functions include: the user group brought to bear, the formality with the functions as approached; the extent of the deliberation to various alternative solutions. In some circumstances certain functions virtually disappear or, are readily resolved since their solutions are quite obvious. But while some of the phases of the process may be nominal importance in concern, it is nonetheless desirable to consider these various functions in an organized manner. If in the basis of such considerations, it seems in order to bypass some function — to make some on the spot determinates related to it, at least the matter would have been consider judiciously. Such consideration can thus help to avoid decisively default.

The concept that is paramount in the framework of man/environment interaction is the theme that such pedestrian system should be so designed that it capitalizes on the optimiaation to human use and characteristics. This chapter will try to crystallize theneed, procedures and establish general guidelines regarding the major strengths and deficiencies of disabled people and environments associated with pedestrianism. It is not in order to reiterate such information, but it is in order once again to focus on these considerations in the pedestrian system development process.

To know that the disabled have certain capabilities that might be utilized in the pedestrian zone, however — is not enough to provide for adequate human performance on any task, the requirements of the task must be within reasonable bounds in terms of whatever human abilities or tolerances are involved. For example, whatever the nature of the sensory inputs, thestimuli in question must be such that they can be discriminated at acceptable levels of accuracy and speed under the conditions that obtain the performance. Likewise, with any other human capability (decision making, memory, recall, physical responses; communication sets or what not). Thus, the pedestrian system must be within the boundaries of acceptable levels of performance. To put it another way, even in those types of functions where the average pedestrian may excel, it it possible to make demands that exceed their reliable level of human performance.

This information can be of different types including "principles" that have been developed through experienced research, sets of normative data (such a frequency distribution of body size), sets of factural data, mathematical formular theories of behavior, hypotheses and general every day knowledge.

With respect to information that would have to be generated through research (as opposed to experience) information available is very skimpy, in fact, draws pretty much a void.

It is here I shall try to summarize and analyze the many human factors in the pedestrian system and attempt to crystalize procedures for How to Rules to achieve the results of the manufactures analysis.

While this user analysis tends to specualte and analyze in regard to optimizing thepedestrian environment for the least capable or most limiting usage, It is impossible in this thesis since it is an analysis and not a research orientated experiment, to compensate for each and every individual for stated more precisely each and every level of functioning performance. Therefore, I have subdivided the groups into classificaions; but because within each classifications the depending level differs, I shall approach the human performance factors on the basis of the independent individual and his mobility. Assuring his independence and mobility then there are only those factors which may affect mobility performance. (strength, speed, stamina, discrimination, age, etc.).

In order to give the broadest range of mobility performance issues as identified by independent disabled person, I have divided the mobility problems into 3 categories. Age induced mobility phenomena, wheelchair limiting performance capacities, an ambulant disabled support aided mobility limitations.

These categories can be described with no equal proportions in the following 3 classifications. See following page:[2,6]

Classification of Disabled People

Group 1:

Ambulant disabled people, whose power of movement and locamotion are not seriously impaired and who can move about without external aids.

They comprise:

- Persons with circulatory or locomotory defects or deficiency functioning of the lungs. (no high steps)
- Persons with prostheses and or thoses (artificial limbs and wearers of surgical braces.)
- Persons wearing appliance for artificial openings from the intestinal or urinal system through the abdominal wall or with portable urine collecting device (special toilet facilities)
- Persons wtih impaired vision(markings, no obstacles)
- Persons with impaired hearing (acoustics hygiene)
- Aged.

Group 2:

Semi-ambualant disabled people (cane user), whose powers of locomotion are impaired to such an extent that they have to use external walking aids, sticks, elbow crutches, armpit crutches , tripods or wheelframes.

People in this group are often unable, or not easily able to

- Stand by themselves
- Sit down
- Rise from the sitting posture

In addition,the sphincter of bladder may be paraplysed.

Group 3

Non-ambulant disabled people (wheelchiar users) whose locomotion is so impaired that they are unable, or scarcely able to walk and stand by themselves. They can move about.

- Independently;
  - in a wheelchair propelled by means of handrails, if the person retains sufficient functional capacity in his arms
  - in an electric wheelchair if there is still only a little residual capacity.
- With an attendant
  - seated in a special car chair in an ordinary wheelchair

Classification of Elderly

Basic physical limitations of the elderly include one or more of the following:

1. reduced strength
2. slowed reaction time
3. impaired sense of balance
4. reduced sense, sight, hearing, etc.
5. less, mobility, less agility
6. confusion and forgetfulness

At present time these user groups have two options available concerning their environment. 1) to learn to adjust to or live in a reduced environment as a result of physical losses or, 2) to modify the environment to make up for these deficiences.

The problem then is 1) to find alternate devices that improve behavioral and physical space relationships, and 2) to determine how and what to design in the way of formal space and furnishings that will assist in lessening the effects of their physical limitations.

This in then aids in overcoming or preventing certain behavioral problems. Behavioral responses are brought about by physical changes. These uses depend upon their space and its furnishings to assist them in adjustment to their limitations. They actually lean on their environment - this analysis will try to determine the extent to which the leaning can be compensated for.

Sensory Modalities

The sense organs are of course the avenue through which man receives informational input from his environment, and the motor processes are important in his output. With respect to the informational input, much of the information regarding the objects and events in the environment about us comes directly to us through our various sensory apparatuses. Thus a person sees directly the traffic about him and the tenancy of the earth. He hears the engines and with other sense organs he senses the temperature his body posture and many other environmental stimulators. Since some of this information comes to us in coded form it is useful for human factors to know how the sensory mechanisms operate in man and what their capabilities are.

Having stated earlier the physiological, subjective and accident attributes of human factors theory of the elderly and disabled one must then analyze the human performance measures in conjunction with pedestrainism. These attributes are basically concerned with the sense modalites and motor activities of the body functions. Thus before we analyze these user groups in light of their human performance factors, some relative comparison of the advantages and disadvantages of the different modalities may aid in deciding after analysis which modality to emphasize (or in deciding to use different modalities in combination.

Relative Characteristics of Vision,Hearing[1,26,50]

1. Auditory stimuli are essentially temporal; visual stimuli are essentially and characteristically have a spatial quality.
2. Auditory stimuli arrive sequentially in time; visual stimuli may be presented either sequentially or simultaneously.
3. By reason of the sequential presentation of auditory stimuli, they have poor referability; although they can be repeated periodically. Visual stimuli offer good referability, because information can be stored.
4. Auditory offer fewer dimensions for coding than visual stimuli.
5. Auditory offers greater flexibility such as off-the-cuff variations connotations, nuances and inflections; visual stimuli requires advanced coding.
6. The "selectivity" of messages in auditory(speech) offers a time advantage since the pertinent information is already selected for the receiver. With visual searching for the information may be necessary. Such as looking for information from tables, charts, maps.

7. Auditory delivery time is slower than visual.
8. Auditory stimuli are more attention-demanding, the source "breaks-in" on the attention. Visual stimuli do not have a captive audience. The operators must be looking toward thedisplay.
9. Hearing is somewhat more resistant to fatigue than vision.

For our concern in the design of pedestrian systems and informational processes for getting around, it is possible in some circumstances to combine sense modalities to conveying the same information. There is some evidence that with near-threshold stimuli, the use of two types of stimuli slightly increases discrimination. For example, visual acuity can be increased slightly by simultaneious cueing - presentation of sound and touch stimuli. In other words,using two sense modalities in combination usually increases thelikelihood of the signals being detected when the stimuli are at their threshold-values. Thus if visual or auditory or tactile signals are weak, it seems reasonable to believe that the use in combination of two sense modalities would be beneficial. There is no clear evidence to suggest the combinations of signals of different senses are systematically preferable to signals of a single sense.

Since this text deals with human factors of disability. It is of course helpful to have some understanding of the human organism. While, it is not feasible to discuss in detail the aspects of the human organism we shall discuss the human factors areas essential to pedestrianism since these are of particular concern to design problems.

Human Motor Activities

The motor abilities of human beings are of particular pertinence to the field of human factors in connection with physical output - response made with the body members especially in arms, backs. fingers and legs. The abilities (and limitations) of human beings to perform various types of motor actions can have implications relating to three factors of human factors engineering.

1. The design of the components of the environments.
2. The development of the support criteria.
3. Methods, procedures, and sequences for carrying out activities.
    - the physical arrangement of space
    - the associated equipment
    - the materials of use and construction

   The method may involve the direct use of the body (such as moving, assembling) and the use of equipment (which moderates directly or indirectly between the body member and the activity performed.

Note - (1) Since the sense of smell has not found to be an aid or hindrance to the general subject of pedestrianism, it is not voted a major factor under the sensory modalities.

(2) Since the state of the art of tactile (tactual) mobility processing is such a complex and intricate subject in itself and because little research has been made as to how its value could be made more effective for all pedestrians (Because of the difficulty in training those sense modes to

correspond to that sense of stimulation) a brief inference has been made in the summary section of this chapter and the ways of "getting around" for the blind in comparison to the process fór the mobility impaired (namely the wheelchair user). This comparison was done to highlight the crossover of supports (matchup) and the deleterious effects (mismatch) to asses and develop program and policy for pedestrian space management.

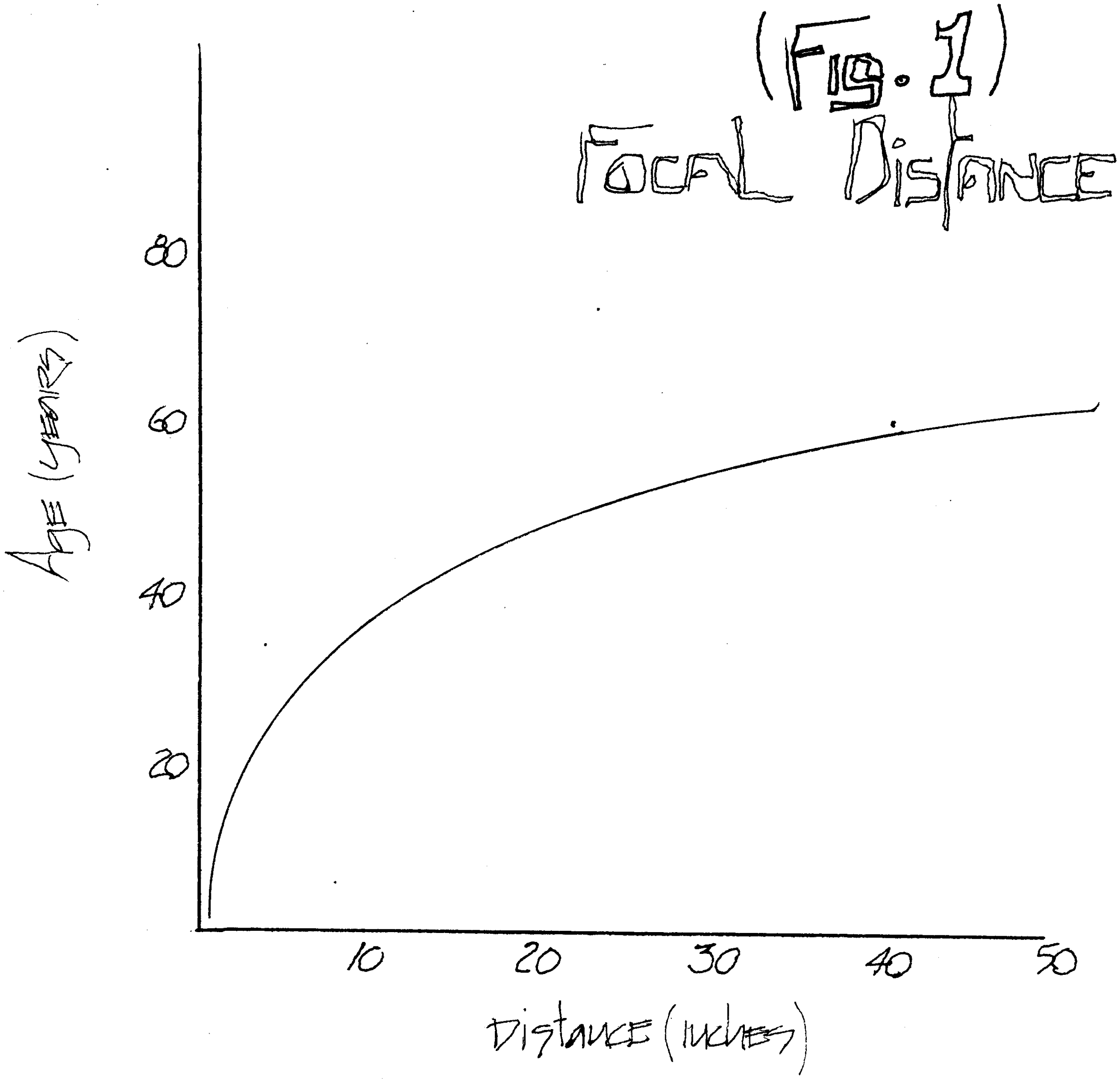
Age Induced Mobility Factors

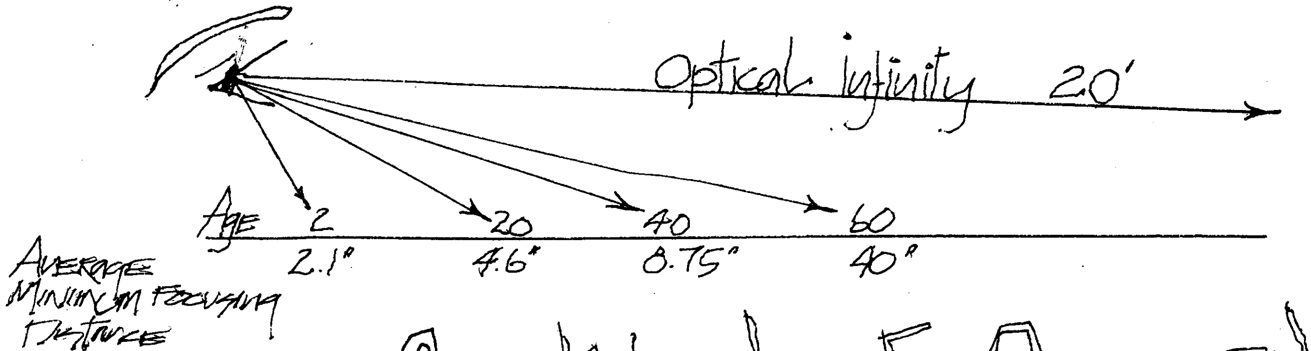
Human Performance Measurement

1. It is estimated that 80% of our knowledge, interaction and stimulus come to us from our visual sensory modal process. As we age this information becomes very obscured and diminished because of a number of physical states which takes place in the eye. These visual disorders can cause serious impairment to mobility because it can affect locomtion balance, the rate and speed of walking, the ability to negotiate stairs and inclines and greatly affect the orientation problem and processing of the aged.[1,32A-F,59] (Fig. 1, p139)

2. The Ability of aged individuals to make visual discriminations is especially reduced becuase of this decreased visual ability or visual skill, which is especially predicated upon their visual acuity. The ability to percive and see black and white detail at various distances, which is caused by the accommodation of the eyes is effected. This accommodation effects the adjustment of the lens in trying to focus the light rays in the retina is caused by a hardening of the lens shield. Aside from individual differences however, there are certain other environmental conditions variables which may affect effective visual acuity. Since this

(Fig. 1)
FOCAL DISTANCE





AMPLITUDE OF ACCOMODATION

acuity is defined by the smallest visual angle to detail that can be discriminated it(acuity) may be affected by 1) brightness contrast - the difference in brightness of the feature of the object bein viewed.[53,54] 2) illumination level, 3) time to see object, 4) brightness ratio, the ratio of the brightness of the object being viewed in relation to that surrounding the object, 5) movement eitherof the object or viewing.[26](Fig.2,14)

2. In turn these eye affixations can affect the visual capacity sometimes called visual fixation in assimilation – the ability of the eye to fixate on an object before one gets a clear image. This fixation time usually lasts 1/4 to 1/5 second. Age causes a reduction in this necessary fixation time such that the eye never calls the exact detail of a true image.[26,30]

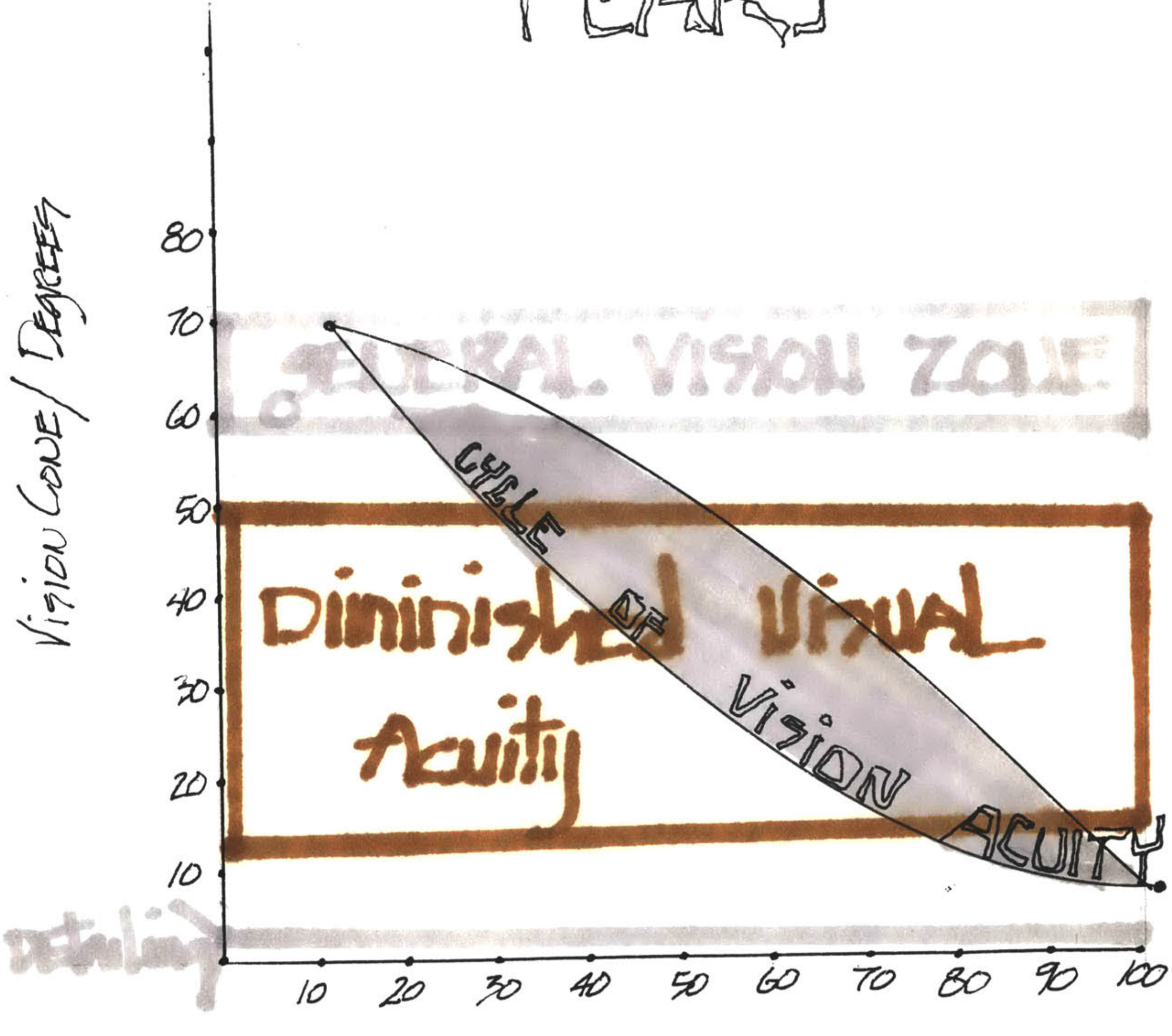
There are other visual skills which are necessary to good vision ability - convergence, depth perception. Color discrimination and dark adaption.[26] Convergence (phoresis) is the ability to bring both eyes into symetrical focus to see an object clearly. This is usually more difficult with aging because of hardening muscles and the inability for quick reflex motion.[53,54]

Depth perception (stereopsis) ability to articulate depth - because this is reduced in the elderly they may base it on the articulateing with the size of an object or context.

Color discrimination is a lack of the discrimintion ability of the light wavelengths by the rods and cones in the eye. Some people blind (not totally) to color because of their inability to achieve angle acuity which focuses

EYE STATE VS. YEARS

(Fig.2)



different color at different angles away from the phorian focus in the eyes. Only about 4-5% of the people are totally color blind.[54]

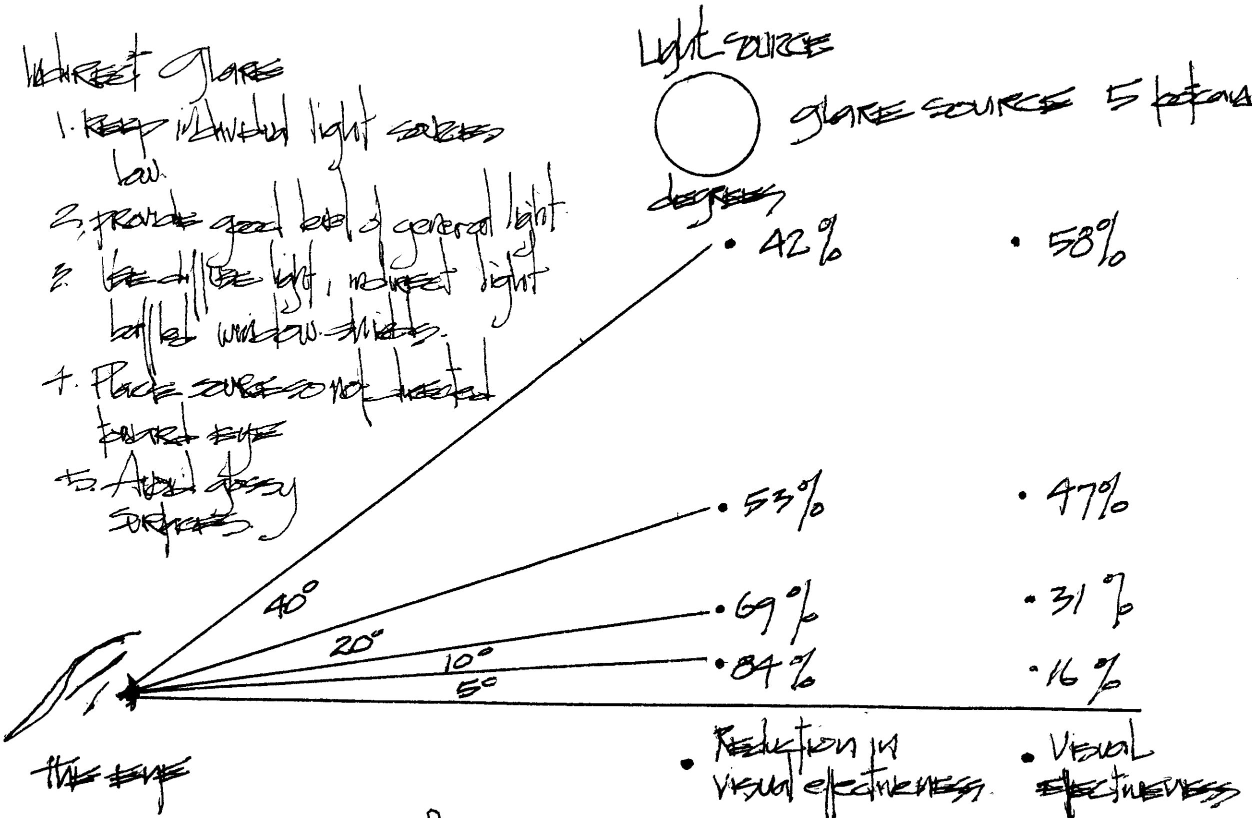
Dark adaption - simply implied but with the elderly the length of time which is usually 15 minutes to adjust from total light to total darkness, is considerably longer than any other age group. Approximately 10 to 15%.[55]

3. While general practice is tending toward increasing the levels of illumination, there remains certain unresolved aspects of illumination practice. There is some evidence to suggest that high levels of illumination may suppress the visual gradient and reduce visual information. This is achieved by suppressing the pattern of density through minimizing the perceived ability to differentiate in shadows.[30]

Other standards for measuring criteria to evaluate the eye, are blink rate, muscular tension, critical levels, and subjective levels. One such measure is glare. While this cause is of course physical the discomfort is essentially subjective.[32A] There are two types of glare, direct glare which is caused by light sources in or near the line of vision and reflected glares, which is caused by lightbeing reflected from a surface to the eyes. Glare in the elderly can effect visual performance and also visual comfort. While some of the discomfort is subjective many of the symptoms are physical, such as fatigue. Direct glare can be minimized by reducing the brightness of light sources out of the line of vision, by increasing the brightness of areas around the glare sources, and by using shields, hoods, prisons and other such devices. Reflected glare can be reduced by keeping the brightness

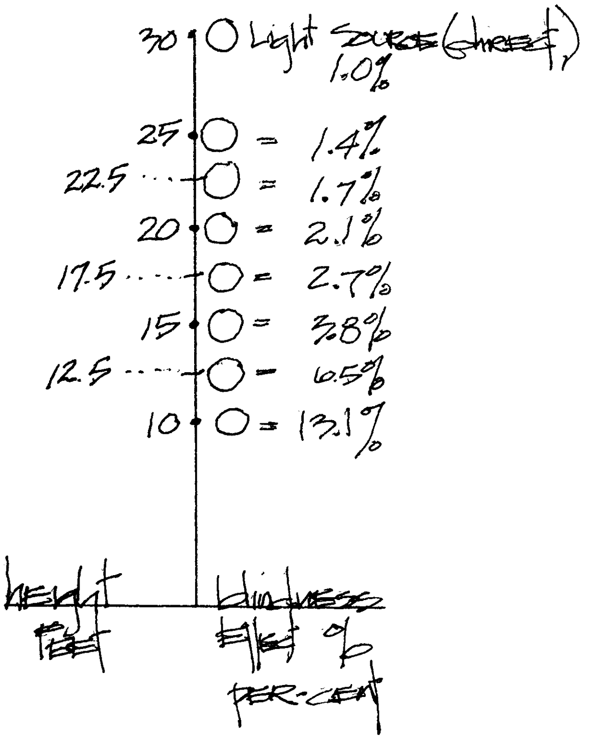
Indirect glare

1. Keep individual light sources low.
2. Provide good level of general light.
3. Use diffuse light, indirect light baffled window shields.
4. Place sources so not directed toward eye
5. Avoid glossy surfaces.



GLARE (fig. 3)

Relative blindness effect



to reduce direct glare

1. Reduce brightness of direct light source
   - ⓐ low intensity lights
   - ⓑ baffles
   - ⓒ diffusers
2. Place light source above 60° angle of horizontal line of vision.
3. Increase brightness of area around glare source.
4. light shields, visors

(fig.4)

Recommended
Relative Legibility of Color Discrimination

Very good	* Black letters on a white background.
good	Black on yellow * Dark Blue on White * Grass green on White
Fair	* Red on White Red on Yellow
poor	Green on Red Red on Green. Orange on Black Orange on White

* Note: because of the effects of glare and effects of visual acuity highly reflective surfaces should be minimized but not reducing the contrast - qualities.

Ex. The assumption that equal visual angles regardless of distance result in equal discriminability.

Contrast - Brightness Ratio $= \frac{B_1 - B_2}{B_1} \times 100$

white = 80
black = 10

$\Big\} = ① \frac{80-10}{80} \times 100 = 88\%$ Contrast

$② \frac{10-80}{10} \times 100 = -700\%$ Contrast

High contrast quality but using the darker surface to avoid glaring reflectance qualities.

of individual light sources reasonably low, by providng good general illumination, by diffusing light, by proper sanctioning of light sources and by avoiding the use of glossy surfaces. While experience and research generally argue for fairly high levels of illumination some evidence suggests more local lighting and less general light may be preferable.[55](Fig.7,143)

4. The brightness or illumination qualities of some lights, however can cause undesirable reactions in people, or may affect visual performance. The reflectance of surfaces determine the utilization coefficient of the light sources. Roadway and street lighting has been found to reduce accidents. Such installations can be designed to optimize visual comfort, and visibility by appropriate 'geometry' of lighting systems, by providing transition lighting, by improved design of luminaries and by the use of more highly reflective road surfaces.(Fig.4, 144)

Visual performance improves with increases in illumination from 10fc to 100fc, although the curve tapers off noticeably around 10fc very slight gains are noticed beyond 20fc.

Measurement of light: 1. candelar (c)

2. candel power (cp)

3. foot candle (c)

4. footlambert (fl)

The candelar is a measured luminar intensity.

Candlepower (cp) is luminous intensity

Footcandle (fc) is a measure of illumination of some given distance from a source when the foot is taken as the unit of length.

The distribution of light follows the "inverse square law"

D = distance in feet $Fc = \frac{cP}{d^2}$

The footlambert is a measure of the photometra brightness (luminance) and is equal to $1/\pi$ candela per sq. ft. Typically used as measure of light reflected from a surface.

Some measurement ratios - brightness ratio[26]

3:1 ratio between area of task and adjacent area

10:1 ratio between area of task and remote area

30:1 ratio between luminous and surface

40:1 pedestrian and visual field.

5. There are 4 major considerations of pedestrian ways:

(1) transition lighting (especially at intersections) to allow for some adaption to the changes in illumination, (2) system geometry using cut-off angle procedures to reduce glare, and luminance refelction is usually about 3.5 times mounting height, (3) improved luminance design to control street brightness exactly under the luminance, (4) roadway surface - asphalt reflects about 8% and concrete about 20%, thus about 2:1 with respect to reflective levels of illumination. the American Standards Association propose .75 and 1.0 fc of 20% and 10% respectively. (Fig. 5, 147)

Thus the required illumination (fc). = $\frac{\text{required brightness (fl)}}{\text{reflectance}}$

In terms of specific procedures:

1. In any given location the seeing task should be studied to determine if more than one is involved. Where a combination of tasks of varying degrees of severity is encountered, select the one that is the commonly used, most

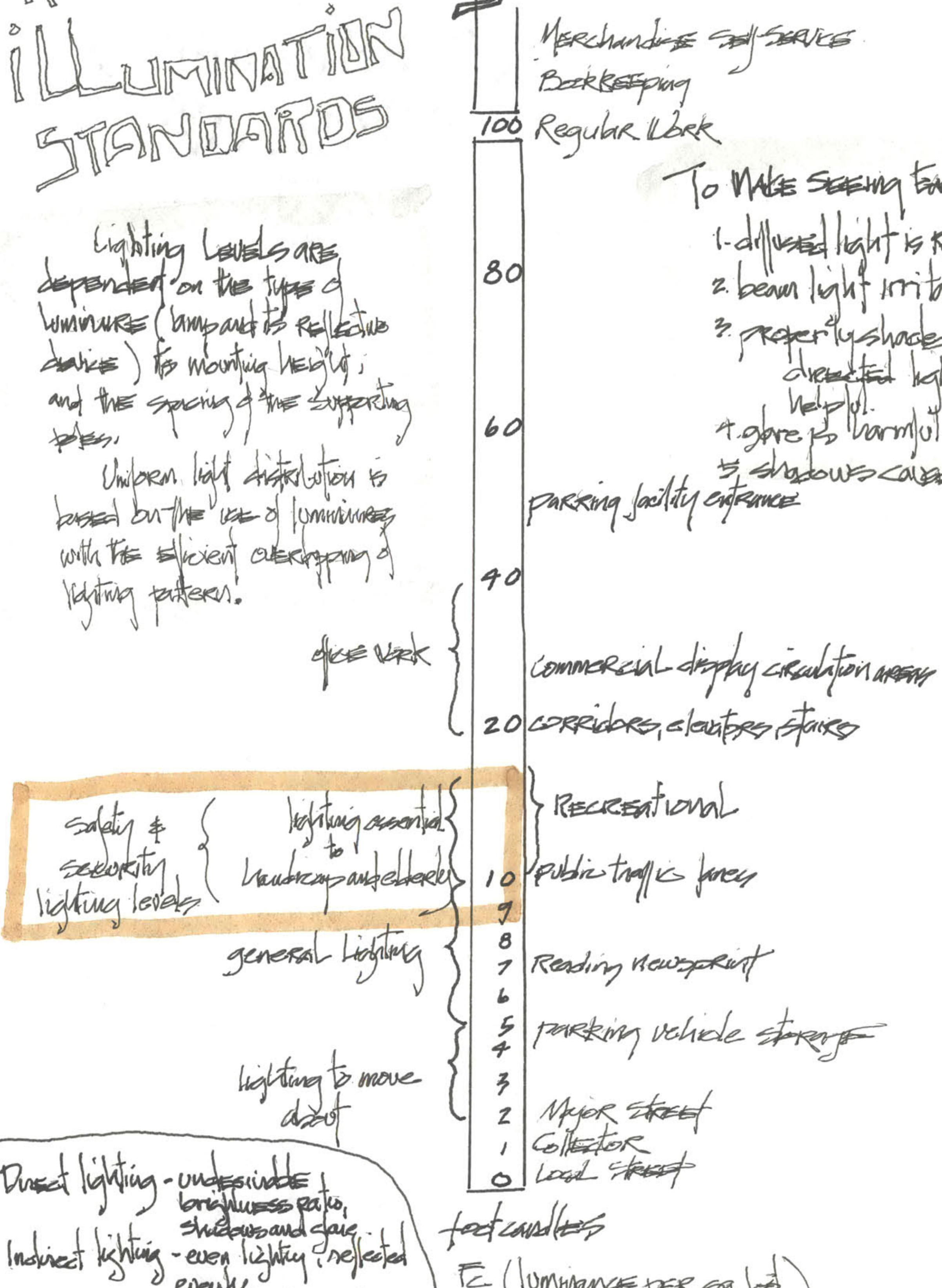
RECOMMENDED ILLUMINATION STANDARDS (fig. 5.)

Lighting Levels are dependent on the type of luminaire (lamp and its reflective device) its mounting height, and the spacing of the supporting poles.

Uniform light distribution is based on the use of luminaires with the efficient overlapping of lighting patterns.

To MAKE SEEING EASIER

1. diffused light is restful
2. beam light irritates
3. properly shaded directed light is helpful.
4. glare is harmful.
5. shadows cause strain



1. Direct lighting - undesirable brightness ratio, shadows and glare.
2. Indirect lighting - even lighting, reflected evenly.
3. Diffuse - requires low wattage, glare and shadows.
4. Ozuku - efficiency is decreased 10% over 3½ hrs.

difficult task.

2. Find tasks that are most nearly comparable to the unrated task and select the corresponding brightness with footlamberts.

3. Divide the brightness by the average reflectance of th unrated task to determine the range of footcandles.

4. In establishing the recommended illumination value engineering judgement based on economic factors should be considered.

5. Consistency of illumination values should be checked.

6. In determing the illumination for service areas, it is recommended that such be not less than one fifth that in adjacent areas and in no case less than 10-12 fc.

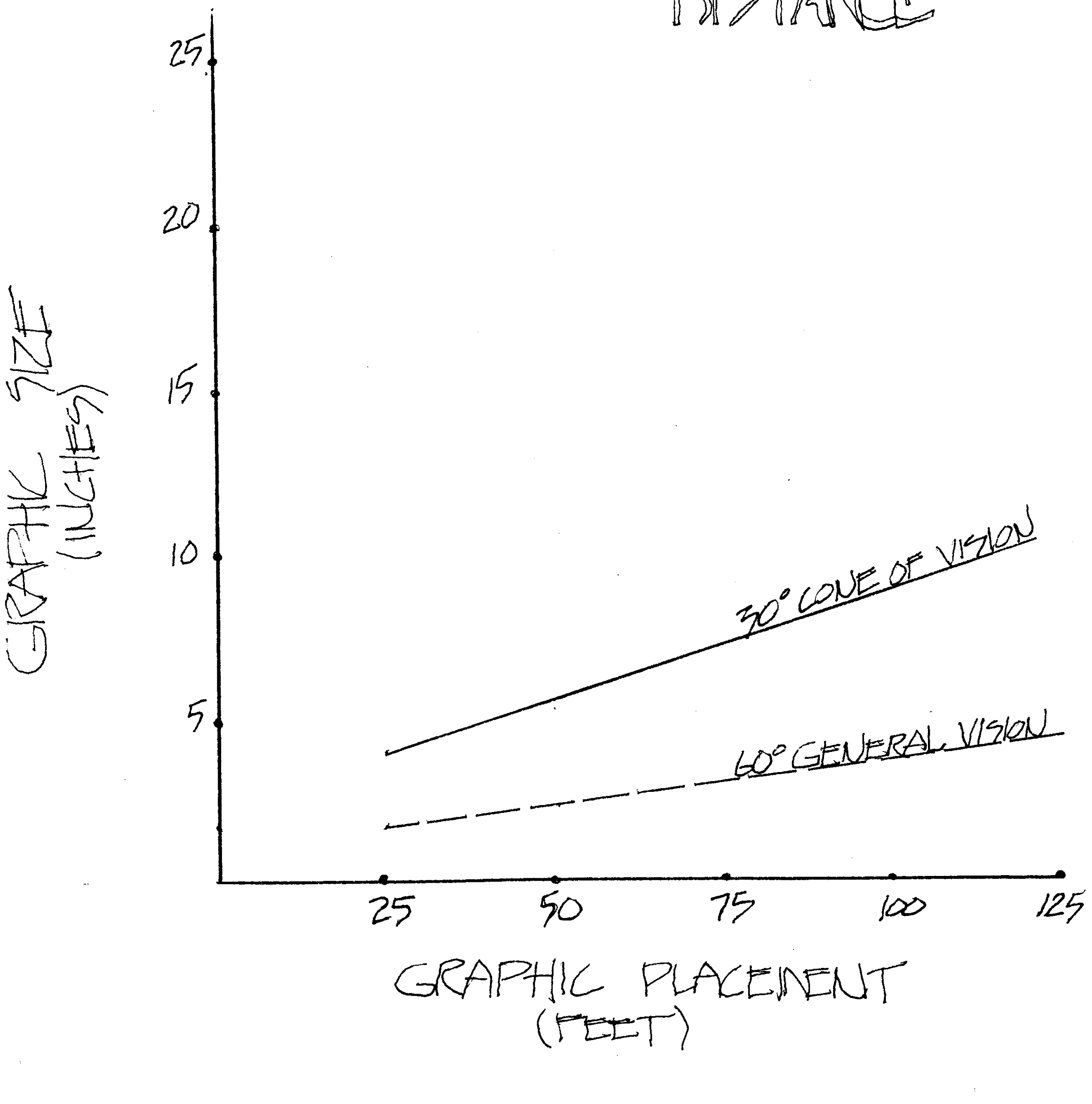
6. Aging thus reduces the ability for navigation using visual perceptors because of the diminished cone of vision. Usually thought to be 30°. In comparison to the healthy eye states:[1] 1. Normal cone of vision 60°-70°, 2. Detailing ability 3°-5°, 3. Eye become less acute as it tends toward 12° to 30°. (Fig. 6. p. 149)

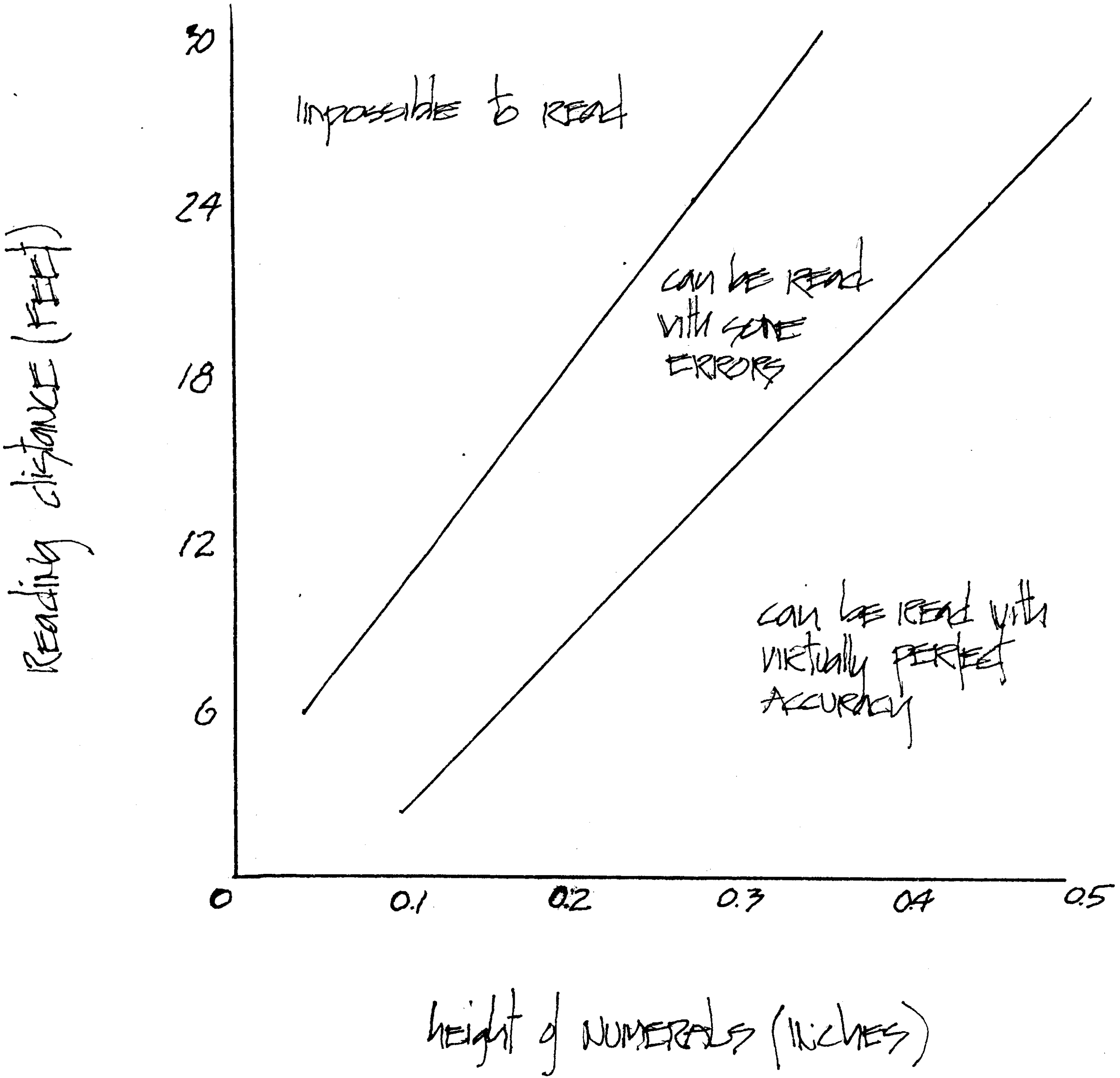
Therefore this inability to achieve proper focal angles increases focal distances which in turn creates longer reaction time. On this basis the ability to perceive perceptual orientation is decreased. This focus affects and in turn is affected by convergence,depth perception and glare. (Fig. 7. p. 150)

Auditory: Hearing is our second most important sense in terms of information gathering. Hearing depends on (1) the ear and its associated neurology (2) the social source, a vibrating body and (3) transmission mechanism. The first is termed the auditory system, the second and third combine to become

GRAPHICS (Fig. 6)

LETTER SIZE VS. DISTANCE





Ratio values Stroke Widths

1:5 Bold
1:6 - 1:10 Medium, Medium Light
1:12 - 1:20 Very Light

(Fig 7.)

Discriminability Relation

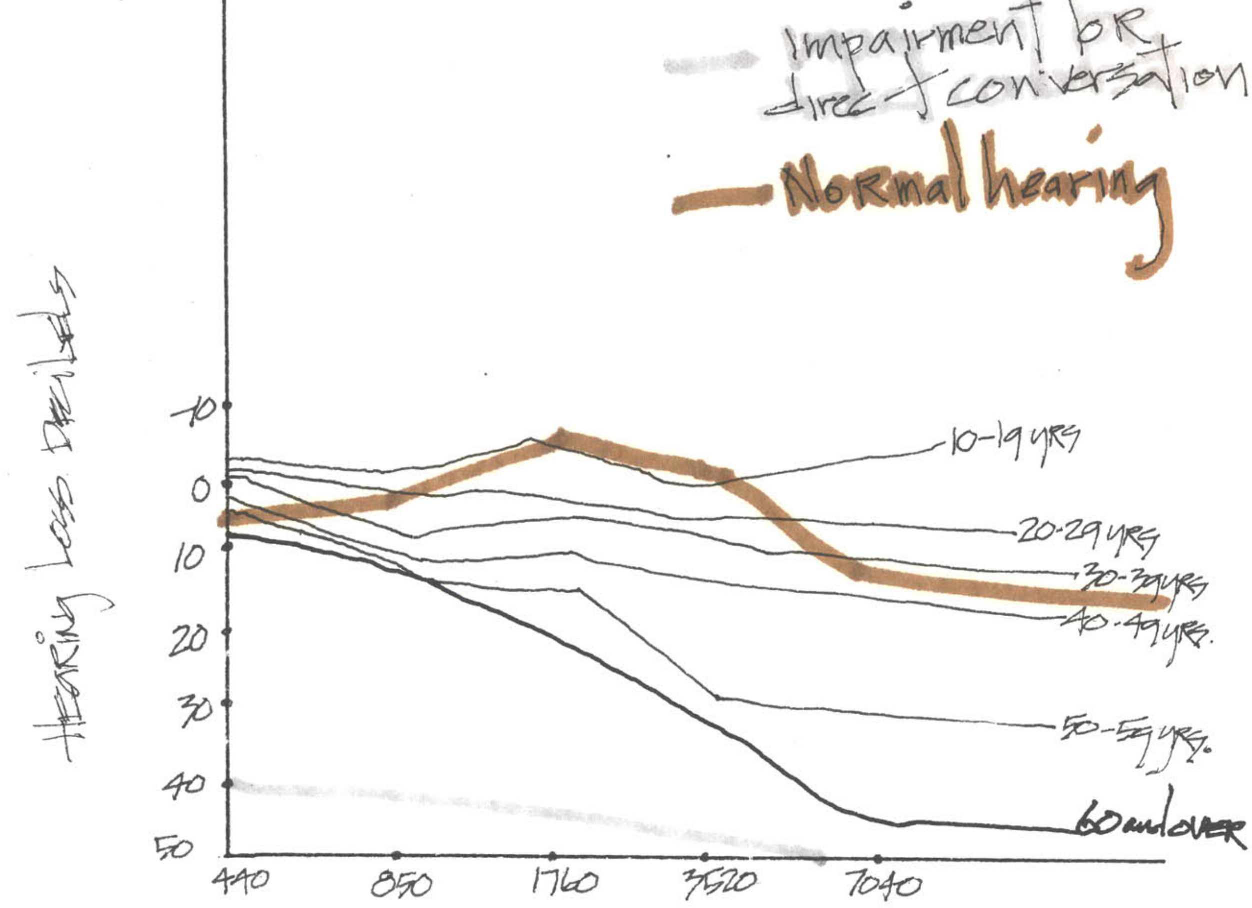
Legibility by height vs. distance

the sound system. We are concerned primarily with the auditory system as it is affected by the products of a sound system. We can redesign sound products but the auditory system is unalterable.

The magnitude of a sound may be measured in units of sound pressure or sound energy (degree or watt per sq. centimeter). To identify interaction of ratios of loudness/softness, we use a unit called a bel then sub-divid this into ten units the decibel. The intensity of sound diminishes according to this in one square of distance. Under ideal conditions doubling the distance results in a loss of about 6 decibels.[26,27,30]

Because of the visual response in different people to threshold frequencies, I shall not try to elaborate in the technical aspects of the ear structure, limits of hearing and/as association and composition of sound. The available research materials don't indicate environmental affects of sound in hearing and physical performance. Basically I shall outline the guideline principles involved in acceptable hearing levels and distortions. Hearing acuity varies greatly within the population. The differences are chiefly casued due to age and sex and noisy environmental background. "Normal" hearing covers a considerably range of ability, even within a homogeneous age and background. Advanced age usually results in the lowering of sensitivity for the higher tones (above 1500 - 2000 cycles). Although there is little loss in the lower frequencies. An important consequence of loss of a reduced hearing is the impairment of verbal communication. The human auditory response to frequency is commonly accepted as falling between the frequencies of 20,000 cycles per second. The ear is most effective at about 20 decibels.[30](Fig. 8-9, pp. 152-153)

Hearing Acuity (Fig 8)



1. Aging usually results in the lack and/or loss of sensitivity for higher tones About 1500-2000 cycles per second

2. The effect of noise on mental performance varies as the task changes in complexity.

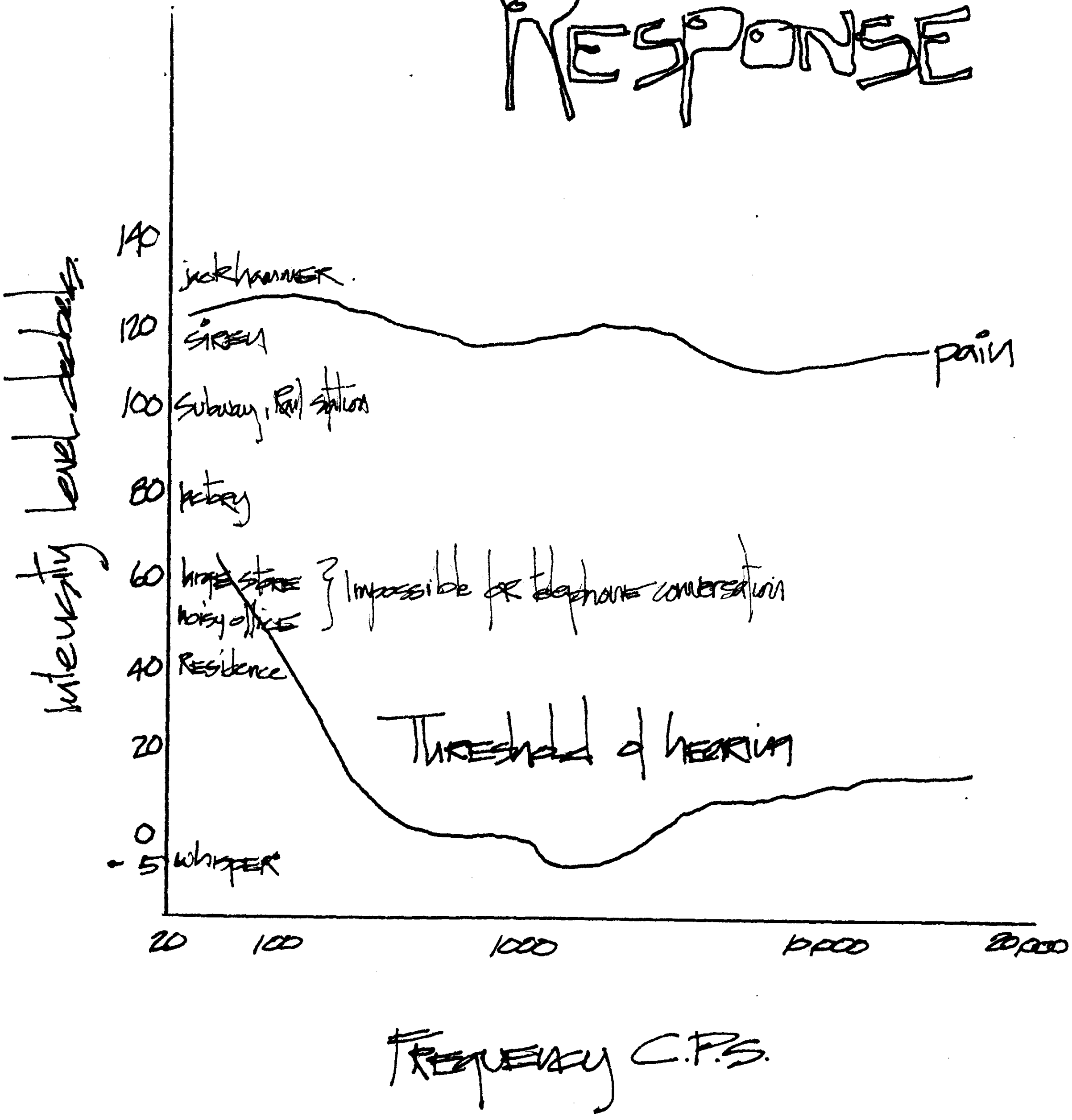
3. Simple repetitive tasks are not effected although more energy is required

4. There is no apparent effect of noise on visual accommodation, dark adaption, or distance judgement.

5 Noise affects fatigue levels

(fig 9)

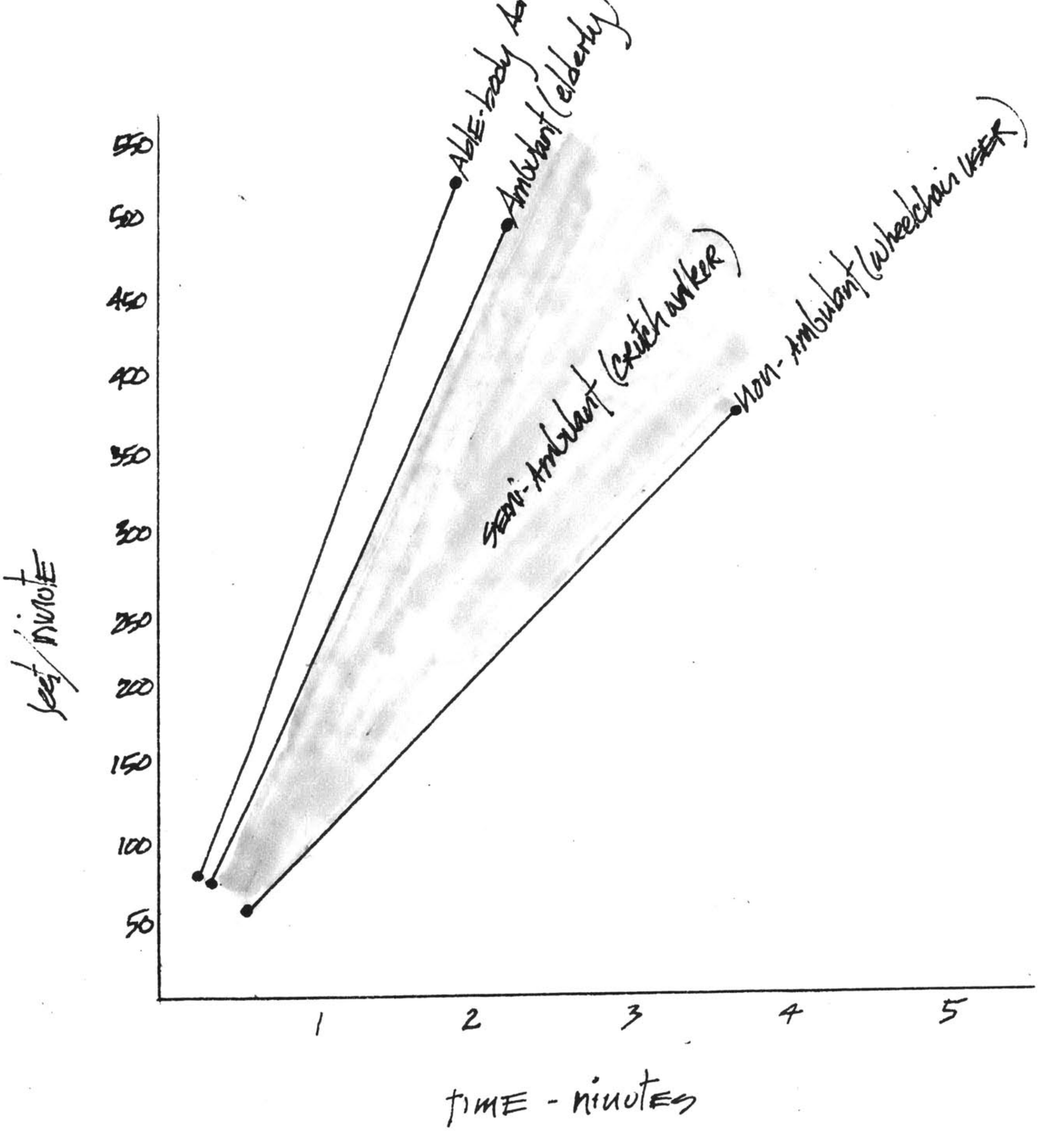
HUMAN AUDITORY RESPONSE



Sound extending in reaction beyond the auditory system may influence the preformance of a task and may contribute to such feelings as fatigue, boredom or relaxation. Any increase in noise tends to increase muscular tension consequently increase in expenditure of energy. In muscular performance task requireing a high degree of coordination can be adversely affected by sound. The effect of noise on mental performance varies as the task complexity. There is no apparent effect of noise upon visual accommodation.[27]

Motor Capabilities

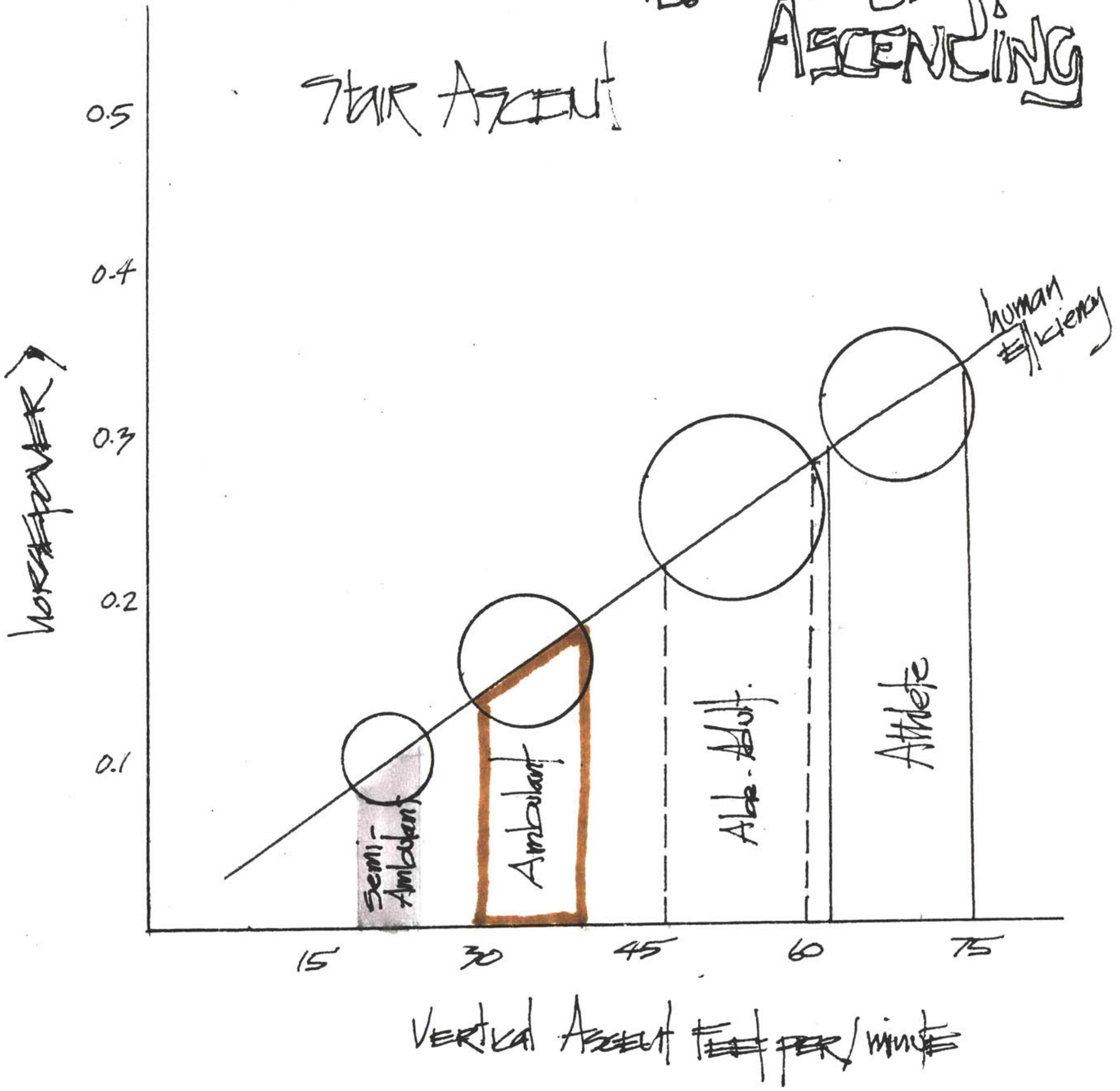
Biped walking has evolved into the most efficient means of animal locomotion. It can be divided into two activities, the pacing zone and the sensory zone. Many of the characteristics associated with the sensory zone - sometimes referred to as locomtion vision - have been covered under the visual and auditory requirements. But there are others more directly associated with walking, these being judging of velocity, distance and direction of others during walking. Using vision to keep track of varying speeds and angles and to accurately adjust their pace. Other actions of pedestrians with poorer vision, confirms the importance of vision to locomotion. These persons were observed to walk more slowly, negotiate stairs more cautiously and stop momentarily to get bearings. Reaction time between visual stimulation and physical reaction, as an element of the human sensory zone. Eye-to-foot reaction time increased with age. Ground friction is a factor in locomotion because the force of the push-off is dependent on sufficient opposing frictional force (or lack of).[1]
(Fig. 10, 11, 12, pp. 155, 156, 157 Respectively)



WALK RATE VS. TIME (FIG 10)

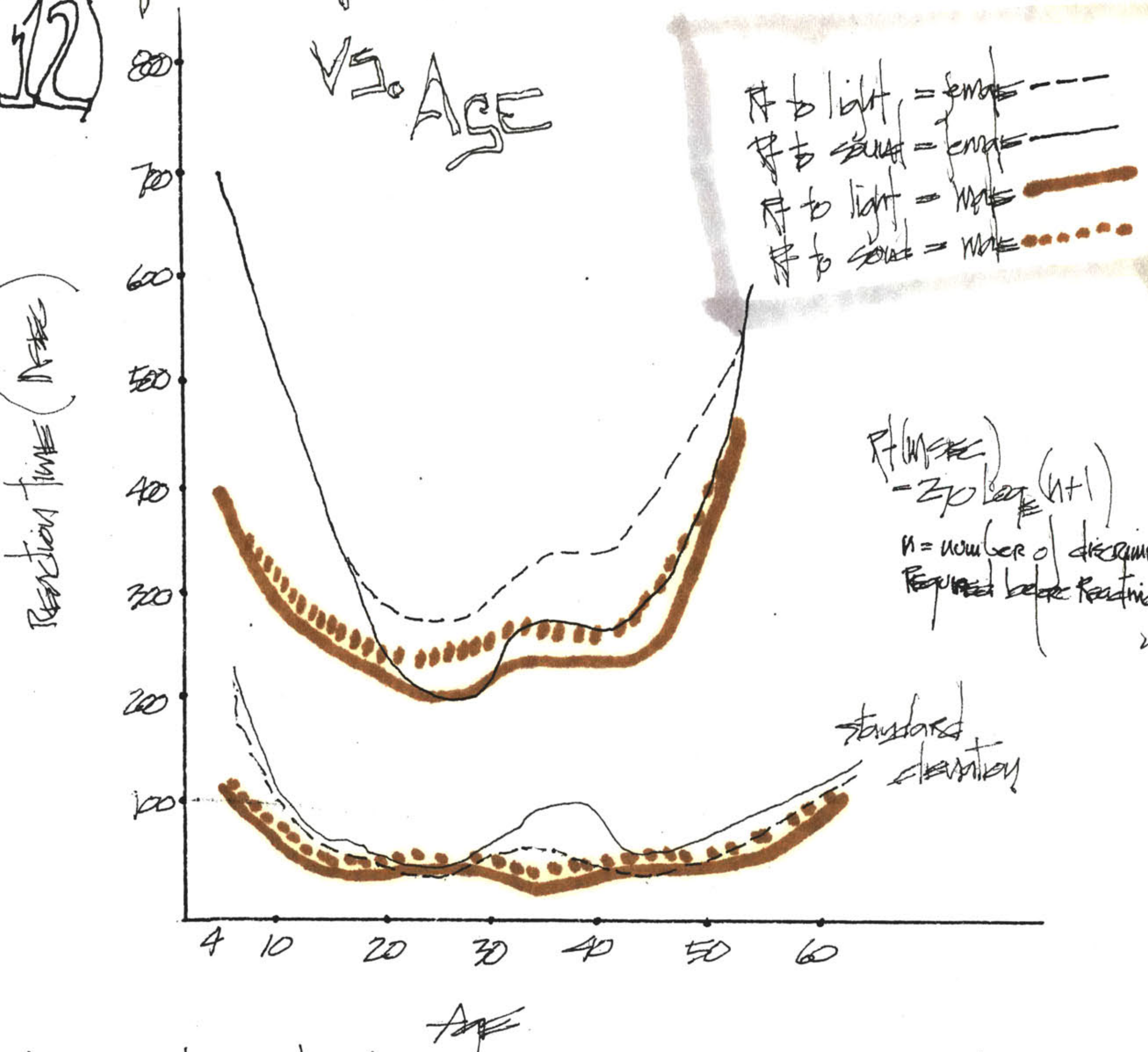
(Fig 11)

Net Power vs. Rate of Ascending



REACTION TIME vs. AGE

(Fig 12)



$Rt\ (msec) = 270 \log_e (n+1)$

n = number of discriminations Required before Reacting

Translation - Speed of Perception to Action (180 Msec)

- Brain Perception of what eye sees .... 0.1 sec.
- Brain Recognition .... 0.4 sec.
- Decision .... ~~4.5~~.0 sec
- Motor Response .... .5 sec
- Reaction .... 2.0 sec

7.8 sec

equals 30' in walking scale.

Complexity - Reaction time may be simple as when a key is pressed in response to a light, or complex as when a Key of Red, Rather than green alternative is possible.

Elderly ~~Comparative~~ Analysis (150 msec)

$\frac{180}{7.8} = \frac{150}{x} = 1.7$ sec

walking rate $\frac{215}{60} = \frac{x}{12} = 43$ ft.

NOTE:

Reaction Time is ~~dependent~~ on:

1. the sense to which it is presented - auditory is faster than visual
2. stimulus intensity
3. Practice can Reduce Rt. by 10%
4. Preparation - Ready signals reduce Rt.

The timing and pacing sequence of the walking cycles is thought to be a deeply ingrained neurological pattern which is relatively fixed through the greater part of theindividual's life span. There are then aspects of humanwalking based on age and size of the individual. Aging has the effect of reducing the degree of pelvic rotation for both male and female walkers, reducing the length of stride and thus reducing normal walking speed.[6]

Because of these irreversible and inflexible body conditions of the aged, walking can become tedious since the free reign of the center of gravity is somewhat restricted. This restriction in the natural free movement of the body affects the ability for the maintenance of balance, the ability to adjust and regulate pacing length, the coordination of timing to alter speed and direction and lastly an event which is controlled as much by sensory zone as the pacing zone the ability to adjust in application of foot for differences in terrain scope and slope.[23,24,22] (Fig 13,14) (P.159,160)

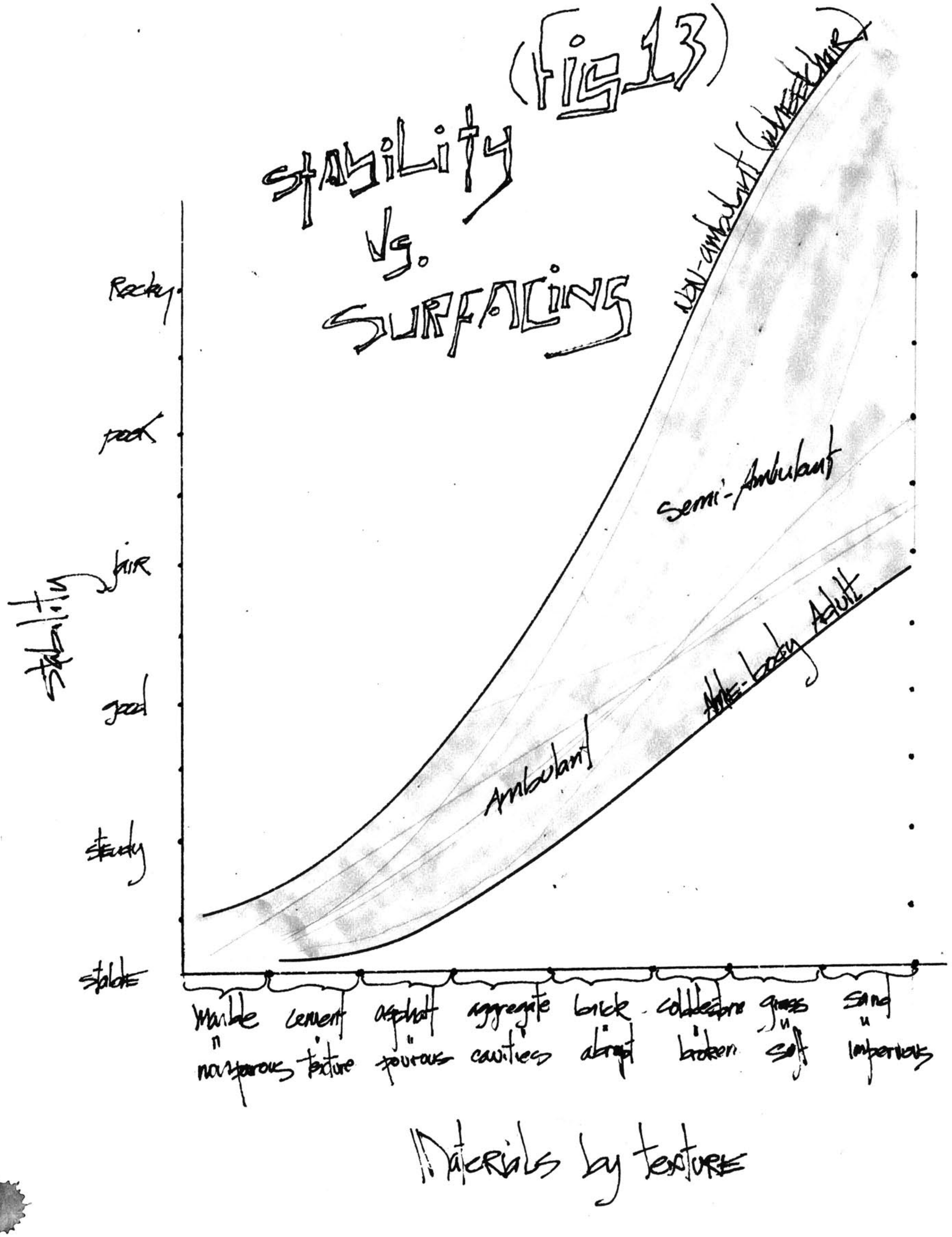
The efficiency of walking varies with the rate of work. The objective of a system should be supplemented by a set of system performance requirements that characterize the desired system output. To determine a performance evaluation for the purpose of determining the extent to which actual performance fulfills specified performance requirments meant devising both from attributes inherent in the system and policy extended to that system a guideline concept; which I call efficiency.[26]

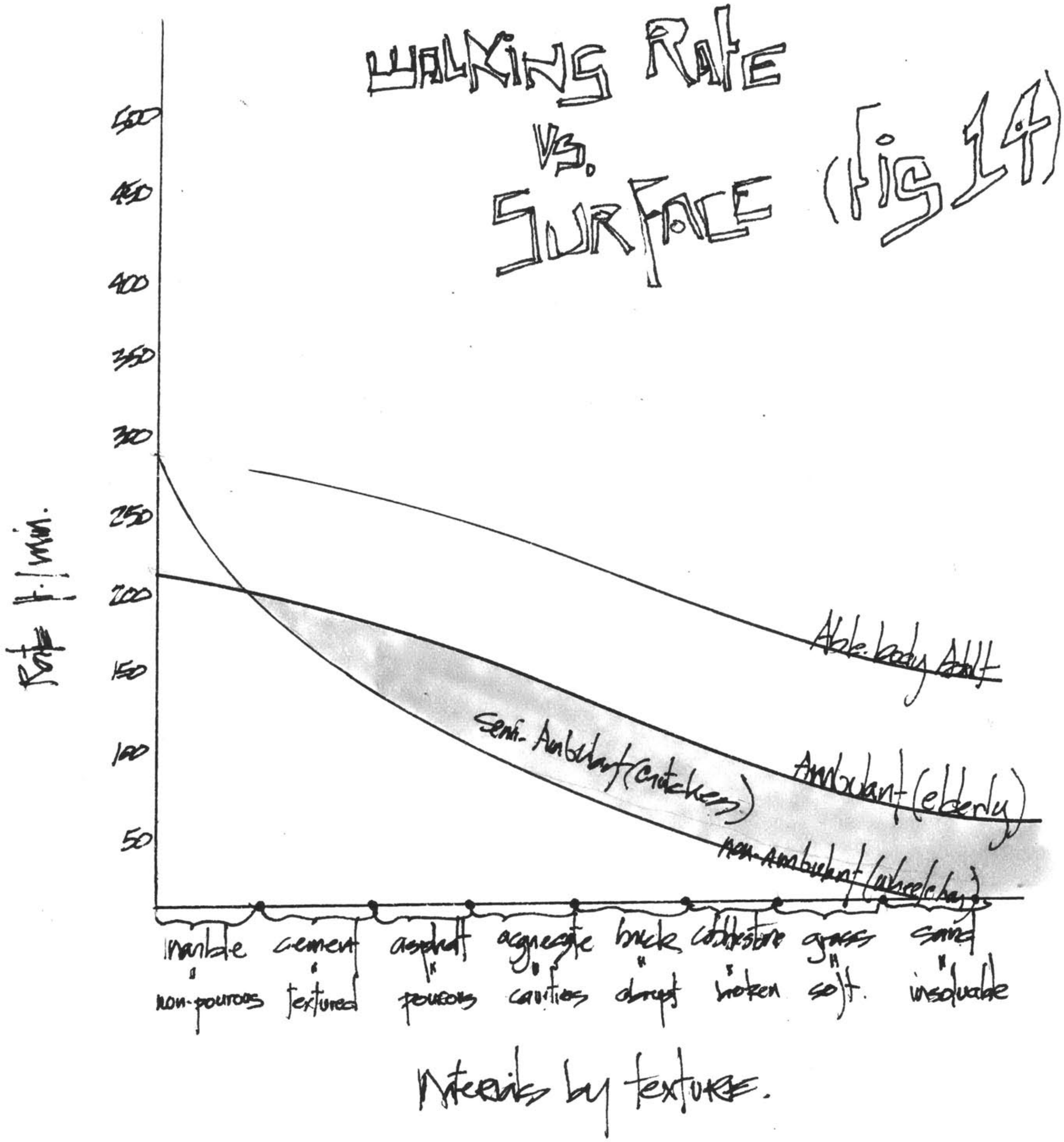
$$\text{Efficiency} = \frac{\text{work output}}{\text{work input}}$$

$$E = \frac{\text{work performed (footpounds)}}{\text{work performed and heat produce}}$$

(fig 13)

STABILITY vs. SURFACING




WALKING RATE vs. SURFACE (Fig 14)
Rate ft./min.
500
450
400
350
300
250
200
150
100
50
Able-body Adult
Ambulant (elderly)
Semi-Ambulant (crutches)
Non-Ambulant (wheelchair)
marble
non-porous
cement
textured
asphalt
porous
aggregate
cavities
brick
abrupt
cobblestone
broken
grass
soft.
sand
insoluable
Materials by texture.

Heat expressed in Calories - 1 Cal = 1000 cel.

Correlating this to the basic metabolic rate which is that which is required to simply maintain the body in an inactive state.

Average 1500 to 1800 Cal per day, then what is the cost of work.

Cost of work (cal. per minute)

Supine	1.17	Walking	2.3miles/hr.	4.3
Sitting	1.8		4.8 m/hr.	10.7
Standing	1.98			

Using energy consumption is directly related linearly to speed as measured by sex, it becomes more exponential as speed is increased by age. Normal efficient rates of walking are about 274'minute for average persons and about 215'minute for the elderly. NOtice how the rate drops off with age.[1]

average - 440'minute
elderly - 272'minute   Increased speed (Fig 15, p.162)

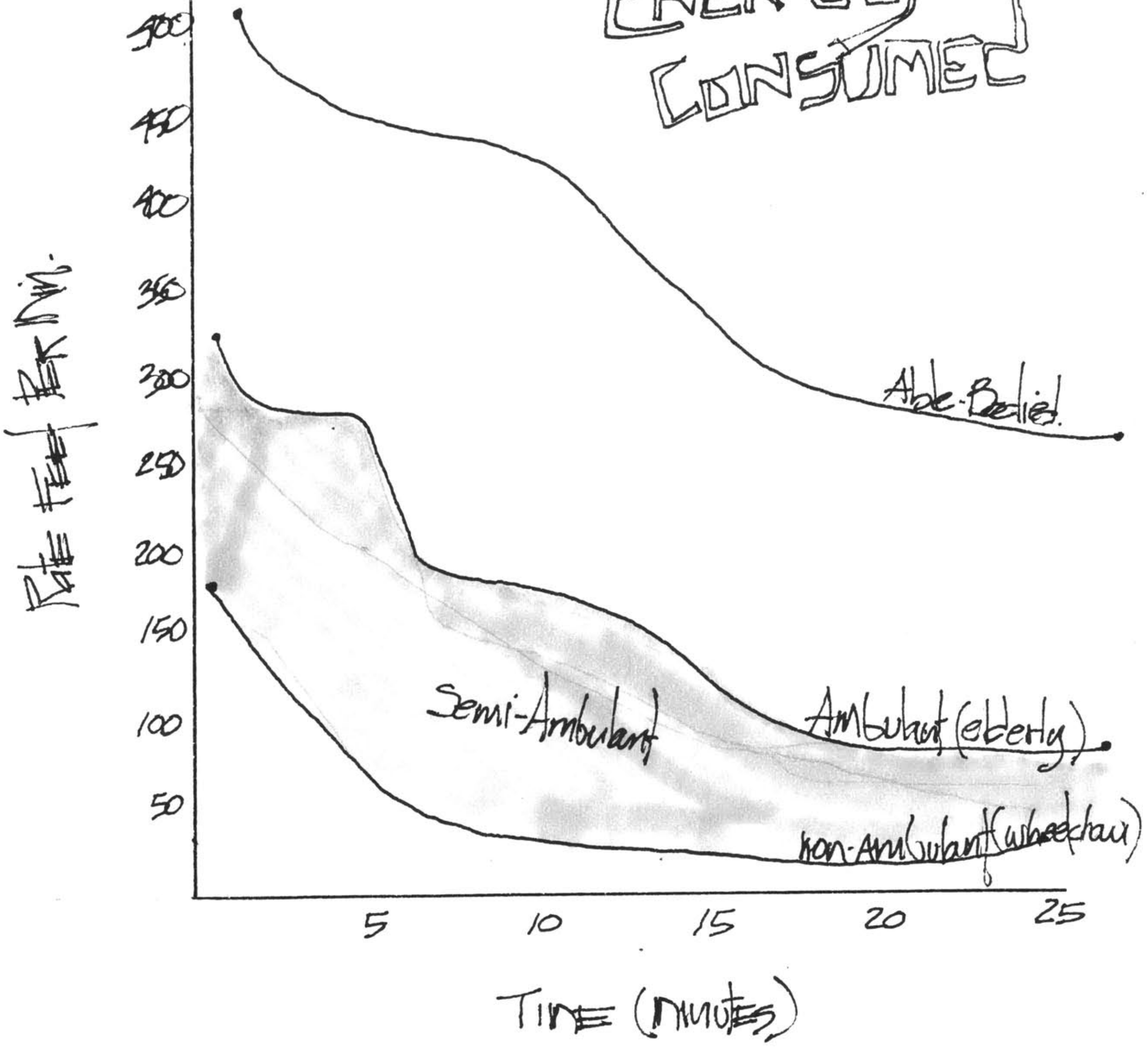
Locomotion in stairs is more restricted because of the safety considerations and the restraints imposed by the stair tread and riser configuration. This is also reduced to visionary locomotion.

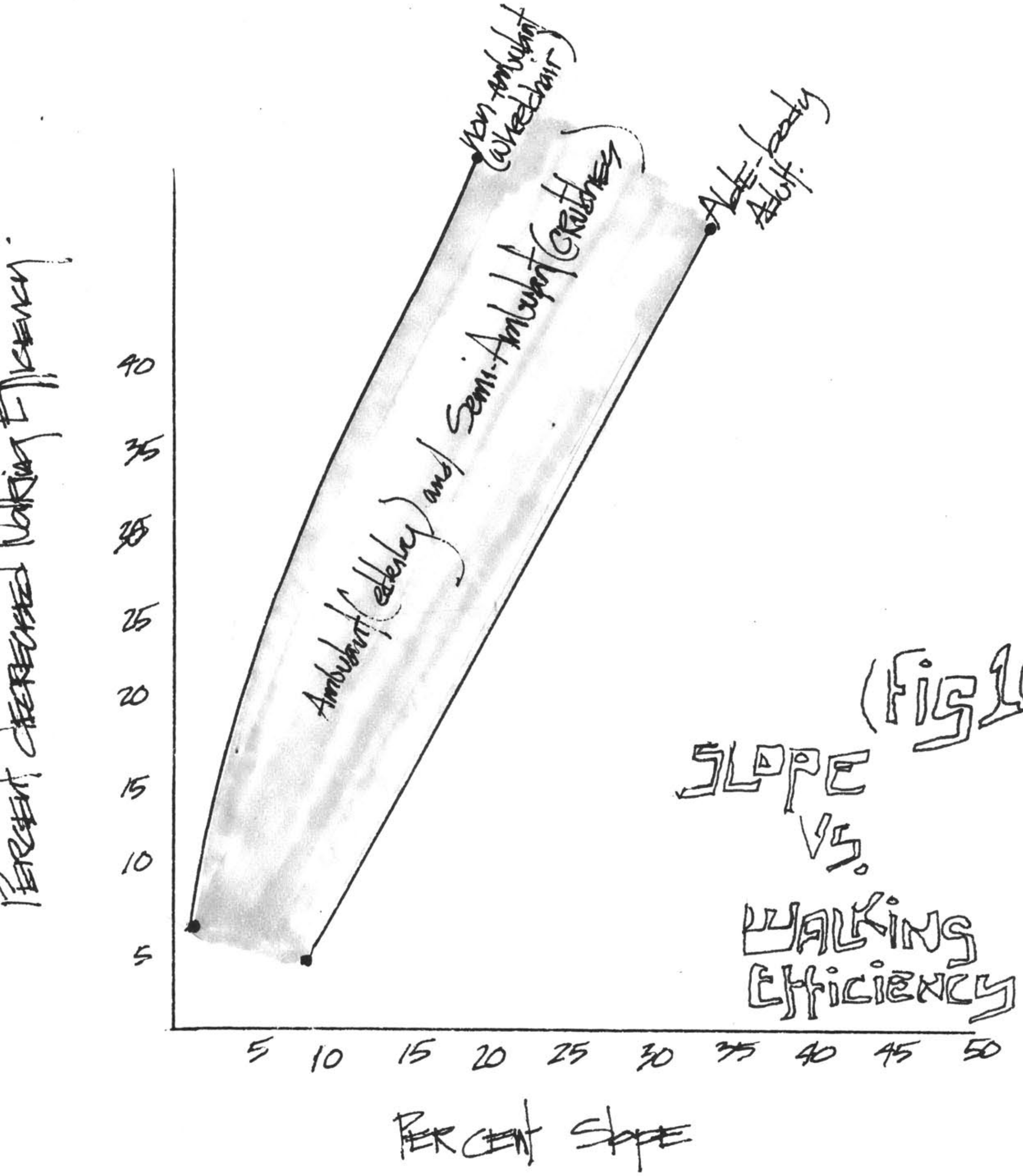
Energy consumption is about fifteen greater climbing stairs than in horizontal planes. While the energy consumption is only one-third greater than needed for climbing, greater concentration and visual discrimination are required to control the rate by which gravity acts on the body. (Fig 16, 163)

Gradients of 6% do not affect the walking rate but is "linear" relationships to grade, age and sex. A gradient change of 37 1/2% or (Fig. 17, p.164) from 6" to 8.25" results in an energy expenditure of 96% ascending an 50% descending. There is no direct relationship to the percent of energy expended and age groups. Significant increases in pulse rate and blood

(Fig 15)

Fast Rate by Time vs. Energy Consumed





(Fig 16)

SLOPE VS. WALKING EFFICIENCY

NOTE:

20% slope = 25% walking decrease

ELDERLY = 215'/m horizontal

x .25

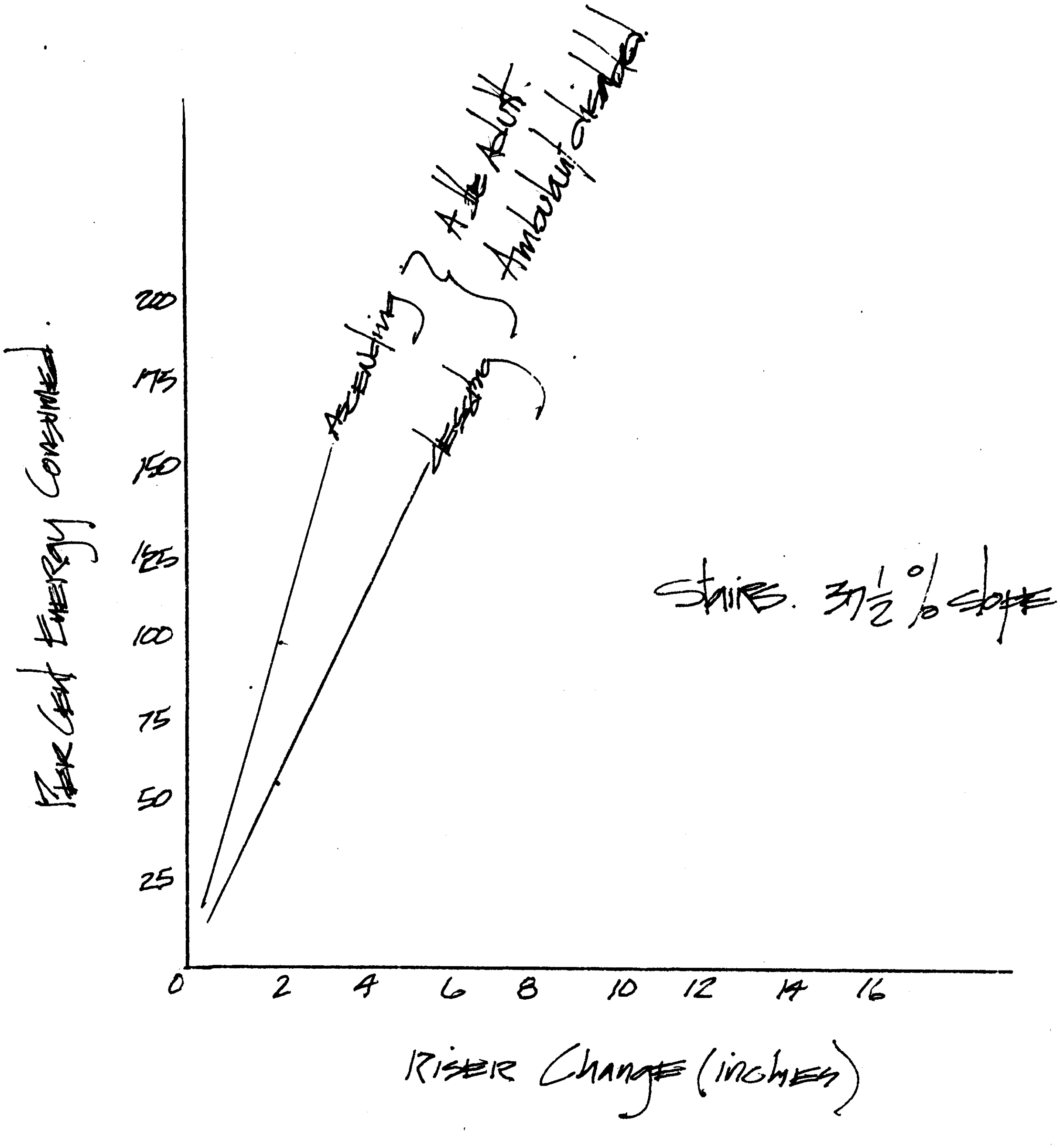
53.75

215

− 54

161'/m

20% = 161'/m walking speed.



ENERGY CONSUMPTION VS. RISER HEIGHT (Fig. 17) pressure were also noted in greater stair angles. From there human factors standpoint, there are many examples of poorly designed stairs, the range of permissable stair angle design is between 20 and 50 degrees with the preferred range (by convention) between 30 and 35 years.[1,35]

Walking distances of the elderly have been measured at about 50 yds intermittently; while major stopping distances have been calculated at 440 yds.[33,34] One must remember that these distances are only relative to the pyschological taxonomy involved, physical nature of route, time involved and the nature of the trip.(Fig.18,19, pp.166,167)

Some of the subjective data as related to the distances at which people walk are related directly to a specific activity or event. For instance parking has been recorded as not being more than a 7 minute walk, which is a ten minute for the aged or 1000' which is approximately 300 meters from a main distributor and pedestrian street. The average promenade of a city dweller was about 60 minutes decreasing to about 15-20 minutes each hour thereafter.[2,3,6,7]

The length of these good promenade streets varied according.[3]

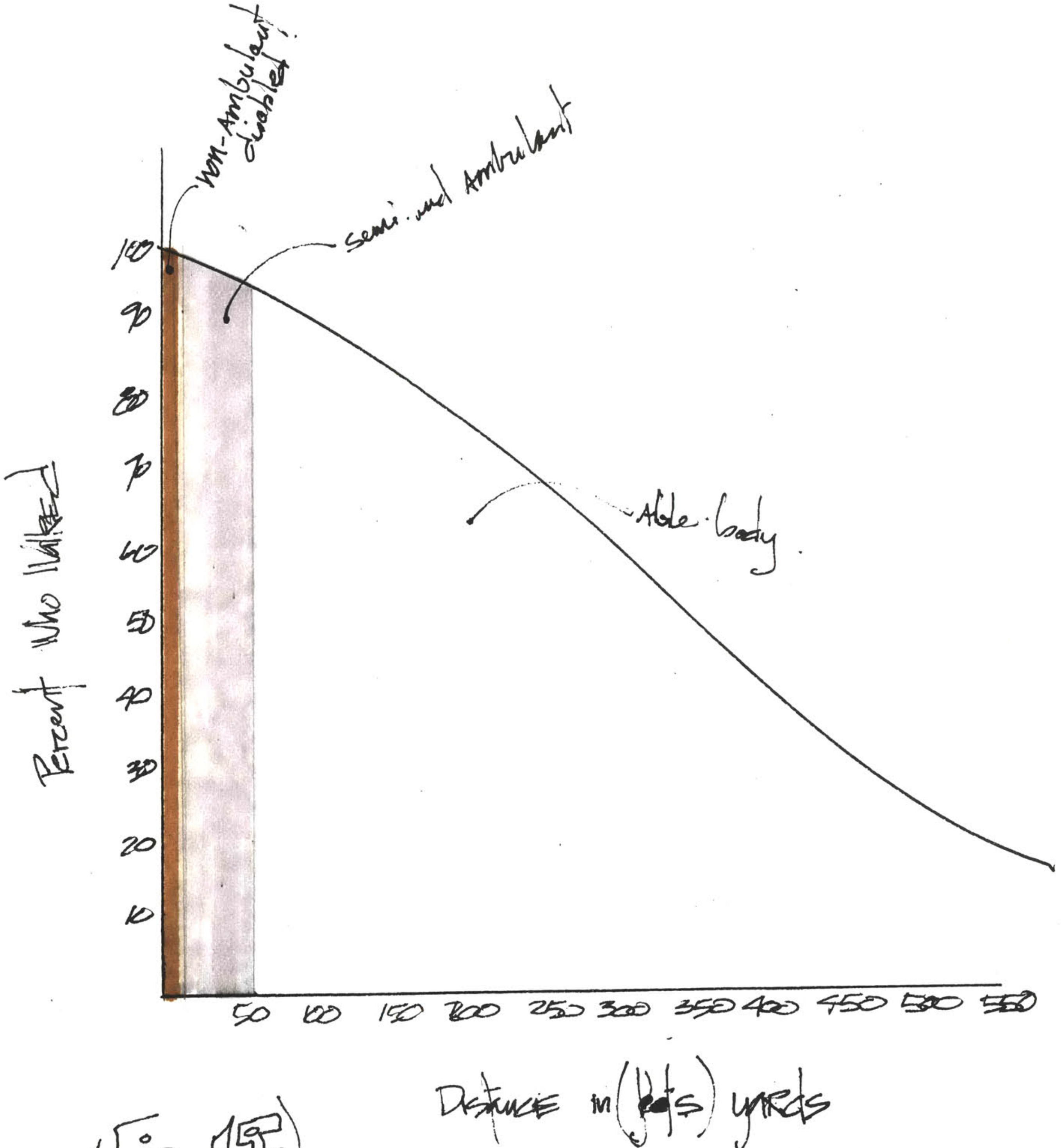
57.8% = 3200' or 1000m approximately 10 normal walking speed minutes

32.5% = 6500' or 2000m a little more than a mile or 2-25 normal walking minutes.

This distance represented a maximum that people would walk before assuming other means of circulation.

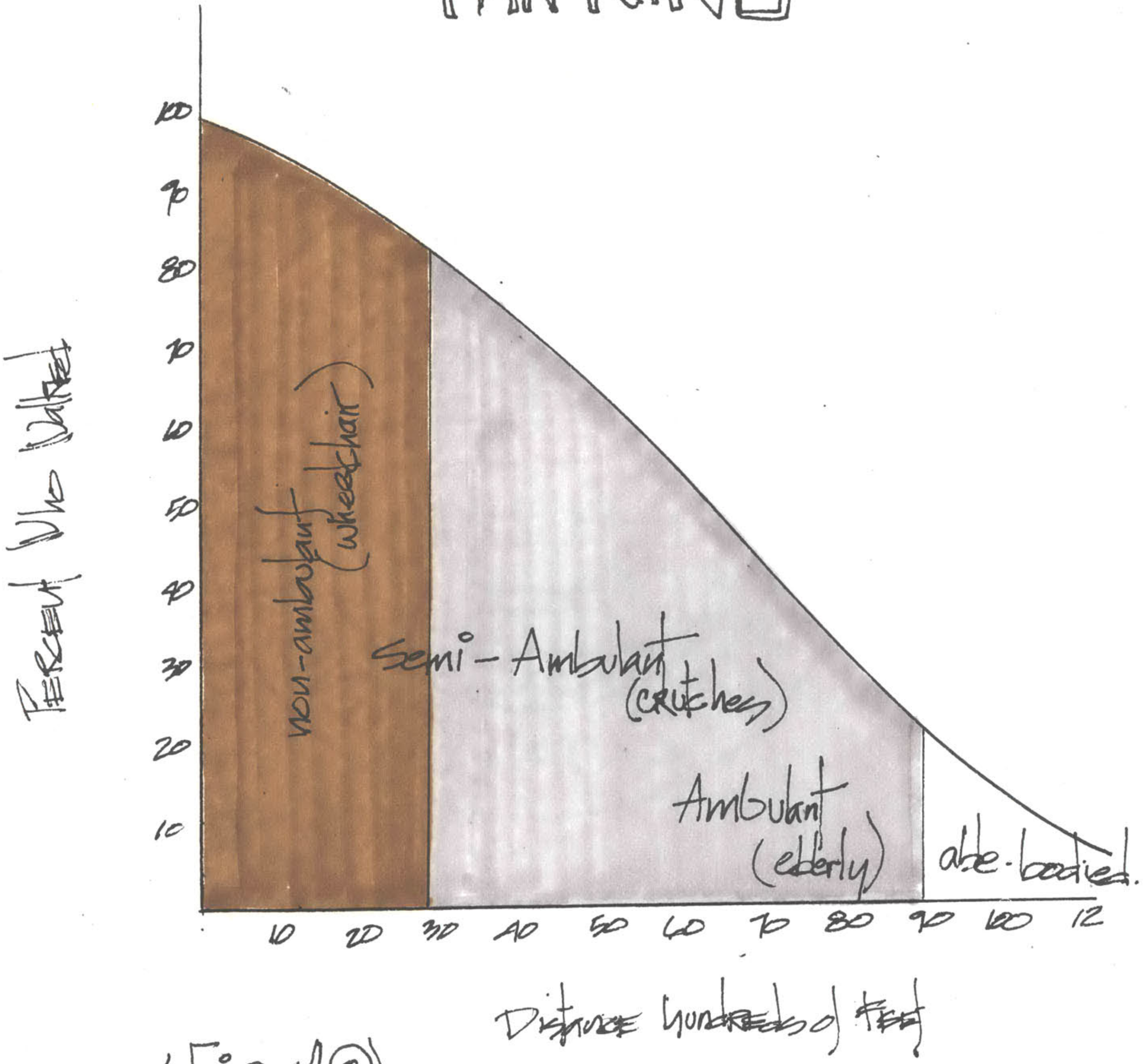
9.7% = larger

In regards to circulation the use of open spaces. Circulating planning was clearly distinguished by measuring several plazas around the world.



(Fig 15) PERCENT WALKED VS. DISTANCED STOPPED

PARKING



(Fig 19) DISTANCE VS. PERCENT WALKED

Table Disability and Problems

Disease	Disability	Problems
Rheumatoid Arthritis	Stiffness,swelling, pain in many joints of limbs, particularly small joints of hand and feet.Muscle weakness. Limitation of movement. Malaise and lack of vitality	Kneeling. Standing from sitting. Moving about. Standing for long. Lifting and carrying. Reaching up, forward or down. Stooping. Gripping and sustaining hold. Handling and manipulating. Stimulation to activity due to inertia and pain.
Osteo-Arthritis	Stiffness and pain in weight bearing joints particularly hips and knees. Loss of hip movement.	Activities involving weight bearing. Walking and standing. Stooping and bending to reach low oven or shelves. Picking up from floor. Kneeling. Need for two weight relieving aids, therefore cannot carry.
Polio-myelitis	Complete or partial paralysis of muscles. Paralysis of upper limbs shoulder girdles and chest. Paralysis of lower limbs and trunk. Loss of balance.	Activities involving use of affected muscles. Reaching forward and up. Maintaining hands in functional position. Holding, handling, manipulating. Moving, carrying, maintaining posture. Wheelchair mobility, sitting balance. Reaching forward.
Hemiplegia	Spastic paralysis of one side. Loss of position sense affected arm and leg. Possible loss of dominant hand. Poor balance, slow response. Loss of speech.	Unsteady and slow thinking, may not know where foot is. One-handedness, possibly non-dominant hand. Lifting and carrying. Two handed activities. Moving, carrying, handling, manipulating.
Paraplegia	Flaccid paralysis of lower limbs and trunk. Impairment or loss of sensation.	Mobility in wheelchair. Space and working levels. Reaching. Safety - Avoidance of heat, pressure, knocking, friction of lower limbs.
Congenital Tri-plegia	Spastic paralysis of lower limbs and one upper limb. Ataxia - Inco-ordination of muscle action.	Balance and control. Moving and carrying. Moving and lifting hot dishes and hot liquids. Balancing and one-handedness. Lifting, handling, manipulating. Reaching and stooping.
Multiple Sclerosis	Spasticity and weakness of limbs, particularly lower. Inco-ordination. Intention tremor of arms Eyes may be affected. Fatigue. Sensation may be impaired.	Moving and balancing hot dishes particularly hot liquids. Carrying. Reaching forward, up or down. Activities involving inco-ordination of hand and eye, using the hands while balancing. Directing and controlling movements.
Cerebellar Inco-ordination	Inco-ordination of arms and legs. Weakness of all limbs. Fatigue.	Moving and controlling movements. Balance while using hands. Walking, carrying, lifting, reaching. Hands occupied with two quadrupeds.

Wheelchair (non-ambulant)

The observation was that only 4 sq./ft. in every 1000 sq./ft. was being used.[3]

The basic assumptions that may be limiting to the mobility of a wheelchair user because of eye problems have been covered under the Vision Section of the Aged. One point that I could make is that the visual angle of the wheelchair user is diminished because of the reduced visual plane. A person seated in a wheelchair whose seat is 21" high has a mean eye level of 3 feet 9 1/2" as opposed to the average height and mean eye sight of 5'6 1/2". This reduced horizontal focal plane affects the mobility orientation because the ground becomes the focal plane instead of the horizon This reduced focal plane has affects upon the reaction time of the wheelchair user. Events must now directly enter the focal plane before any observation is made aware of. As an example of distance relationships, using the same 60" cone of vision as the measure; a person 6' tall would have to be 12' from a wheelchair individual as opposed to 7' from an average person 5'9 1/2" tall. The visual sensory zone is very important to keeping the chair in track (going straight) as well as out of rut holes and soft spots. The ability to freewheel (push and roll for awhile more) is nearly impossible.[31] (Fig.20, p.170)(Fig.21, 22, pp171, 172)

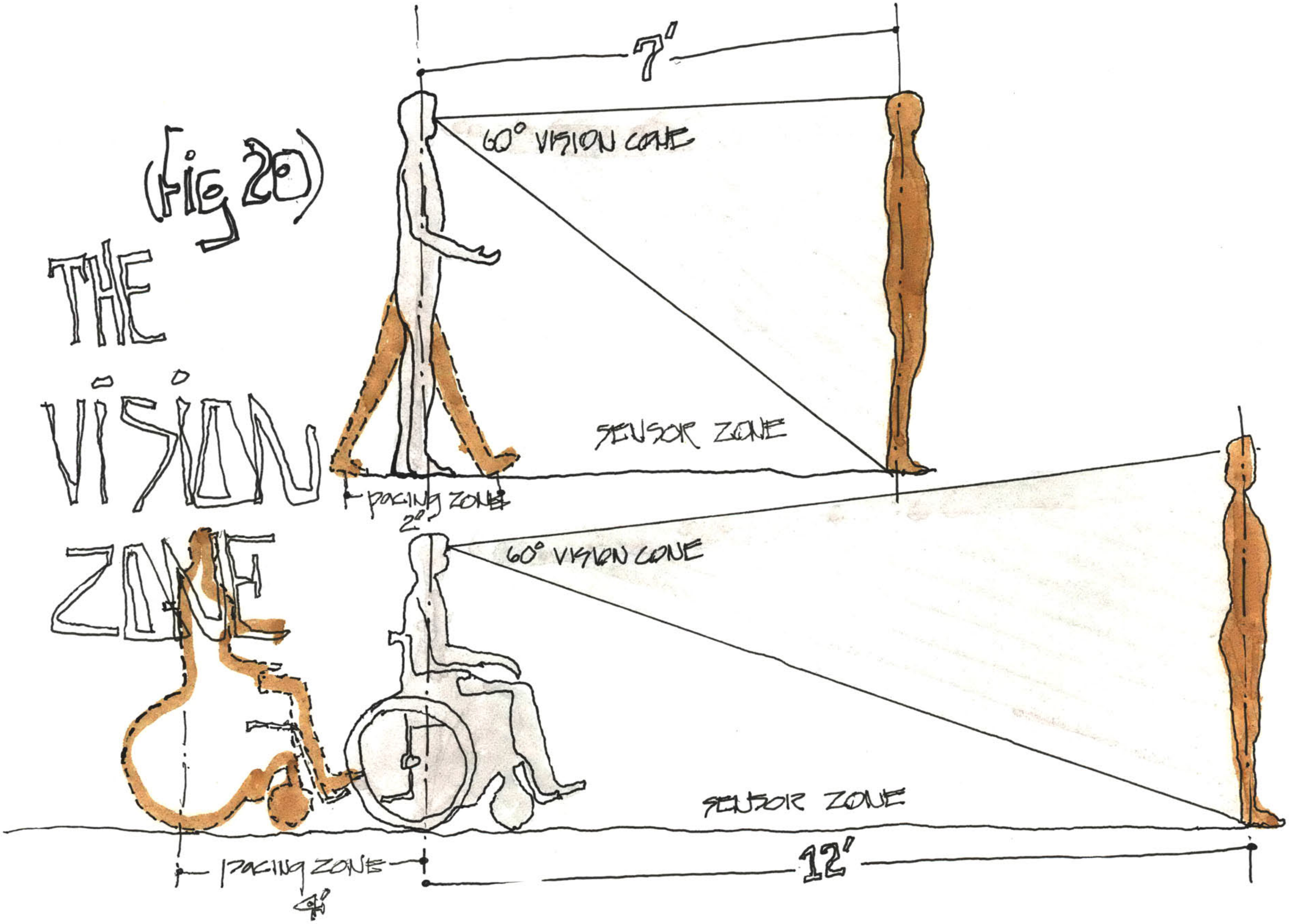
Auditory:

The reader can refer to the section on Auditory response in the section on the elderly.

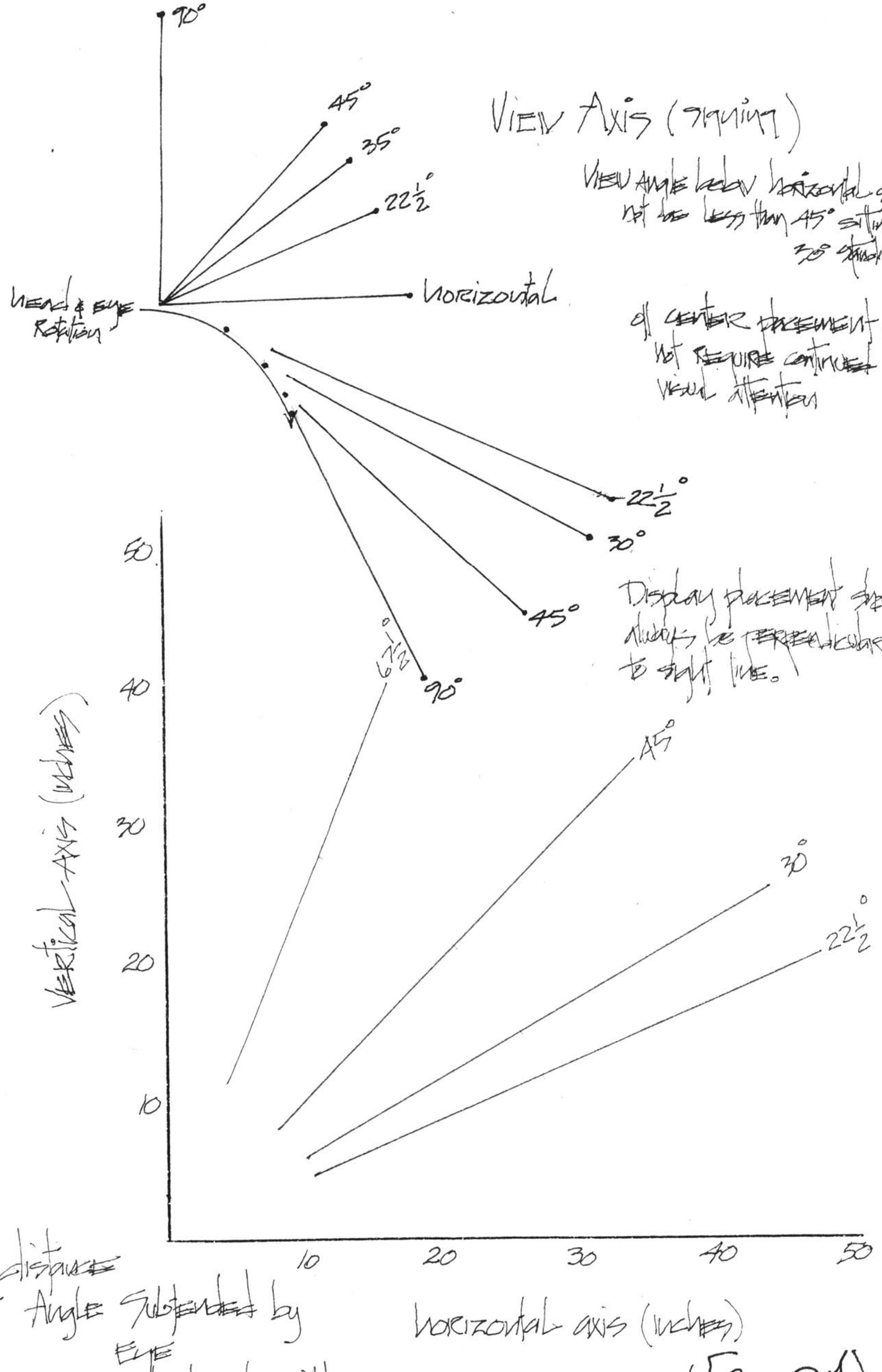
This analysis will try to give an overview of the general symptoms that affect those who are physically bound to wheelchair. The broad implications

(fig 20)

THE VISION ZONE



View Axis (sitting)



View angle below horizontal shall not be less than 45° sitting 30° standing

of center placement shall not require continued visual attention

Display placement shall always be perpendicular to sight line.

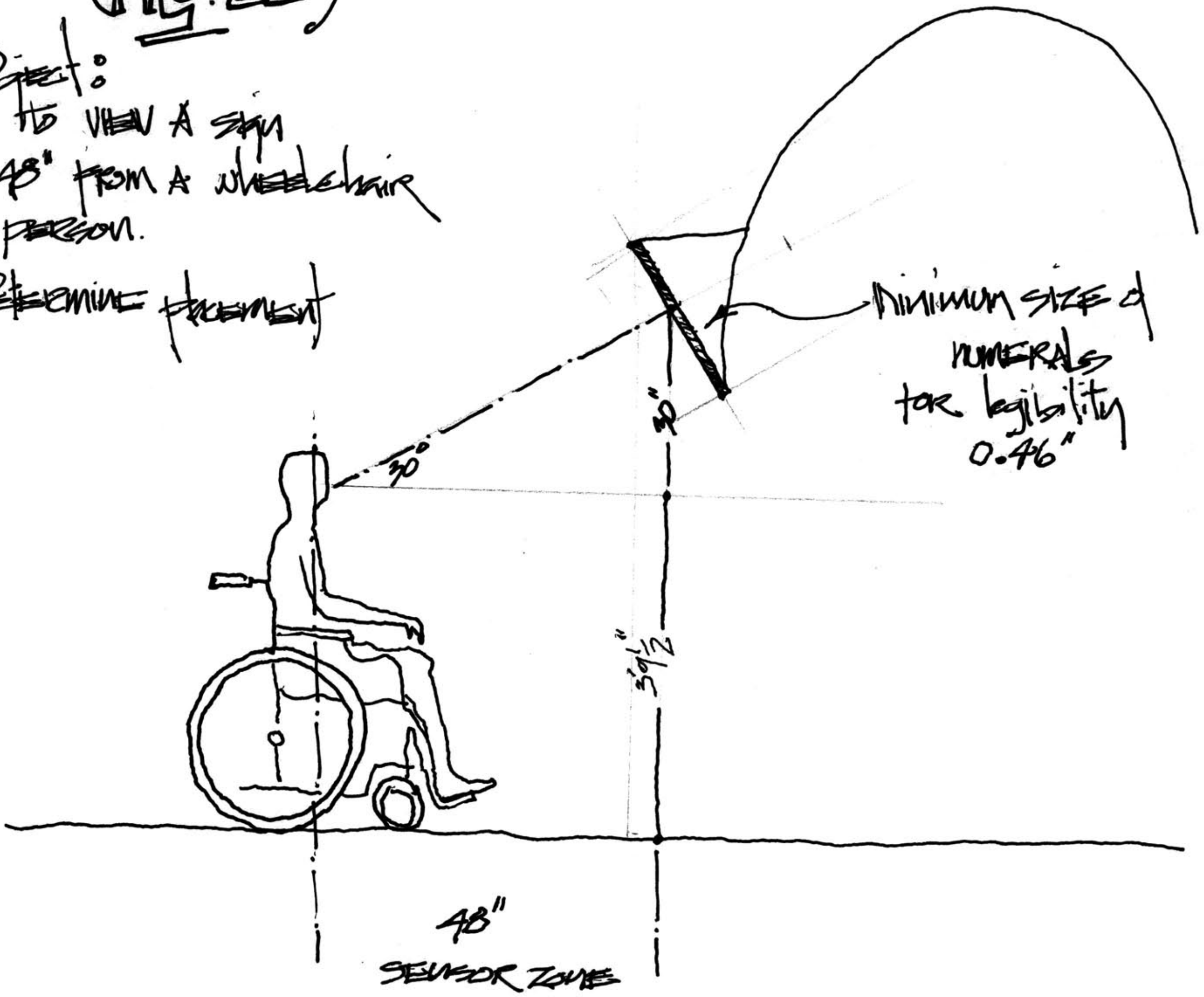
View distance to Angle Subtended by Eye Perpendicular to sight lines

(Fig 21)

(Fig. 22)

Object:
to view a sign
48" from a wheelchair
person.

Determine placement



are the symptoms of paralysis. The cutaneous senses have their origins in nerves ending in the skin, in a paralytic victim (which is the cause of a neurological disorder) these nerve endings will loose their sensation. Those sensations being touch, heat, pain, cold. The level of this dysfunction will vary with the level of the lesion injury. In a paraplegic this sensation may be just from the legs down to the feet, in a quadraplegic this sensation may be from the chest down, in a hemiplegic it may affect one half of his body, etc. Coupled with this deficiency is the diminished response of the kinesthetic receptors which are located in the muscles, tendons and bone coverings and around the joints. These receptors and proprioceptors feedback information regarding movement and positions of members. Therefore we can assume that there is a lack of confirmation knowledge due to diminished sensation in knowing where body parts are situated through movements. Therefore the use of other sensory mechanisms become very important in establishing an equilibrium with environment, especially balance. For example, vision is especially important to orientation especially in terms of the perception of upright; where there is a conflict between the sensation of gravity and visual perception, the visual perception will usually tend to dominate. This is necessary just to retain balance while manipulating the wheelchair (on level and smooth surface). Since the skeletal muscles are subject to being paralyzed not only will major tendons not function, but these average muscles will not bring about any movement of any body members in that area. Since certain types of sensory nerves serve to provide input information to the central nervous system for use in the control of muscles; the wheelchair user may suffer the incoordination to synchronzie signals, inability to bring them in accurately on time or not at all. One, because of cutaneous senses and two, because of neurological interference. The impaired motor nerves which serve as pathways through which action signals are transmitted to the muscles cannot be repaired but motor responses can be trained and reinforced through usage.[6,26,30,31,32A-F]

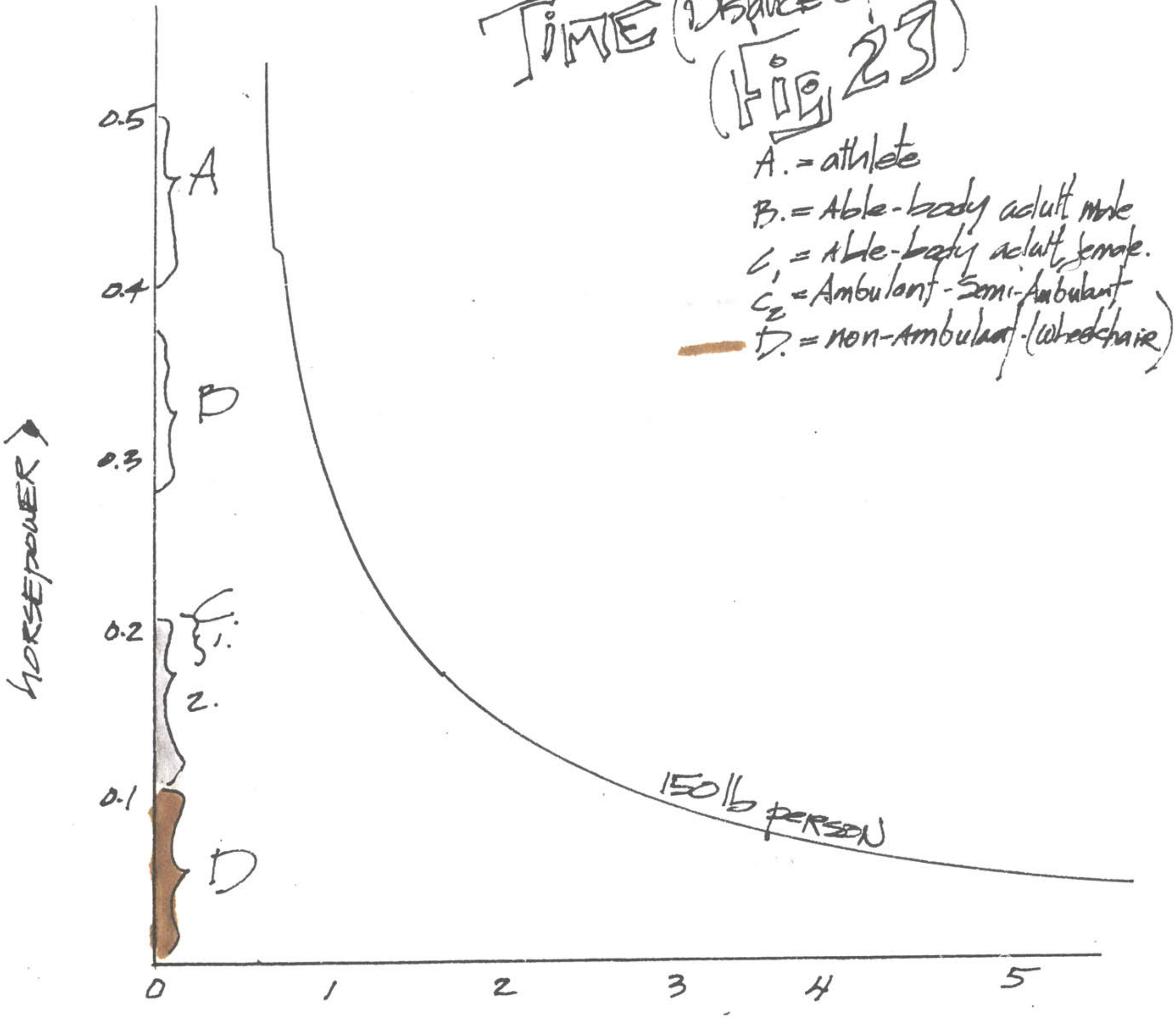
In various forms, such evaluations can be devoted toward strictly engineering features, toward personnel proficiency, or toward combined man/environment performance. The difference among individuals in performance with any given type of motor activity, however may have a very different type of implication. Some motor activities may be interested in the range of individual differences in order to establish some reasonable bounds. Such as minimum force to be required. The range of individual differences might also be pertinent in connection with other considerations such as adapting the mechanics of equipments to limits of human performance.

In regards, to the wheelchair user thus, the factors necessary to achieve efficient mobility are ability to maintain balance, ability to maintain path, ability to turn smoothly, ability to regulate physical strength to adjust to terrain scope and slope and turning to alter speed and direction. Lastly the queing space necessary to achieve safe movement corridors.[1,2,6,31,32A-F]

(Fig.23) The strength factor as opposed to walking is an exponential relationship by age, weight, sex and power. The symptoms associated with energy factors

POWER REQUIRED vs. TIME (Distance of 60 feet)

(Fig 23)



Note: to carry this exponential Relationship further
The Results of arm power means A person using his arms would burn up muscle power 4 times as fast, cover 1/4 the ground area in 4 times as much time.

Semi-ambulant disabled

are very similar to those considered under age-induced, mobility phenomena.[1]

The human factors associated with travel times, distance, and gradients are as follows.[1.2.6.7.31] (Fig. 24, p. 177)

Stairs are impossible, gradients of 1:20, 1:12, 1:10
best, good, fair (Fig. 25, p. 178)

Parking should not be located more than 300 feet from main distributors, or large facilities.

time to transfer from car to chair
3-15 minutes very good
5-10 " average
10-15 " good
planning area[2,6,]

Street crossing of 48' - 30 seconds

Travel horizontal 40 yds. - 120 seconds, 2 min.[2,6]

Vision,Auditory

Since I am trying to optimize theenvironment for the totality of the disabled pedestrian group, I shall not reiterate factors relating to vision and auditory sections for the ambulant because the age group could be considered the high value and the wheelchair user the low value.

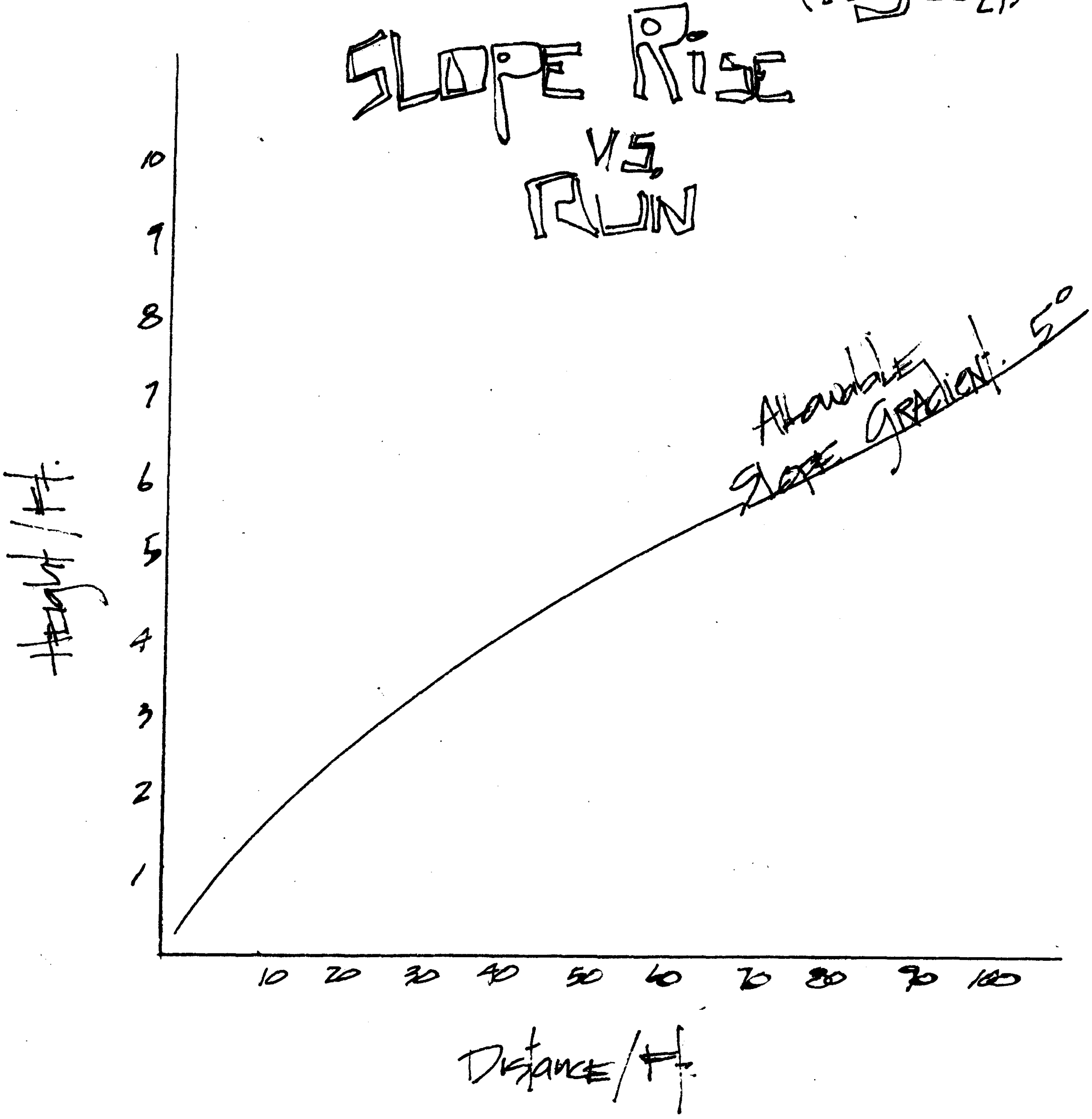
Motor Capabilities

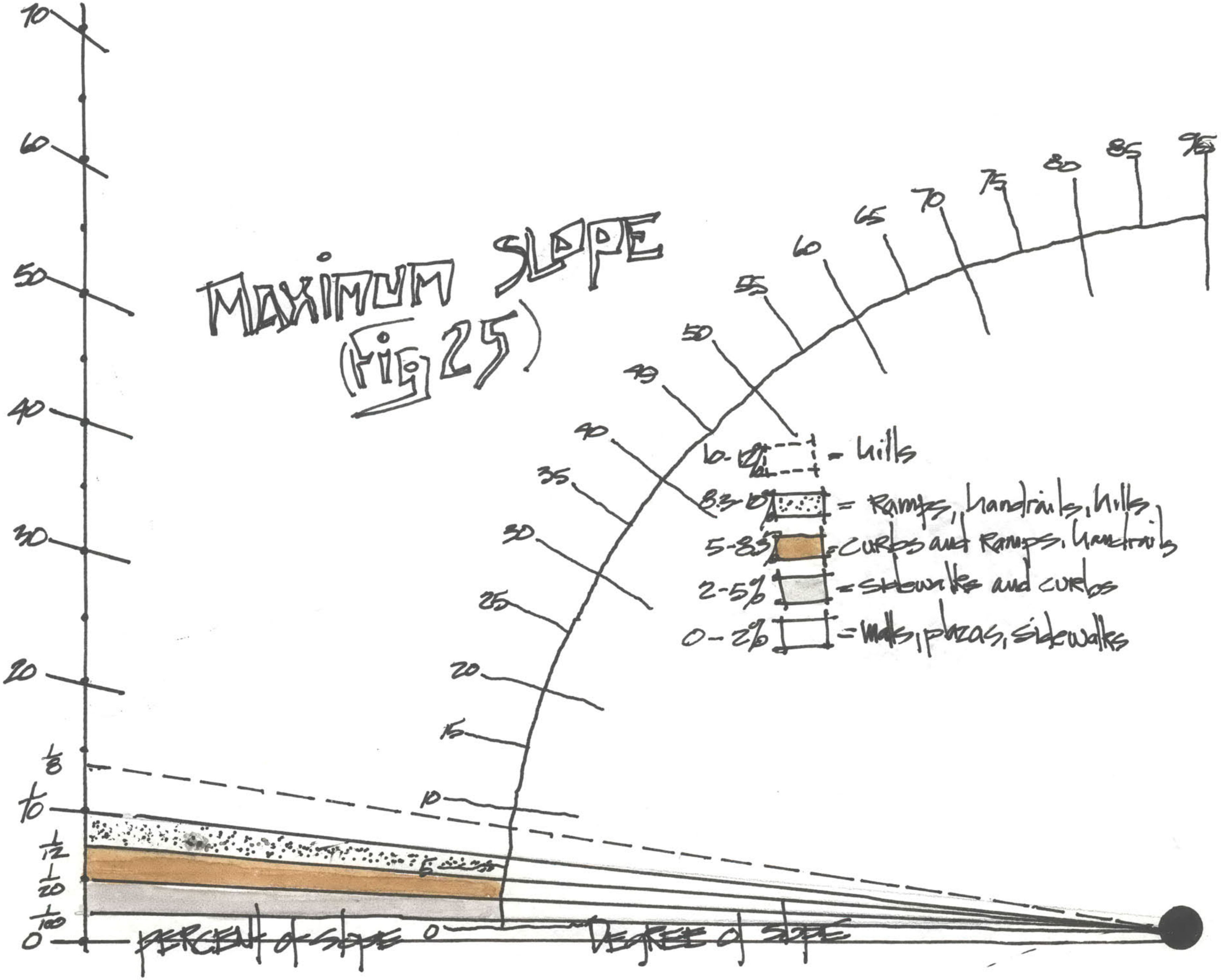
I shall just mention the methods of mobility here. The first is the swing thru "gait" which means using the crutches as poles and controlling yourself thru them. The distance covered per gait varies from 3 1/2' to 4'.[6,7]

The next is the hop-to gait which means using the crutches as canes and hopping to them. The distance covered per hop varies from 2 - 3'.[6,7]

The shuffle is exactly what it sounds like alternately swinging one side

(fig 2a)


SLOPE RISE
V.S.
RUN
10
9
8
7
6
5
4
3
2
1
Height/Ft.
10
20
30
40
50
60
70
80
90
100
Distance/Ft.
Allowable
Slope Gradient. 5°



MAXIMUM SLOPE (Fig 25)

and leg of your body forward and then the other. Distance covered range from 1 1/2 - 2'.[6,7]

The actual needs for mobility are quite similar to those of the wheelchair user.[2.6.31]

The ability of people to use various types of equipment depends upon psychomotor abilities and anthropometric characteristics. The following are the principles that can be used for the arrangements of elements and components. (Fig. 26, 27, 28, pp. 180, 181, 182)

1. functional
2. importance
3. optimum location
4. sequence of user
5. frequency of user

Actual Motor Capabilities[2,6,7,31]

1. Walking 30' - 30 secs.
2. Walking backward 40' = 30 secs.
3. Rising from seat = 1 minute
4. Getting in auto = 2 minutes
5. Getting out = 3 minutes
6. Open and close doors = 30 secs.
7. Walking up ramp 4' = 30 secs.
8. Walking down ramp 4' = 15 secs.
9. Down 3 standard stairs = 30 - 40 secs.
   one handrail
10. Down 3 standard stairs = 40 secs.
    no handrail
11. Up 3 standard stair - 40 secs.
    no rail
12. Stepping down curb = 5 sec.
13. Stepping up curb = 10 sec.
14. Going up bus steps = 40 secs.
15. Going down bus steps = 30 secs.
16. Walking 300' = 4-5 mins.
17. Crossing street 48' wide = 45 secs.
18. Ability to travel one mile by bus standing

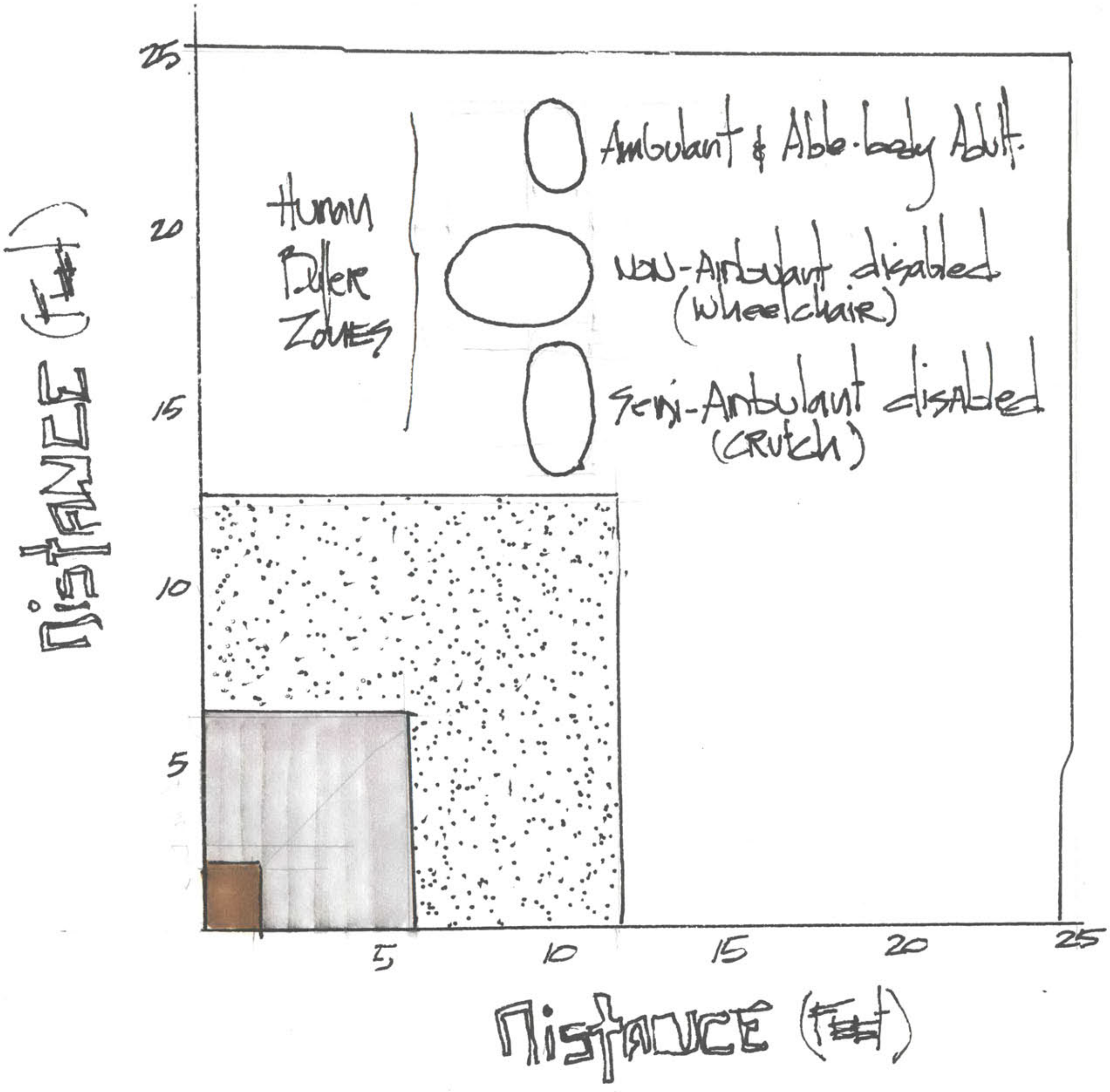
Gradients

1:20	1:16	1:12	1:10	1:8
best	better	good	fair	poor

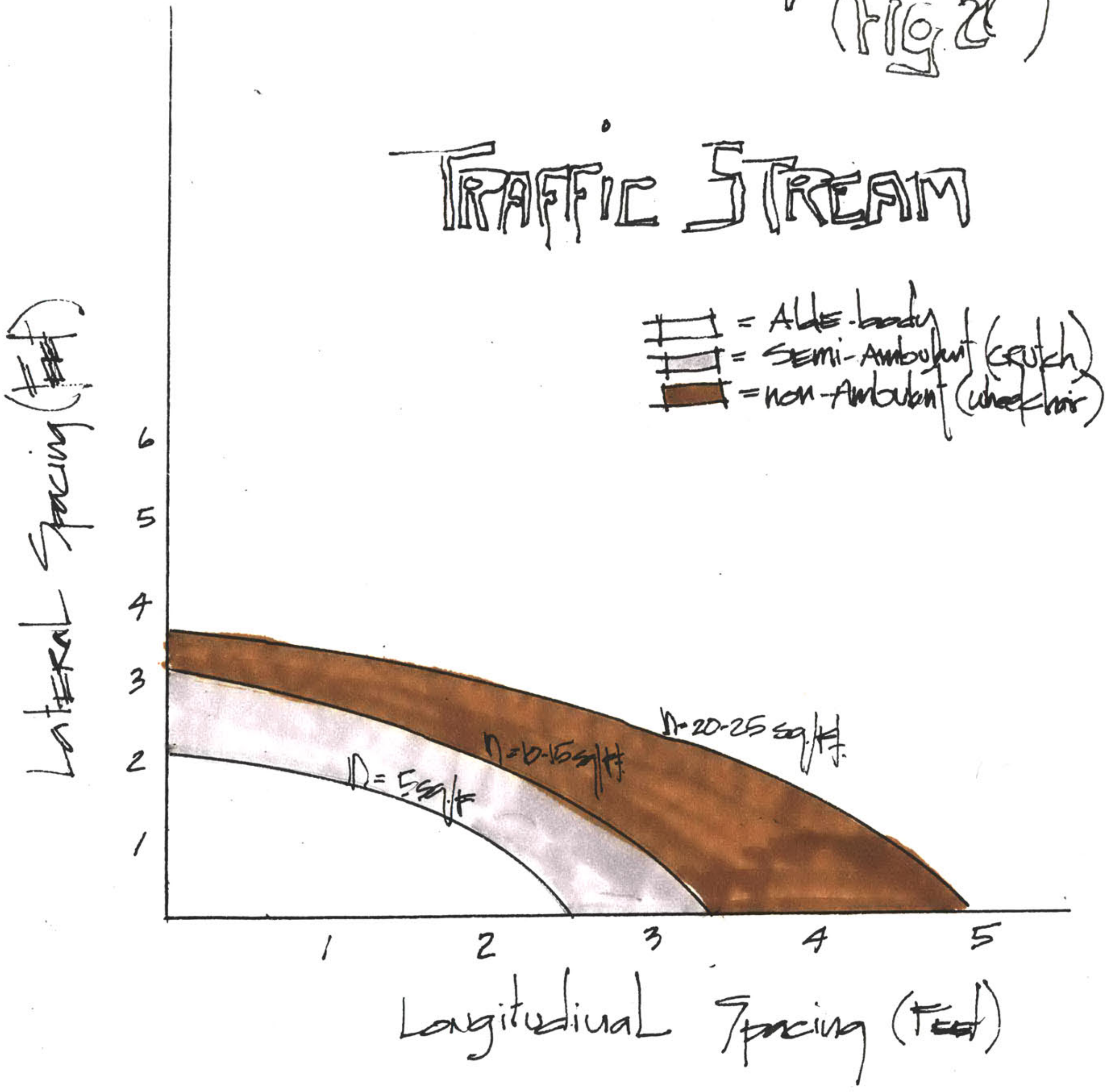
Sensory Territory (fig 26)

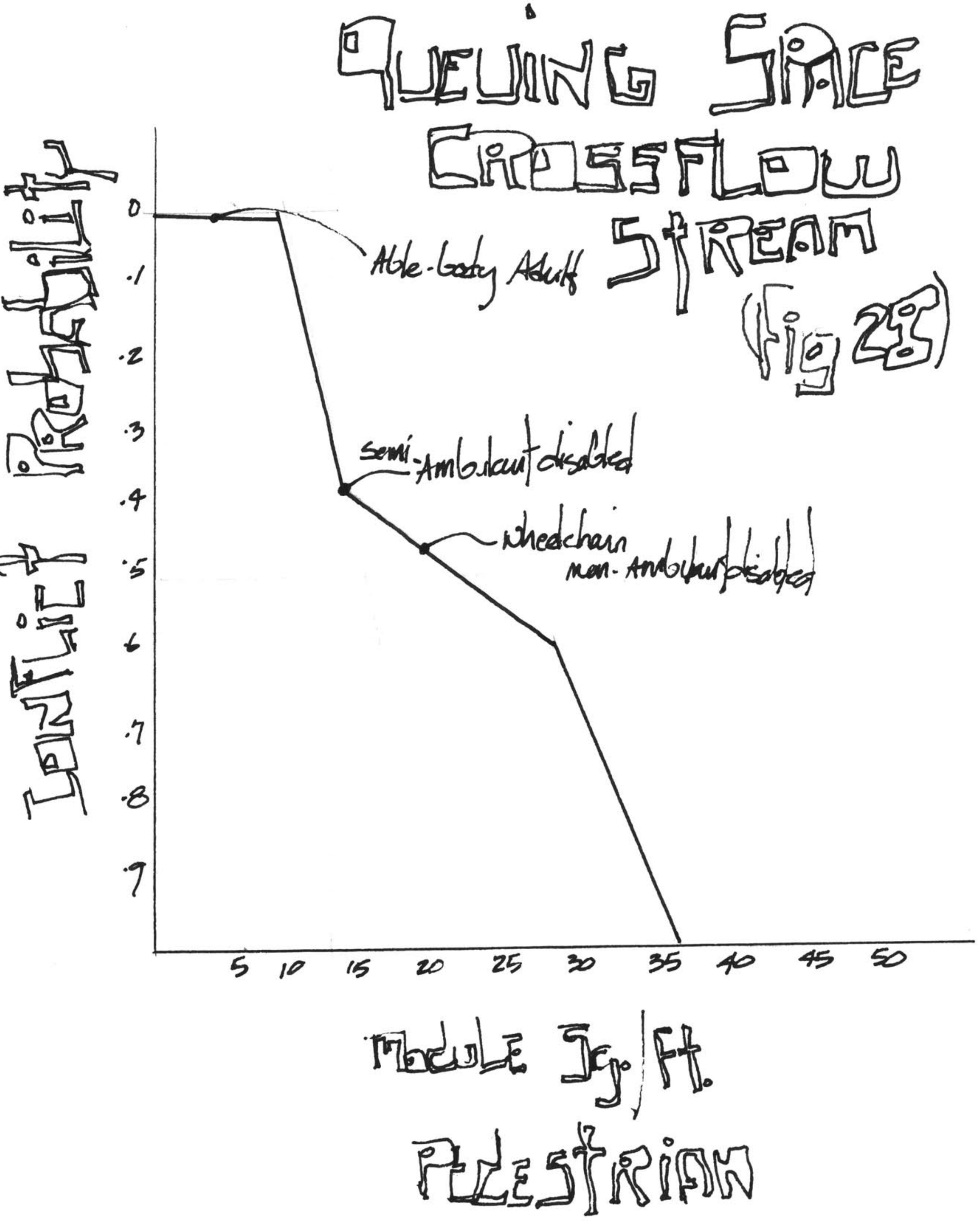
Distance

public	☐	Limited sensory involvement, non-verbal element detection of facial expression not detail - human flight zone
social	▨	conversation, details descernable
personal	▩	conversational, circle of trust, fine details
intimate	■	heightened sensory involvement



QUEUING SPACE (Fig 27)





Equipment Performance Measures

The wheelchair

The design of the wheelchair has perhaps benefited mobility impaired persons through its effective use of its geometrical arrangement. That is, the seating position perhaps being the second most efficient, with the aid of wheels, positions the human body can utilize. There are misconceptions or rather points I would like to make clear about the functioning of a wheelchair and the control needed by its operator.

Because of the wheelchairs irreversible fabrication process the wheelchair is rather limited in the direction of mobility it can perform and even more important in its angular movements it can perform with an operator. A wheelchair is unlike a slinky and therefore cannot do fantastic acrobatics on stairs. Being more serious, because the wheelchair has wheels it obviously can do only one thing roll. But even this rolling ability is limited:

1. The wheelchair cannot roll over highly impervious or soft materials due to the small front wheelcs which are the steering mechanics for the chair.

   Granted if these wheels were like the rear or drive wheels; large where they could gain plenty of ground contact many different types of grounds would be coverable. Of course, increasing the size of these wheels would create other manuevering problems not only with the chair; but having to do with various living spaces.

2. Very hard and bumpy surfaces act like waves when the chair is moving and cause a state of instability for its occupant.

3. Very hard and very rough surfaces act as a friction pad because the wheels are rubber - very high coefficient of friction, bring energy for the user.
4. Surfaces which are interrupted by a vertical plan of 1" or more create movement barriers in the chairs horizontal plane.
5. While gradients are merely horizontal planes sloped, the greater the angle the greater the resistance for forward movement. This is because the gravity effect on a chair of 40-70 lbs.&occupant of 120 = 210-240lbs, is about 40% more weight plus the 1/4 power of arm muscles.
6. Ascending hills or gradients are possible for even the most athletice wheelchair person of about 10°. With 1.33% being the most efficient.
7. Gradients are somewhat of a problem upon descending for more of control problems than strength.
    - (a) Because of the factors in 5 the chair has a tendency to build up speed.
    - (b) The braking system was not designed for hill descents but for merely keeping the chair steady duringtransfer functions.
    - (c) A small hump could upset chair stability.
    - (d) The operator, who is probably deficient in muscular skill and coordination will have trouble to maintain his sitting balance which will affect his coordination and navigation balance.
    - (e) Any slope greater than 30° will not only affect balance but will have the tendency to dislodge the operator from the chair. That angle is beyond the moving and sitting center of gravity.
8. The wheelchair doesn't roll straight backwards in any plane.

9. The wheelchair is very difficult to navigate on pathways which curve. The most efficient movement is either very large radius circumferences or 90° turns.

10. To operate the wheelchair requires the simultaneous navigation with 2 hands.
    (a) for straight pushing
    (b) especially for turns
    (c) always to make an about face
    (d) motions which cause jolting, vibrations or rolling can affect sitting balances

11. Since where still on gradients, Wheelchairs cannot roll horizontally on a surface with a cross fall pitch without rigorous control by its operator. The cross fall creates a force in the castor steering mechansim, which if it is any greater than 1° creates terrible forces in the operation, wrist, forearm and tropezones.

12. The wheelchair does not stop on a dime.

13. The pedestrian space of a still wheelchair is 12 sq./ft. planning module.

14. The seated operator is at a height disadvantage in the pedestrian environment.

15. While the wheelchair is only 25" the operating queuing speed must allow for elbow space.

16. Because of the functioning of the wheelchair the operator is limited in the manueverability through 360° with time.

17. The operator is limited in his reach abilities.

18. General space provision should be based on the dimensions of the wheelchair in forward projection and on its manueverability through 360°.

Efficient Wheeling Process

- Both hands shall start and end the power stroke simultaneously.
- The motion of the arms shall be simultaneous.
- Rythm is essential to the smooth and an efficient performance of an operator and designer should permit this natural rythm.
- Any movement against gravity is fatiguing.

(See Appendix)

The Ambulant Disabled - Walking Aids

Ambulant disabled whose powers of locomtion are impaired to such an extent that they have to use external aids, walking sticks, crutches, elbow cutches, or armpit crutches, tripods or wheelframes is further restricted as with the wheelchair user by the composition of walking surfaces. Often the mobility of these persons while dependent on crutches or still further dependent on leg bracing apparatus. The combination of these aids together can affect the center of gravity (balance) of these persons because of the following:

1. Because braces keep legs in a peg leg position the ability to adjust to contours is difficult and restricted.
2. The ability to maintain balance is diminished because of limb inflexibility.
3. The ability to adjust the foot to different slopes and terrains scopes is restricted because of the hinged foot to leg brace mechanism.

4. The pacing styles and pacing rate are restricted but 2 conditions are necessary: (1) a firm launching pad, (2) a firm landing pad.
5. The ability to change direction is dependent on the ability to stop, and pivot eitherin 90° dierection or in 360° direction. The pivot motion in roadways is circular.
6. Surfaces which are interrupted by a vertical plan of 1 1/2" to 2" or more creates movement barriers in the plan of movement of the walking aid user.
7. While gradients are negotiable by the ambulant disabled, they do have their restriction. Because of the elements identified in items 1-5,slopes become very difficult to negotiate.
    (a) Often there is little use in the lower limb and therefore all the work is put upon the upper torso and so the person ends up dragging dead weight.
    (b) The dragging changes the center of gravity which becomes very detrimental to the ascent and descent of hills.
    (c) Hills of greater ascent than 10° can be very difficult and tiring. Ascending one must be able to lean forward and for an ambulant often this is impossible because of the lack of control of thelower limbs.
    (d) The same is somewhat true for descending because the ability to lean backward, is restricted by the mobility problems.
8. The number of hands used to assist one in ambulation is dependent upon the mobility aid and the type (level) of disability.
9. The basic strength of a disabled (ambulant) is dependent upon the shoulder girdle muscles.

10. Must guard against vibration, rolling, jutting motion. The same conditions about mobility are true for the ambulant disabled as for the wheelchair user. The factors of efficiency, rythm, performance, gravity and fatigue. (See aged-induced mobility) (See Appendix)

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Environmental Framework Analysis

It is very difficult to adjust the accessibity and service-ability of the environment to the requirements of each and every different category of the different aspects and forms of physical disability. Since in general, because of the spatial requirements, it is the crutch and wheelchair user who experience the greatest difficulties, environments have been designed as accesible if they fulfill the requirements more particular to these user groups. The criterion as to judging the accessibility and usability is that the disabled person must be able to make use of the environment and its facilities independently without attendance and unassisted.

It is important to understand the mobility process in terms of its support aids (maps, energy reduction components, and psychological and physical stress factors) in relationship to each individual user but more important in an identification process which not only supports that individual user, but can be offset to other user groups or the supports positive and/or negative relationships to identify conflicts as well as simulative support relationships.

In order to insure a functional environment for all the following qualitative orientated user analysis, is such a comparative survey between the blind, whose mobility is affected by the deficiencies created in the reduced quality of perceiving the environment through their sense modalities as opposed to the semi and non ambulant disabled, whose decreased mobility is affected by their reduced physical performance levels. This reduction in the semi- and non-ambulant disabled's motor capabilities can ultimately lead to a reduction of psychological (cognitive) image.

This analysis will focus on the needed supports, correlate matching support elements and pin-point conflicts. The following is that analysis in a diagrammatic scheme.*

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* Analysis developed from the following resources.

1. Interviews

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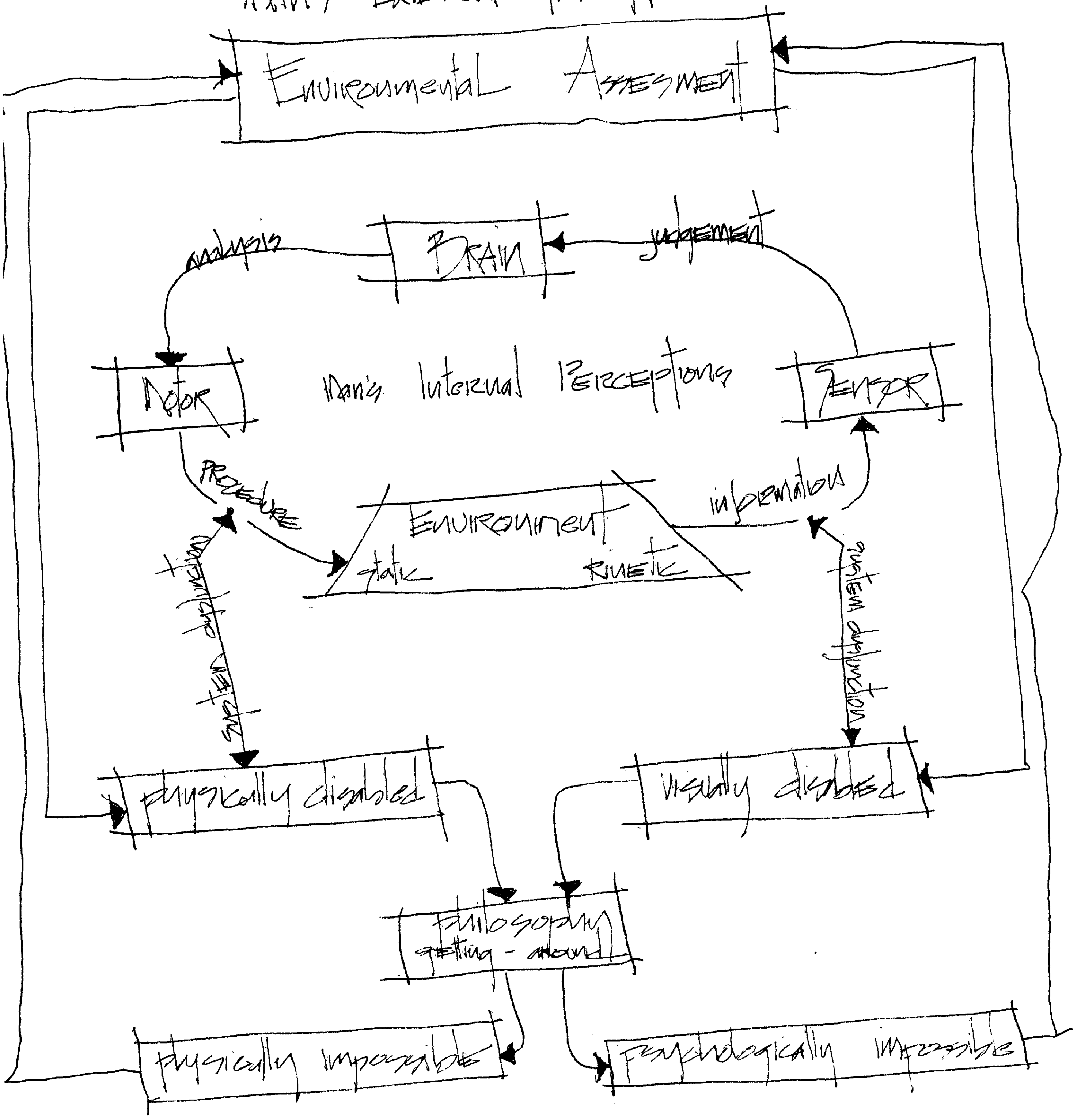
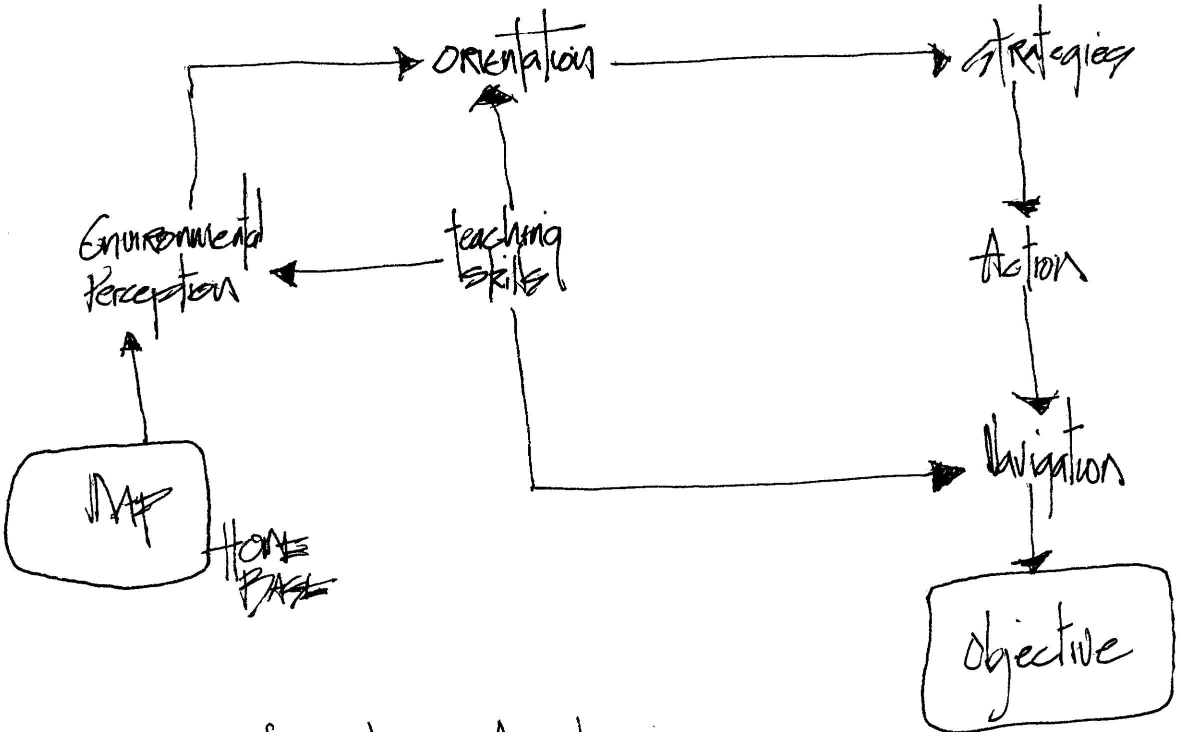
Man's External Perceptions

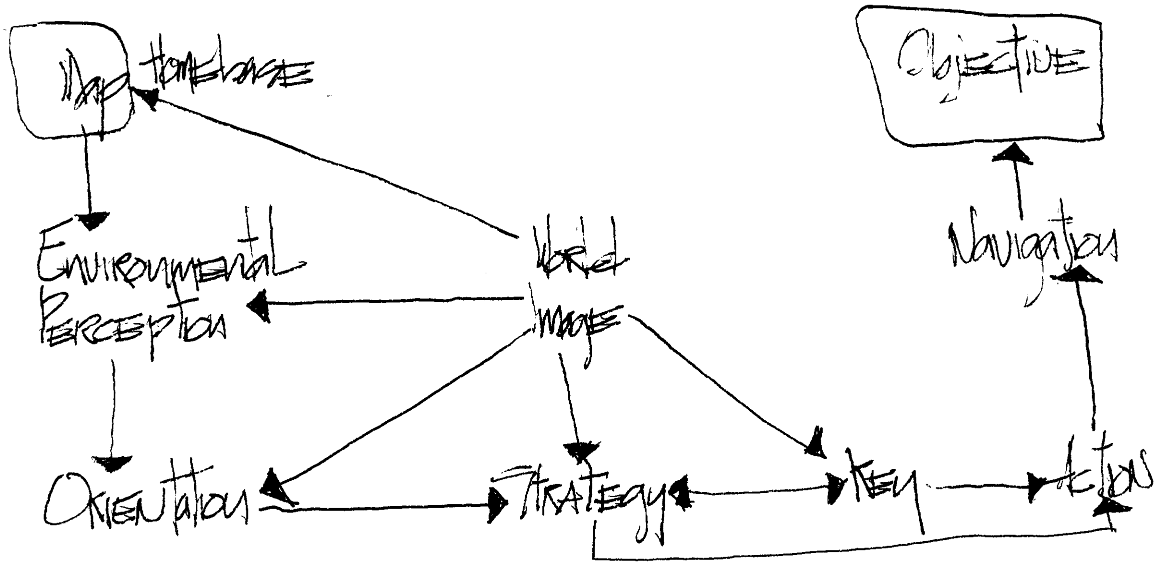




Navigation Analysis

Visually Impaired (blind)

1. The analysis of the home base is dependent on 3 dimensional maps or the familiarity through cognitive map image.
2. The environmental perception is dependent upon the map efficiency and teaching skills used to develop map to understand touch sensitivity
3. The orientation is dependent upon the perceived perception and teaching skills.
4. The strategies are dependent on psychologically efficient path choice,
5 The Action is dependent on convenience factors
6. The navigation is dependent on Action competence and mobility training developed in teaching skills.
7. The objective.



Navigation Analysis
Physically disabled

1. The analysis of the homebase is dependent upon the visually perceived cognitive image of the world image and/or 2 dimensional understanding of map to world image
2. The environmental perception is dependent upon Map perception and world image perception
3. The orientation is dependent upon the cognition of environmental perception to perception of world image perception.
4. The strategies are dependent upon orientation to world image, map key of barrier free route (psychological and physical efficiency), the world image perceptions
5. The key is dependent upon barrier free strategies related to the real world image
6. The Action is dependent upon convenience factors developed in the strategies defined by the key.
7. The navigation is dependent upon physical competence.
8. The objective

The orientation component is dependent on the world indicators used. This next section is an analysis of the measures of compatibility:

1. Methods and needs in levels of information pertaining to maps.
2. Methods and needs in environmental assessments and supports

Note on Measure of Compatability

○ = support for physically disabled
● = support for visually disabled
● ○ = compatability
●̸ ○ = conflict for visually disabled
● ø = conflict for physically disabled

The compatability formula is base on the following assumptions:

○ The physically disabled
  1. wheeling capabilities
  2. turning radius

● The visually disabled.
  1. rythm of travel cane sweeping
  2. man & dog zone.

The Environment (Outside)

Maps making components
- ● ○ 3 dimensional
- ○ 2 dimensional
- ● ○ tactile
- ○ color

Circulation - Movement Corridors
- ● ○ continuous surface
- ● ○ blending of different level paths
- ● ○ curb cuts
- ● Railings along sidewalk
- ○ Reduced cross-fall
- ● ○ minimum width 60"
- ● ○ non-slip surfacing
- ● ∅ hard curb edges
- ● ○ markings at intersection
- ● No thin street impediments
- ● ○ Ramps textured and colored
- ● ○ lights at major intersections
- ● Sonic Audible control
- ● ○ lengthened walk time
- ● ○ Signing minimum height 7ft.
- ● ○ increased illumination levels.

Public Spaces

● ○ shelter
● ○ directional movement corridor (to/from main arteries)
● ○ Maps at analyzed junctures
● ○ Wind Baffles
● Sound Baffles.

Building Edges.

● material change in front of entries
● Extension of entrance (overhang)
● ○ illumination of entry
● ○ signs from various approach destinations
● Audible indicator over entry
● Avoid cavernous type entry
○ Display windows minimum 29"

Entrances

● Extended entrance
○ LEVEL
○ Ramped to platforms
○ elimination of thresholds
● ○ wide paralleling doors
● ○ electric eye doors
● ○ electric eye doors that slide
● ○ door kick plate identify door swing direction
● ○ light tension door mechanisms
○ Double entry set doors minimum 5 ft.
○ No revolving doors
● ○ Railings at stairs
● ○ Light color paint

Door Hardware

● ○ Knobs
● ○ handles or levers.
● ○ Bar or L handles
○ Low window panes
○ Knurled hardware.
○ Lower door bells.

This analysis has overviewed the major elements the major elements may be encountered in the external pedestrian environments by the disabled pedestrian.

ENVIRONMENTAL ISSUES

SUMMARIZED

Street Performance: Overview

The coherence of pedestrian space is dependent on the process, variables, and elements recognized, the consideration of their make up (components) and the objective criteria used to formulate these in the desired framework. Before defining the performance measures associated with the pedestrianised space of the disabled, one should briefly emphasize and overview the measures that go into the pedestiran's space development process, since each has its own traffic pattern, physical restraints and individual environmental requirements.

A non uniform national approach to pedestrian safety causes confusion for both motorist and pedestrian, and undoubtedly results in unnecessary pedestrian casualties. Pedestrian safety is a problem that crossing all state lines. This reruies the establishment of a national system of traffic laws, traffic signalization signs and codes implemented uniformily throughout the country. The fact that many authorities have their own level of service rating concepts compounds the problem and reflects theneed for an evaluation technique.

Since human convenience is a primary consideration in environmental design, pedestrian design standards must be based on a relative scale o f this factor. The first level of service concept was just used in traffic-engineering. This most authoriative reference on highway design practice (HIghway Capacity Manual) develops standards for six levels of design, based on service volumes and a qualitative evaluation of driver conveninence. This qualitative evaluation includes the freedom to choose desired vehicle operating speed, the ability to overtake and pass other vehicles, and the freedom to chang lanes. The level-of-service concept provides a useful model for the design of pedestrian space as well. Pedestrian service standards should similarly be based on the freedom to select normal locomtion speed, the ability to by-pass slow moving pedestrians, and relative ease of cross and reverse-flow movements at various pedestrian traffic concentrations. The breakpoint that determines the various levels of service has been determined on the basis of the walking speed, pedestrian spacing, and probabilities of conflict such as developed in previous chapters: The standards provide the means of determining the design quality of corridors, taking into account the human propsentiy to maintain a separation from stationary objects, and walks as well as other pedestrians. Such considerations when designing sidewalks should be observed especially crosswalk areas, with its multi-dimensional flows. conflicts with turning vehicles, and space requirements for standing pedestrians. This area is also a prime location for walkway impediments. Vertical and sloping corridors need consideration to the role of human characteristics, because of the greater safety hazards and energy required in locomotion. Standards based on thehuman body discussion andpersonal space preference are called queuing standards. The designer should not only apply queuing standards in areas designed primarily for pedestrian waiting, such as lobbies and elevators, but in other areas in which queuing is likely to result from service stoppages or inadequate capacity of pedestrain service facilities.

The primary goals and objectives of an improvement program for pedestrians are inter-related and overlapping. Improvements in one objective generally result in opportunities for improvements in the others. The basic concern - safety is the reduction of the pedestrian-vehicle conflict. Pedestrian security has become an important objective in building archstreet design. Street configuration and construction should be arranged and formed to enhance clear observation of the stree, nodes and topography of paths as well as allow observation by other and police. This convenience may be enhanced if careful planning application is applied to sidewalk obstructions, such as mailboxes, telephone booths, newstands, refuse cans and planters , etc. Other more stationary items such as traffic light standards, fire hydrants, and fire alarm boxes could be moved under normal replacement schedules. Ramped curbs into provide conveniences for disabled pedestrians, persons wheeling baby carriages for others who have difficulty in using high curbs. Tactile tracts could be included in and around building complexes. Continuity, convenience and comfort are the primary objectives. The first premise the systems coherence is based not only in its physical transitional qualities, but also in its perceptual space qualities. A confused pedestrian searching for orientation has limited receptivity to secondary visual inputs such as aesthetic. All elements of the urban core, including street systems, transit facilities, office buildings, civic centers, theatre complexes and shopping areas should have clear visual statements that convey their direction, function and purpose. When pedestrians are assured of his primary concern of orientation and direction, his level of receptivity to sensory gradients such as changes in color, light , ground slope, smells, sounds and textures is increased.

Thus the basic elements of an improvement program would be the upgrading of pedestrian safety, street lighting, pedestrain circulation. area image, and pedestrian amenities. Pedestrian safety programs should concentrate on education, engineering and enforcement. Safety education is especially directed towards the most accident prone segments of the public, the old and the young. Engineering for pedestrian safety involves the provision of physical improvements to reduce pedestrian accident exposure and achieve greater pedestrian environmental legibility. This would include standardization of signing signals, distinctive crosswalk delineation, improving motorist and pedestrian line of sight, upgraded street lighting, and other physical features that contribute to pedestrian safety. Street features are comprised of an endless list of impediments. There has been little if any regulation of the locationof those sidewalk incursions. Such supplementary use of sidewalk space should become fully controlled. In addition to this intrusion into the pedestiran's space, the utility and continuity of the sidewalk system is reduced further by vehicular conflicts and signal systems which are timed to poor vehicles. Enforcing this involves the development and implementation of legislation that protects the pedestrian, and that is uniformly recognized by both pedestrain and motorist alike.

OPERATIONAL STREET
PERFORMANCE
SPECIFICATIONS

(See Appendix A - Visual Analysis)

Performance Standard Criteria : Matrix Analysis

The disabled Pedestrian - Human Factors

Components of the Pedestrian Environment	Street lighting	Sidewalk lighting	drains, grates	Signals	telephones	Mailboxes	Receptacles	Call boxes	Street signs	fire plug	landmarks	billboards	Crosswalks	Corners	Sidewalks	wide streets	Parking	Sign posting	Street graphic	Plazas, Mall	Rest stops	Information	Weather	Curbs
reduced visual angle	●	●		●	●				●			●	●	●	●	●	●	●	●	●	●	●	●	●
Reduced eye sensitivity	●	●		●					●			●	●	●	●	●	●	●	●	●	●	●	●	
narrowing visual field	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
diminished visual acuity									●			●	●	●	●	●	●	●	●	●	●	●	●	
low tolerance of glare	●	●		●					●			●	●	●	●	●	●	●	●	●	●	●	●	
sensitive to brightness	●	●							●			●	●	●	●	●	●	●	●	●	●	●	●	
Poor night vision	●	●	●	●			●		●			●	●	●	●	●	●	●	●	●	●	●	●	●
decreased hearing acuity				●	●																●	●	●	
sensitive to motion		●		●											●	●		●		●	●	●	●	
Reduced muscular skill			●			●									●	●		●		●	●	●	●	
Reduced coordination		●	●	●		●							●		●	●	●	●		●	●	●	●	
															●									
limited balance ability		●	●	●									●	●	●	●				●	●	●	●	●
Reduced pacing length				●									●		●	●				●				
Reduced time speed				●									●		●	●				●				
Reduced walking speed				●									●		●	●				●				
lengthened Reaction time	●	●	●	●					●			●	●	●	●	●	●	●	●			●	●	●
Reduced stamina													●	●	●	●	●			●	●	●	●	●
Reduced bone flexibility													●	●	●					●	●	●	●	●
diminished nervous system.													●	●	●					●	●	●	●	
increased sensitivity													●	●	●					●	●	●	●	
sensitivity to dizziness	●	●											●	●	●					●	●	●	●	
sensitivity to faintness													●	●	●					●	●	●	●	
susceptibility to infection																				●	●	●	●	
increased chronic desease																				●	●	●	●	
increased heart symptom													●	●	●	●				●	●	●	●	
bone weakening															●					●	●	●	●	
Pneumonia exposure																				●	●	●	●	
Reduced strength			●	●		●							●	●	●	●				●	●	●	●	●
disorientation	●	●		●					●		●	●	●	●	●	●	●	●	●	●	●	●	●	
fear of falling	●	●	●	●		●	●	●		●			●		●	●			●		●	●	●	
fear of car fatalites	●	●		●									●	●	●	●	●	●	●		●	●	●	
fear of attack	●	●											●		●	●					●	●		
fear of being lost	●	●		●					●		●	●	●	●	●	●	●	●	●	●	●	●	●	
nervousness	●	●		●					●				●	●	●	●	●	●	●		●	●		
non-ambulant	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
semi-ambulant	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
ambulant	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
blind			●	●	●	●	●	●		●	●		●	●	●	●		●		●	●	●		
able body																								

Operational (Performance) Specifications

1. Element - Street Lighting

Many variables will affect the type, strength and continuity of lighting required along streets. The elimination of vision glare, the ability to give visual clarity, and capacity to achieve heightening affects by visually highlighting surfaces. Remember the extent of night usagess will depend on related adjacent land use activities.

Operational Spec.

1. Lighting source should have one discernment, that is to reveal and not silhouette objects.
2. Fixed obstacles should be adequately illuminated (ramped curb, crossings, etc.)
3. Transition lighting should be provided along movement corridors into intersections. Levels for Urban Design
    ex: Average 3 to 4 Fc(lumens per square ft) intersections
        Major streets = 2 FC (footchandles)
        Collector streets = 1.2 FC
        Minor streets = .9 FC
4. Security lighting should change these levels too - 10, 8.8, 7.1 respectively. Both people security and path safety.
5. Luminaires should be asymetrically positioned, shaded and broad beamed.
6. Pale positioning below 15 ft. should not allow two sequential light sources to subtend a light arc greater than 80° to eliminate glare.[30]
7. The light source should be intensified at model points and major areas of distribution of generators for orientation.
8. Identification of special key symbols on road signs should be emphasized.[20,27]
9. Lighting of special informational graphics such as disabled symbol of access.
10. Crossing should be reflectorized.

2. Sidwalk lighting

Adequate lighting is prerequisite to the safe operation of any movement corridor for which considerable nighttime use is anticipated.

Specifically lighting provides information concerning the demarcation and direction of the corridor, its surface conditions and the presence of obstacles including pedestrians, vehicles, and fixed objects, whether stationary or in motion. It is not important that lights, be the specific design element but it is more important that heightened expression of the environment be attained.[5,19,20,25,35] The luminaires must not only light the path, they must also reveal the presence of pedestrians, by cyclist, etc.

Operational Spec.

1. To illuminate path so as to distinguish slopes, changes in form, obstacles and street furnishings illumination levels should be no greater than .3fc at a height of 4 ft. or less.[5,9]
2. To envision greater path distance or obstacles or pedestrians the luminaires must be mounted at least 8 ft.
3. Miniations levels should be at least 8 fc.
4. Light should not have a downward cast angle greater than 30°.
5. Special light should highlight special sidewalk events - public rights-of-way, building entrances, etc.[19]
6. Special lighting of seating, rest spaces,

3. Traffic Control Devices (Signalization)

To reduce the high fatality of vehicle, pedestrian conflict in intersections three things should be considered. The first suggestion is the standardization of traffic signals and control devices, the development of pedestrian type actuators and the maintenance of time schemes with the amber interval in most signals. These considerations were based on the following observations. (1) Some cities used green-walk, red-don't walk, while others used white-walk, orange-don't walk, (2) the flashing don't walk indication for the end of the walk signal was hardly ever used of if so was found confusing, (3) after leaving crosswalk pedestrians had to little time to manage a complete journey. Then 2/3 of the accidents occur in the intersection.

Operationa Spec.

Automatic

1. Clear directional signs be provided.[1,5,12]
2. Clear definition of how the control operates should be mounted on each signal.
3. Brighter intensity lights should be provided where signals are reflected by sun.
4. Light timing should operate according to the averaged pacing speed.
    Example - disabled 1 ft. = 2 seconds. Therefore a street 20' wide equals 40 seconds of walk time.
    Europe 1 metre = 5 seconds[20,25]
5. Walk-Don't Walk - Should have brighter intensity amber, bolder graphic quality for wider streets instead of same size. Just a constant walk and a constant don't walk.
6. An all-walk signal should be installed on streets where intersections allow left turn and pedestrian crossing
7. An audible buzzer system should sound as long as it is safe to walk with lead times.[19,20,25]

Manual

8. Where manual systems are in operation they should provide all of the above plus.
9. Finger touch sensitized pad or pneumatic button
10. Contrasting colour mount plaque.
11. Sensory indicator which vibrates walk for walkand don't-walk for don't walk.
12. Placement height should be between 4'6" and 5'6".[10]

4. Street Signs - turn/no-turn, snow, emergency parking, etc.

Standard signs serve an intra-as well as inter system function. In providing intra-system uniformily, standardization permits greater comprehension. Inter-system uniformity benefits unfamiliar persons with an area with accurate, clearly marked information. Thus these are the following conclusions about signing: (1) Adequate signing, at all decision points, (2) Quiding signs at regular intervals, (3) Warning sings, (4) Modification of existing signs to standardization.

Information Service

Quality in communications is a resource needed and sought after by the physically disabled. They rely on either previous experience or competent information on the environment, especially the environment of moving systems. Transit information is presently inadequate, as there is no systematic way of communicating transit information to the consumer. In our age of such advanced technology, we as a society still have not captured the technique of attitude testing, successful advertising and improving communication channels simpley because of economic trivia. Schedules are confusing and require patient telephoning and decoding systems; system's operators are usually uncertain. Therefore either massive attention is spent on developing efficient information systems or authorities pay the economic burden of supplying an effective media.

In line with the above examples, a promising approach to studying latent demand for transit services is to identify and measure the interest of individuals or groups and then establish the role that transit can play in satisfying those interests.

Information, Communication. Operating modes must identify research factors for the waiting passengers. The information must be provided clearly and effectively; it must be instantaneous and direct. The implications of more and better information aids would, 1) increase the number of riders using more than a single route, 2) improve attitudes toward public transit, 3) increase knowledge of the transit system as a whole, 4) decrease satisfaction with information currently offered.

Information and Route Identification. Useful design criteria for improving the quality of information in transportation systems range from waiting point markers, time table information, route dry runs, and graphics.

Operational Spec.

Stations: Be seen clearly at half block distance
Indication of services (or lines) using the stop; if more than one, then color graphics may differentiate
Starting points (heavily serviced areas)
How one may reach other routes
Indication of which part of the line you are on, where transfer points exist, points of interest, map of the area
Other specific information (station attributes, location of elevators, ramps, escalators)

Reflexive information - Destination Markers:

Each service provide a specific symbol on specific markers
1. Large lettering
2. Bold face type
3. Graphics to reduce words

Destination information
1. Type of service
2. Scenery (on-route visual experience)
3. Install on new buses as well as old

Responsive information - Scheduling:

Take-one time tables or information
Push button audio devices at transfer points indicating stations, major stores
Disseminate through media, movie theaters, shopping center, TV, paper

Experience Information:

Diagramming can be effective in a frame which the user can associate with
1. Beginning, end, transfer point route diagrams are effective for long travel

2. Diagrams which relate the route to community, show facilities (shopping, historical, civic)
3. Diagrams which relate time to stop interval
4. Downtown areas transit in relation to shopping areas

An example of graphic impact is the work of Cambridge Seven and Boston transportation system. The symbol Ⓣ is well known to people of metropolitan and suburban areas of Boston.

Operational Spec.

1. eliminate competing visual display
2. avoid conflict of directional signs as opposed to warning signs
3. signs which inform driver should be placed within 10 ft. of corner (directional, functional)
4. signs which inform parker should be located nearer the middle of the block (situational)
5. lateral street name signs should be placed in the middle of the block with cross-street names placed on corners (locational)
6. sign height should not hang below 7'[1,5]
7. illuminated sign should heighten communication (situational)

5. <u>Sign-posting, Billboards, Bollards</u>

Many disabled people are dependent on public transport. Since they tend to have low incomes, poor modalities, factors, less physical ability and cannot afford to buy a car[20] are often deterred from environmental interaction because of thejolting bus, steps or poor environmental information.[16] Confusing background can reduce sign effectiveness, but sign should only be a supplementary message to confirm visual statement expressed by legibility of the spacial design itself. Good sign can be compared to the factors that enhance human short term memory. Kevin Lynch - <u>Images of the City</u> says a good city should be highly imageable with many known symbols jointed by widely known pathways. To increase the effectiveness of the psychological map, we could construct a cognitive map that would not only show the symbol of the city, but would measure the precise degree of cognitive significance of any given point in the city relative to another.

Operational Spec.

1. Plan for a mean eye height for the disabled
   Wheelchair = 3'9 1/2"
   Ambulant = 4'8 3/4"
   Average = 5'5 1/2"

2. Plan for 30° cone of vision (Refer to graphs previous chapter)
3. Hanging signs should not hang below 7 ft.
4. Use of disabled symbol[20] of access on sign or buildings representing available facilities.
5. Tactual signing should be placed between 4'6" and 5'6".[5,9,10]
6. Sign mounting angle should be perpendicular to line of sight from maximum distance to be viewed by the mean eye height sample of population.
7. Type print is legible to 6' by factors considered above.
8. Tying 6' avove initial 6' should increase print size by 1 inch.
9. Hypothetical scheme for corner cognitive map planning (elements)
   a) your location b) a major landmark location c) major arterial orientation

6. Street Graphics[5]

Information should respond to the user's immediate need and level of receptivity, considering such factors as height, and usual capacity. It should also take into account distance speed, background, location and recognition ability. Legibility occurs when information presented is easily perceived and interpreted. Meaning occurs when the relationship between the environment and individual is reinforced and gratifying. Information that generates orientation and identity can also help to generate a sense of place. The problem of translating decision sequence into hierarchial order of information. (See next sheets for example)

Operational Spec.

1. locate specific objectives
2. discriminate between categories
3. coding standardization
4. levels of information for levels of travel
   ex. Pedestrian speed
   Bicycle speed
   Vehicle speed
5. levels of components for each
   Reflexive (Instant)
   Responsive (Casual)
   Experienced (Studied)
6. minimal number of effective bits of information

7. use, short, familiar consistent terms.
8. illumination in direct area of graphics should be noted.
9. refer to graphs of previous chapter for sizes, dimensions, distance viewed.
10. as sign height increases, sign angle should be perpendicular to sight
line from maximum distance to be viewed
    ex: elderly 25ft - lettering 3 to 4 inches, 30° vision cone = sign angle of 60° at a height of 17 1/2 ft. above ground.
11. graphics should express either direction, orientation, purposes

7. Parking - Vehicle Storage [5,9,10,19]

There is an administrative problem in insuring adequate supervision of reserved parking placing in order to prevent their use by able body drivers.

Operational Spec.

1. 50 or less spaces one space for the disabled
2. 50 or more spaces 5% reserved for the disabled
3. Specific types of building shall conform percentage to building operational capacities
4. desirable to have covered parking
5. catch basins located away from and sloped away from parking spacing
6. eliminate wheeling through blind spotes - such as behind cars
7. parking shall be signposted
8. scheme for through route signposting
    - Roadsign directing disabled driver to reserved parking places
    - Signplate at reserve parking place
    - Directional notice to nearest accessible entrance and accessible route to main concourse
    - Signposting on main concourse to accessible W.C. (toilets)
    - Signposting of and to other accessible routes

8. Crosswalks

Clear destination is an important element in intersection interaction and on all major approaches.[5,9,19,23,25] Where road crossings are unavoidable have curbs been ramped so that they are negotiable. Is there a proper queing space between street, edge and building environment edge to allow safe passage along the pavement not in line with ramps.[20] Shipping surfaces should be avoided in the crosswalk.

Operational Spec.

1. Minimum width markings 9ft. This allows for a 3' displacement of

ramp to avoid hard edge requirements of the blind population.
2. Different paving materials - nonglare, non-slip, contrasting colour
3. Where an island exists a passage through the island should be provided flush with the street and a minimum width of 36".[5,20]
4. Curb-cuts - Kerb Kuts
   (1) non-stip,(2) slop 1:12 where possible, (3) 36" minimum width, (4) blend to common surface, (5) allow drainage, (6) stenciled identification marker.[10,20] minimum 24" x 24"
5. Should be clearly identified as crosswalk
6. Street names could be marked (stenciled) on corner Kurbs.

9. Corners

Are the pedestrian spaces designed adequately for moving disabled pedestrians, who may have larger although transient, spare demands, but the potential danger can arise from serious crowding due to temporary disruptions or loss of control. This queuing either static or kinetic may require coordination both for lineal or bulk type spaces and both in circulation and stationary situation.

Operational Spec.

1. Develop functional and visual priorities as discussed under signing.
2. Define corner as unified place by designing and defining a single vertical element of traffic signal, light, and street identification
3. Define a lower element of which will be consolidated mailboxes, trash receptacles, news, vending machines, firebox and policebox.
   Purpose: 1. places a minimum of 9' from corner just outside crosswalk
   2. eliminate street litter
   3. develop schema which blind may begin to associate with in mobility training
   4. allow more space for landscaping
4. Corner queuing space - buffer zone
   18" average person
   48" wheelchair user in inches
   22" ambulant disabled

10. Sidewalks

Movement corridors should promote maximum ease of travel and barrier free circulating to reduce thephysical and psychological taxonomy.[9,10,19] Disabled people are at a disadvantage when crossing roads because they move very slowly as well as having a reduced statue. Ambulant or semi-ambulant persons may find long sloping ramps unusable.[16,19,20] One consideration should be given to the widths of pedestrian ways.[20] Ground surfaces should be smooth to avoid bumping up and down of wheelchair user or tripping of ambulating disabled. Icy, wet surfaces may cause the wheelchair to skid and be equally vulnerable to walking persons because if poor balance and for irregularities in surface material.[4,5,10] Steps are an insurmountable obstacles to self-propelled wheelchair users. It is possible to negotiate a single kurb if chair is pushed. Flights are obstacles. Ambulant disabled persons can manage short flights, not too steep.[20] Protection from the elements should be provided wherever possible, this is especially important over ramps, steps, wide aisles where wet and icy surfaces can be dangerous and where a wait is involved.[9,19]

Operational Spec.

1. Walks defined
   0-3% = walks
   3-5% = frequent rest areas
   5-8% = ramps and may require curbs and handrails
   8-10% = absolute maximum must accompanied by properly designed stairs
2. Minimum width of walks, 72"
   Add 18" if propensity of wall interference (times 2 for 2 walls)
   Add 25" for a shopping street
   Add 2 ft. for street impediments
3. Maximum cross-fall slope = 1:200, allowable 1:100[10,20]
4. Continuous Common Surface
5. Newly constructed Kurbs should not exceed 4 inches
6. Contouring of surfacing topography
7. Blending intersecting paths
8. Non-slip surfacing - marble - very good for wheeled vehicles
   brushed troweled concrete = best
   asphalt (artificial) = better
   aggregate = good
   brick = fair
   grass = poor
   cobblestone = poorer
   rubble = poorest
   sand = worst

9. Ramps - slope 1:20 best 1:12 good 1:10 poor
   minimum 40 inch clearance
   designed weight 40 lbs/ft
   landings of 5 ft. x 5 ft.
   ramps shouldn't exceed 30' intervals[20] preferably 15'
   double railings wheelchair use 19", normal 33"
8. Stairs(1,2,3,4,5)A
   (1) no abrupt nosing,(2) continuous handrails 12-18" past top and bottom stair, (3) riser not to exceed 7", (4) safety tread, (5) landing different materials, (6) landing minimum 5 ft. x 5 ft., (7) maximum of 9-12 stair spread, (8) avoid white vibrant colors, (9) minimum of 10 ft. munination level, (10) where crossflow or reverse flow traffic occurs stair minimum width should be one direction should be 33", (11) stiar should through visibility promote vertical connection relationships, (12) should promote least energy expenditure.
9. Accomodations for the visually impaired
   (1) sufficient hardness of surface to provide echos, (2) doors should not open into circulation areas, (3) avoidance of projections by street impedimentor, (4) railings may be necessary near curb ramps on the horizontal run, (5) entrances to buildings should be highlighted, contrasting colour, or different surfacing material.
10. Provide overhead shelter where possible
11. Covering over sidewalk should serve to unify route identifications signs, and serve to organize commercial signs with the facial serving to orientate vehicles.

11. Street Furniture

Comprises an endless list of impediments all designed to have some proprietary a pre-emptory right over the pedestrain sidewalk zone. Parking meters, fireboxes, planters, refuse cans, bus shelter, subway tracks, telephone booths, etc. This supplementary use of sidewalk space must be carefully controlled. Efforts should be made to reduce the number by use of incorporating different elements. Overcoming two barriers can be most difficult to one already with a number of disabling effects.

Operational Spec.

1. Telephone installations - phone booths should be accessible to

wheelchair users, public telephones with acoustic hoods are recommended or side baffles are preferable for ambulant disabled. (1) accommodate access by a wheelchair, (2) shall be mounted in reach fo a seated person, (3) should be equiped for extra hearing and sensory deficiencies, (4) should be equipped for vision impaired, (5) should have long flexible cord, (6) headseat no higher than 4 ft., (7) one at all telephone banks.

2. Mail boxes -(1) should intensify their red, white, blue colour, (2) should be redesigned so only a slot would be required to insert mail, (3) should be placed no higher than 4 ft. 6".
3. Trash receptacle - (1) enclosed in non-blow containers, (2) elimination of strapped containers to utility poles, (3) securable to avoid turning over
4. Police and fire call boxes - (1) maximum height should be 4'6", (2) should be able to be manipulated without detailed instructions or much finger dexterity, (3) activation should be detectable by more than one modality (sense)
5. Fire plug - (1) to avoid bodily contacts, should be covered with smooth durable plastic or aluminum as a shield.

12. Nodal Elements - plazas, malls, etc.

Exposure to cold and wet is particularly dangerous to the disabled. Exposure to snow and wind can create an unsteadiness in disabled balance. Especially when exposed to large spaces of wind.[4,5,10,20] Or where winds build up around large forms or urban complexes. Conversely the disabled pedestrians resistance to sun and heat is relatively low thus affecting locomotion balance and perceptual orientation.

Operational Spec.

1. Protection from elements
2. Ability to gravitate along paths of least difficulty
3. Most sidewalk regulation
4. Signs and graphics for orientation
5. Drains, street grating inconvenience people with poor sight, limitations, because of their slippery surfaces and tripping hazards caused by openings in the drains.
   Requirements:[20]
   1. textured or knurled surface grating
   2. screen openings not to exceed 1/2" x 1/2"
   3. should be of contrasting colour
   4. should be in a highlight zone

13. Rest Stops

Some wheelchair users are usually pushed and therefore would accept pedestrian distances usually accepted by the able-bodied. But for the ambulant, semi-ambulant and non-ambulant those distances become markedly different because of energy expenditure, mode of ambulation, terrain and environmental conditions, and psychological stability of the individual. Evaluations have records 50 yds. and 1000 ft. as too different prepared distances for the ambulant and semi-ambulant disabled, with 45-60 minutes, 2 1/2 - 3 miles being the fatigue limit.[9,20] There is no exact information on the wheelchair user and thus we can only do a muscle efficiency comparison. Environmental conditions may be more important than distances. (A subjective factor)

The following is a hypothetical abstraction:

Ambulant - semi-ambulant disabled
Figures developed earlier in text
stopping distance = 50 yds.
leisure distance = 1000" (440 yds)
formal distance = 2000 metres (6000') (mile)
plaza use = 4'/1ooo
fatigue = 45-60 minutes 2 2 1/2 - 3 miles
parking = 7 to 10 minutes or 1000'
Wheelchair user (arms) = 1/4 strenght or net power
Assume
1/4 to 1/6 stopping distance = 12 1/4 yds.
same leisure distance = 200'
same formal distance = 500m 1500'
plaza use = one wheelchair = 15 sq./ft.
6 times as fast fatigue = 1/6(45-60) = 8 - 10 minutes for 1/3 mile means resting 6 times every third of a mile
parking = 1/4 (1000') = 222'(300')

if we assume extreme weather conditions at least every other step should be sheltered. = 1 every 25 yds.

While this is a mathematical abstraction it does begin to show the relationship to environmental supports and spatial programming. If we avoid the statement trip purpose, then an analysis only in much greater depth would be in line. Perhaps at this point in time trip purpose would depend more in psychological factors, but that is only because the disabled has not been granted the desire to be a pedestrian.

Operational Spec.

1. Rest stops categorized by function (explanation to follow)
   - intermittant stop
   - leisure stop
   - formal stop
     social
     service

Intermittant Stop (Personal to intimate distance)

Operational Spec.

1. Bus stop, transit stop, public seating, any place out of the main circulation path
2. May just be display looking, leaning places, benches - short term place.
3. Information, billboard, kiosks, audio-visual, graphics
4. Awning or canopy cover
5. Plan for minimum standing and movement requirements of disabled persons.

Leisure Stop (personal to social distance)

Operational Spec.

1. Wide streets, unique architectural areas, landmarks, distribution of generators vest pocket parks.
2. Option 1-4 above.
3. Formalized seating areas perhaps newstand, venders
4. Possibility of planting artificial green areas.
5. Lighting for night use.
6. Telephone
7. Portable or pre-fab shelter, tents, etc.

Formal Stop (social to public distance relationship)

Operational Spec.

1. All of above
2. Same characteristics of nodal points
3. Squares, small parks, government centers, cafes, game areas
4. Areas prepared as major city elements
5. Vehicular parking may be here
6. Accommodations for biological functions
7. Emergency communication networks
8. Built shelter.

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APPENDIX (Visual Analysis)

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	American Stand.	D.P.S. (Mass.)	House Bill (Mass)	Rochester, N.Y.	Canada	Britain	Range
Handrails: where	on each side	same as Amer.	same as Amer.	same as Amer.	same as Amer.	both sides & inside on back	
Height	33" high	" "	" "	" "	" "	31" high	31-33"
Size	1½" outside dia.	" "	" "	" "	" "	≮ 1", ≯ 1¼ diam.	1"-1½"
Clearance betw. wall & rail	1½"	" "	" "	" "	" "	not given	1½"
W.C: seat height	20"	" "	" "	not given	" "	same as Amer.	20"
location	not given	3'-6" from center fixt. to wall	not given	not given	2'-8" cent. of fixt. to wall	3'2"	2'-8"-3'-6"
Wall mounted urinals	opening 19" high	same as Amer.	same as Amer.	same as Amer.	same as Amer.	not given	19" high
Wash basins	not given	wall mounted w/out legs; 2'-2" clearance to pt. 10" from ft. of fix.	not given	not given	same as D.P.S.	rim 2'8" above floor	
Mirror ht.	≯ 40"	≯ 40"	≯ 40"	≯ 40"	max. 38" from floor to bottom	not given	40"
Towel rack height	≯ 40"	≯ 40"	≯ 40"	≯ 48"	max. 40" from fl. to bottom		40-48"
Water Fountains							
Controls & spouts	up front	same as Amer.	same as Amer.	same as Amer.	same as Amer.	not given	
Operation	hand, or hand & foot	same as Amer.	same as Amer.	not given	same as Amer.	not given	
Ht. for wall mounted	36"	" "	not given	same as Amer.	same as Amer.	not given	36"
Public Telephones							
Ht. from floor	≯ 48"	" "	same as Amer.	" "	" "	≮ 36"	36-48"
Controls: switches:	not given	≮ 36", ≯ 48"	not given	not given	not given	≯ 42"	36", 48"
outlets	not given	not given	not given	not given	18"	≮ 18"	
Elevators: occurrence	multistory bldg.	2 or more operating levels	not given	same as D.P.S.	same as D.P.S.	not given	
opening dimensions	not given	32" clear	not given	32" clear	not given	33" clear	32-33"
size (minimum)	not given	4'X4'	not given	5' X 5'-6"	not given	4'-5" X3'-8" or 3'-6" X 4'-9"	
control height	not given	≯ 60"	not given	≯ 63"	≯ 48"	≮ 36", ≯ 54"	36-63"
handrail	not given	not given	not given	not given	on 3 sides	not given	

	American Stand.	D.P.S. (Mass.)	House Bill (Mass)	Rochester, N.Y.	Canada	British	Range
Exterior Building Ramps							
Slope	≯4°, ≯1 in 12	≯1 in 10	≯ 1 in 12	≯ 1 in 12 (8.33%)	1 in 12	≯1 in 12	1 in 10-12
Width	not given	not given	not given	32"	36"	48"	32-48"
Handrails: frequency	at least 1 side	both sides	at least 1 side	at least 1 side	when gradient 1 /in 20, 2 si	not given	
height	32"	33"	32"	34"	n.g.		32-34"
midrail ht.	none recomm.	16"	none recomm.	none recomm.	none recomm.	none recomm.	
extension	1' top, 1' bot.	same as Amer.	Same as Amer.	same as Amer.	not given	not given	
distance apart	not given	not given	not given	not given	34"		
diameter	not given	1¼", 2" diam.	not given	not given	not given	not given	
Ramp Surface	non slip	non slip	non slip	non slip	non slip		
Platform top, with							
door opening out	5' X 5'	same as Amer.	same as Amer.	25 sq. ft.			
door opening in	5' X 3'	5' X 4'	5' X 3'	4'			15-20 sq.ft
Platform bottom length	6'	6'	6'	6'			
Occurrence of level platforms	@ 30' intervals	30'	30'	at all major turns; runs exceeding length 180°/% gradient			
Building Entrance							
Frequency	at least 1 acces.	1 accessible	@ least 1	@ least 1		@ least 1 acces.	
Doors: type	single effort	2 leaf, each 3'	single effort	single effort	2 leaf, each 30"	clear 31"	
Width	clear 32"	36"	32"	36"	30"	31"	30-36"
Effort	not given	≯ 10 lbs.	not given	≯10 lbs.			
Handles				48" high			
Floor inside and/or outside (foyer)	level 5', 1' extension on sides	same as Amer.	same as Amer.	clear space 3' deep, 5' wide	design to allow for free movem.	not given	
Thresholds: exterior	no "musts"	≯ ½" high	no "musts"	≯ ½"	≯ ½" /of WC	≯3/4" high	1/2-3/4"
interior	"	flush w/ floor	"		flush w/floor		
Floors	non slip	non slip	whenever practicable, nonslip	not specified	non slip	non slip	
Toilet Rooms (access.)							
Frequency	@least 1 spec.	1 spec. for each sex	@ least 1 spec.	1 spec. for each sex; dup/6 fls.	@ least 1		
Stall size	3'wide, 4'-8"de.	5'-6" wide X 5'-6" deep or 6X5'	3'wide, 4'-3" de	same as Amer.	same as Amer.	4'-6" X 5'9"	3'X4'8"- 6'X5'
Door requirements	32" wide	36"	32"	32"	32"	33", hori. pull rail 42" high inside door	32-36"

	American Stand.	D.P.S. (Mass.)	House Bill (Mass)	Rochester, N.Y.	Canada	British	Range
Width, when collasped	11"	12½"	Same as Amer.	11"	9-12"	Not given	9-12"
Fixed turning radius, wheel to wheel	18"	18"		not given	not given		18"
Fixed turning radius, front struc. to rear	31.5"	31.5"		31.5"	not given		31.5"
Ave. turning space (180°)	60 X 60" or 63 X 56"	60 X 60"		63 X 56"	60 X 60"		60 X 56-60"
Min. width for 2 WC to pass	60"	60"		60"	not given		60"
Turning space for 360° turn between walls	Not given	Not given		54"	54"		54"
Functioning in a WC							
Unilateral vertical reach	Ave. 60", range 54-78"	Same as Amer.	Same as Amer.	Average 60"	Same as Amer.	Not given	54-78"
Horizontal working (table reach)	Ave. 30.8", range 28.5-33.2	Same as Amer.	Same as Amer,	Average 31"	Ave. 18" beyond front of working surface	Not given	28.5-33.2"
Bilateral horizontal reach, both arms extended to each side	Ave. 64.5", range 54-71"	Same as Amer.	Same as Amer.	Not given	Not given		54-71"
Diagonal reach	48"	Same	Same	Same	Same		48"
Public Walks							
Width	48"	60"	Same	48"	60"	Not given	48-60"
Gradient	≯ 5% (1 in 20)	Same as Amer.	Same as Amer.	Same as Amer.	≯ 1 in 20	≯ 1 in 10	1 in 20 to 1 in 10
Level platform at top of stairs: door out:	5' X 5'	Same as Amer.	Same as Amer.	Not given	Not given	Not given	5' X 5'
door swings in:	5' X 3'	5' X 4'	"	"	"	"	5' X 3-4'
Surfacing	Non slip	Non slip	Non slip	Non slip	Non slip		
Parking Lot Space							
Width	12'	12'	12'	Not given	12'	Not given	12'

Table 1. Standard code comparisons.

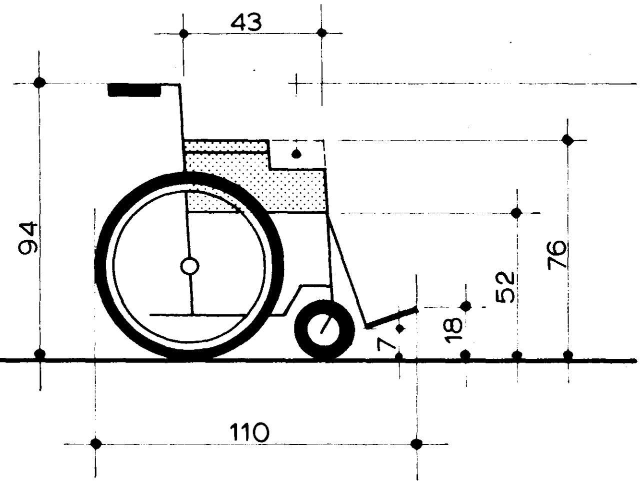
	1961 Amer. Nat. Stand.	1968 Dept. of Public Safety (Mass.)	1967 House Bill #3637 (Mass.)	1967 Bldg. Code Rochester, N. Y.	1965 Nat. Bldg. Code Canada	1967 British Stand. Code	Range
Scope of Application	All bldgs. and facilities used by the public.	All bldgs. (public) hereafter reconstructed, altered, or remodeled.	Bldgs. and facilities constructed with state, county, or municipal funds.	The following types of new bldgs. and structures: public bldgs. institutional bldgs. transportation terminals places of assembly exceeding 150 persons business bldgs exceeding 2 stories ht., employing more than 40 persons hotels, motels, dorms or such complexes restrooms in shopping centers funeral home public areas	All bldgs. and facilities used by the public.	Bldgs. which disabled people might wish to use for purposes of employment, commerce, business, transport, health, & welfare services, refreshment, entertainment, worship, education or cultural activities, communal areas of multi-dwelling units	
Wheelchair Specifications							
Length	42"	48"	Same as Amer. Nat. Stand.	Same as Amer. Nat. Stand.	38½-41½"	Not given	38½-48"
Width	25"	26½"			24-27 3/4"		24-27 3/4"
Ht. of seat from floor	19½"	19½"			19¼-20½"		19¼-20½"
Ht. of armrest fm. floor	29"	29"			28-30"		28-30"
Ht. of pusher handles from floor	36"	36"			35-37½"		35-37½"

the wheelchair

principal dimensions of the ordinary hand-propelled wheelchair

1.1.1.

side elevation



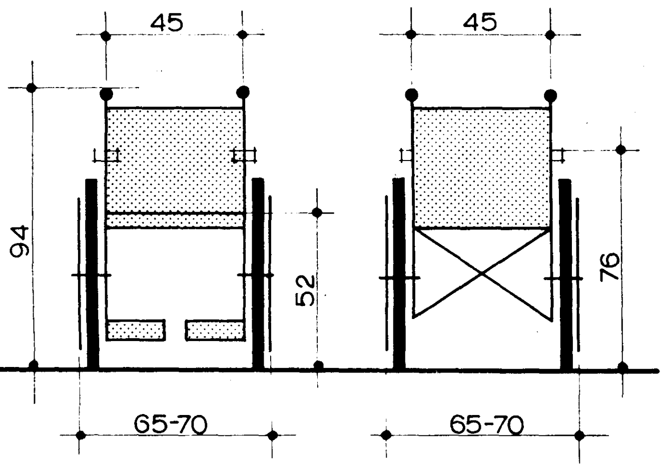
possibly:
stepped and reversible armrest

hand-rim for propelling the chair

foot-rest with adjustable height

left: *front elevation*

right: *rear elevation*



note: there are several models of wheelchairs, including some with swivelling wheels at the rear; these models are usually shorter

the space occupied by the chair and required for manipulating it can, for the various models, be based on these diagrams

most electrically propelled wheelchairs are about 70 cm wide and about 110 cm long

NVR

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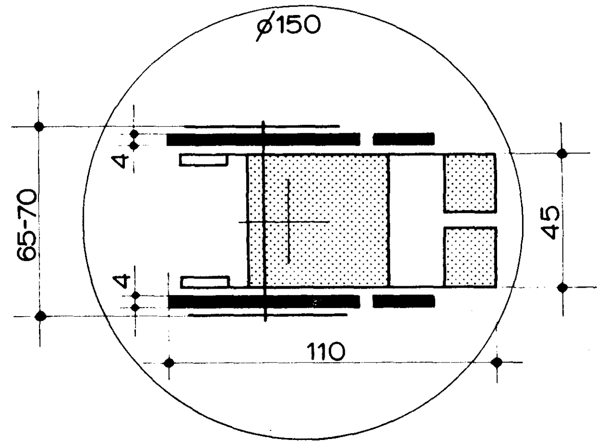
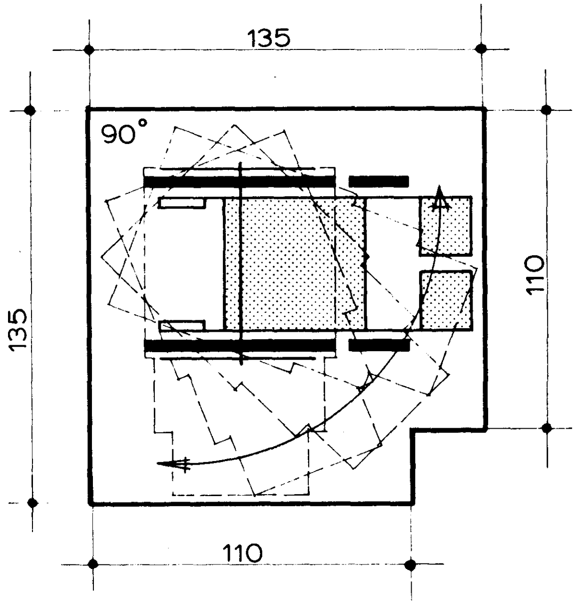
the wheelchair

minimum manoeuvrability between furniture, sanitary equipment, etc.

1.1.2.



minimum turning circle 150 cm ∅



minimum space needed for a 90° turn

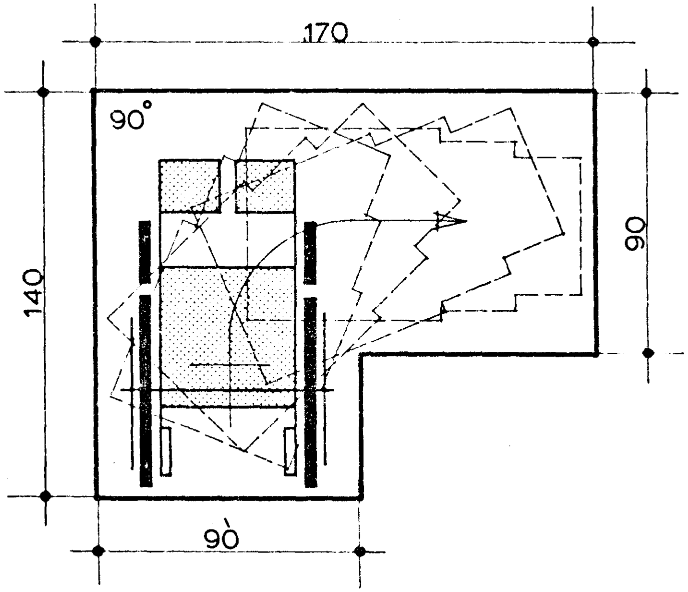
for manoeuvring space in working rooms see 1.1.3.

NV

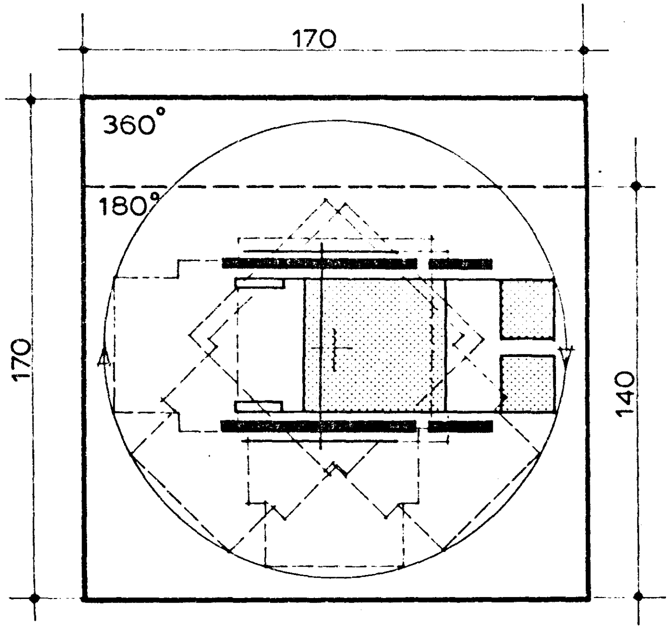
the wheelchair

minimum manoeuvring space in working rooms

1.1.3.



minimum space needed for negotiating a 90° bend



minimum space needed for a 180° turn around one wheel as the fixed pivoting point

NVR

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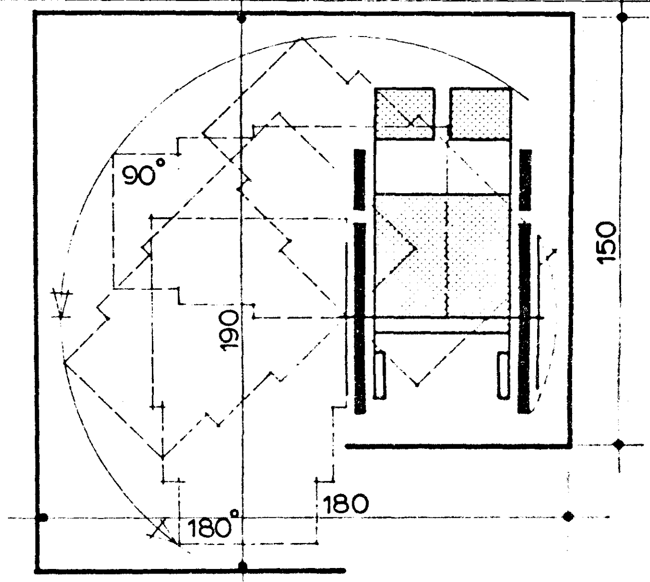
the wheelchair

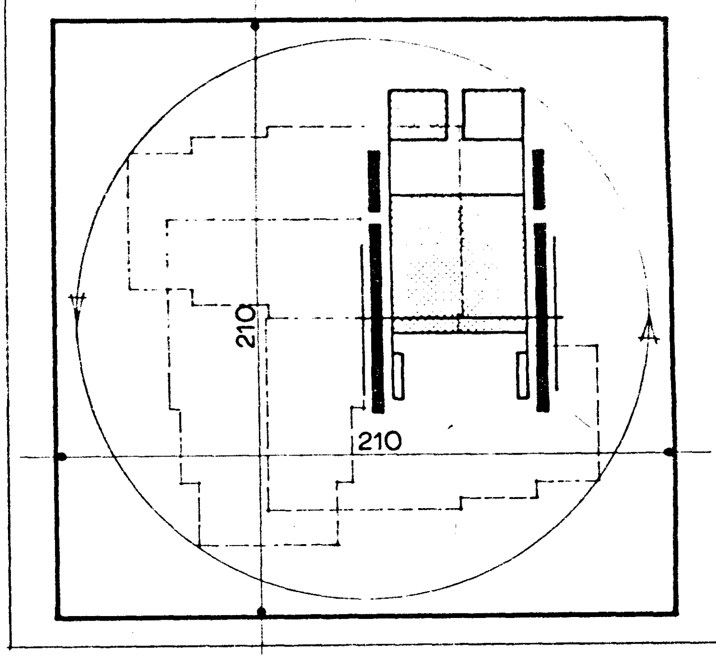
minimum manoeuvring space for electric wheelchairs

1.1.4.



90° turn
minimum space
150 x 180 cm

180° turn
180 x 190 cm



360° turn
210 x 210 cm

n.b.
turning around one wheel as the fixed pivoting point

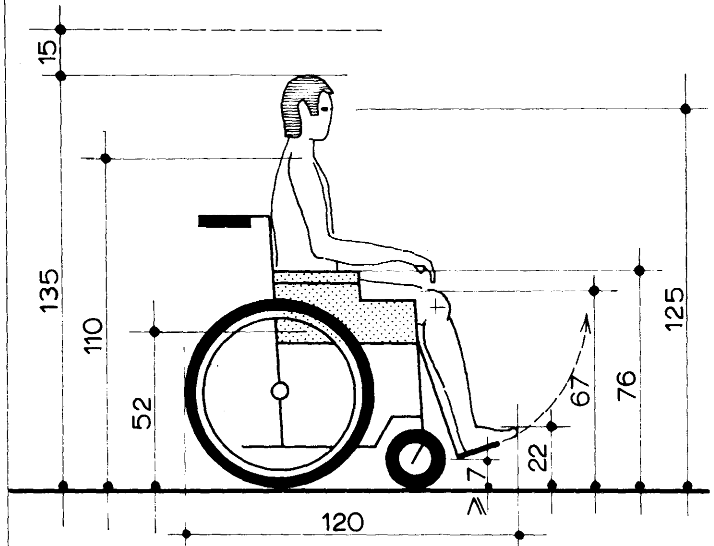
NV

the disabled person

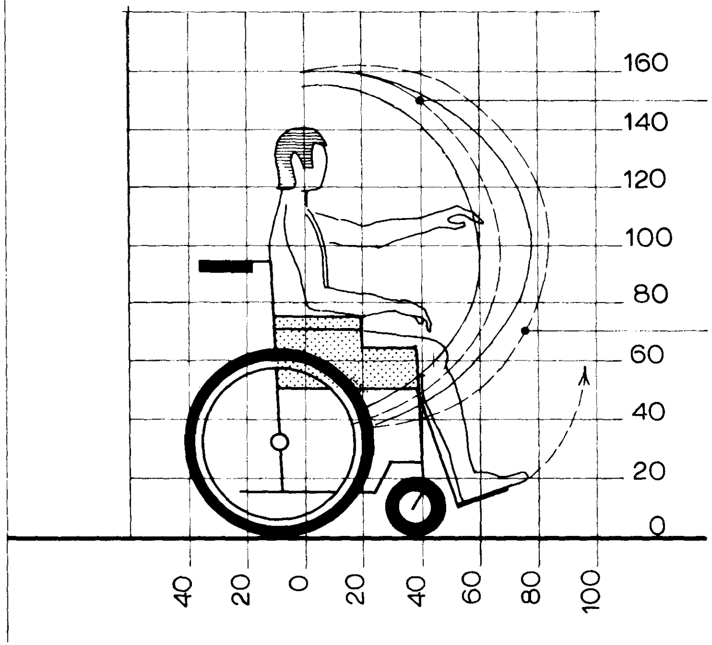
the disabled person in the wheelchair
principal average dimensions

1.2.1.

side elevation



side elevation



reaching zone with back erect

reaching zone with body inclined forward

grid dimensions
20 cm x 20 cm

solid line = reaching zone for women
dotted line = reaching zone for men

NVR

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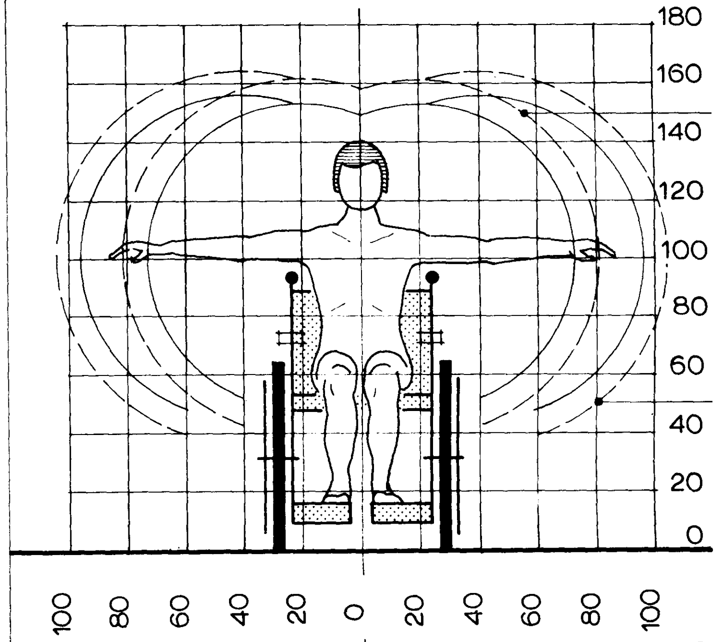
the disabled person

the disabled person in the wheelchair
reaching zones

1.2.2.

front elevation

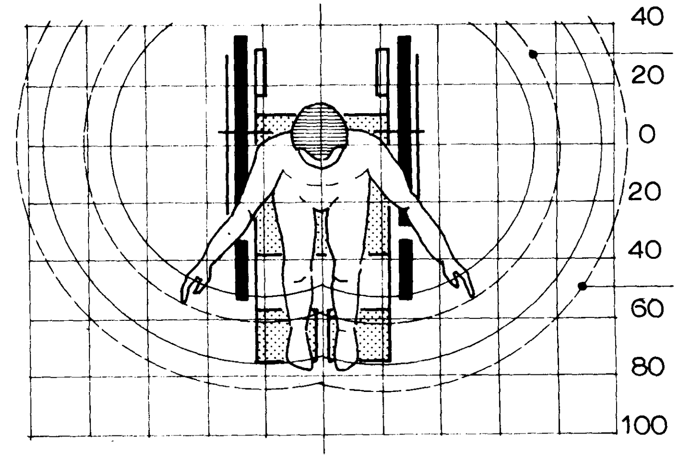


reaching zone with back erect

reaching zone with body inclined

grid dimensions
20 cm x 20 cm

plan view



reaching zone with back erect

reaching zone with body inclined

grid dimensions
20 cm x 20 cm

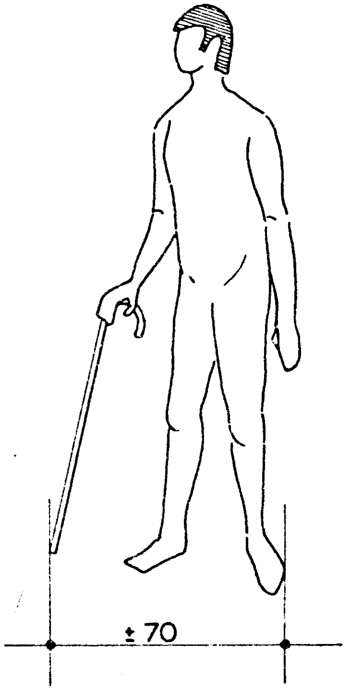
solid line = reaching zone for women
dotted line = reaching zone for men

N\

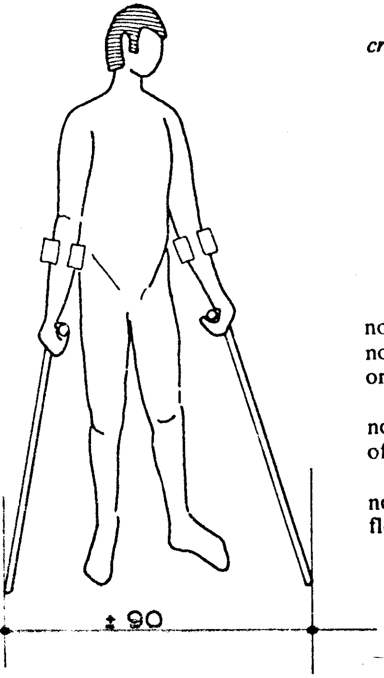
the disabled person

the disabled person using a stick or crutches
space for movement

1.2.3.



stick user



crutch user

note:
no loose carpets
or mats

no grating apertures
of more than 2 cm

no highly polished
floors

NVR

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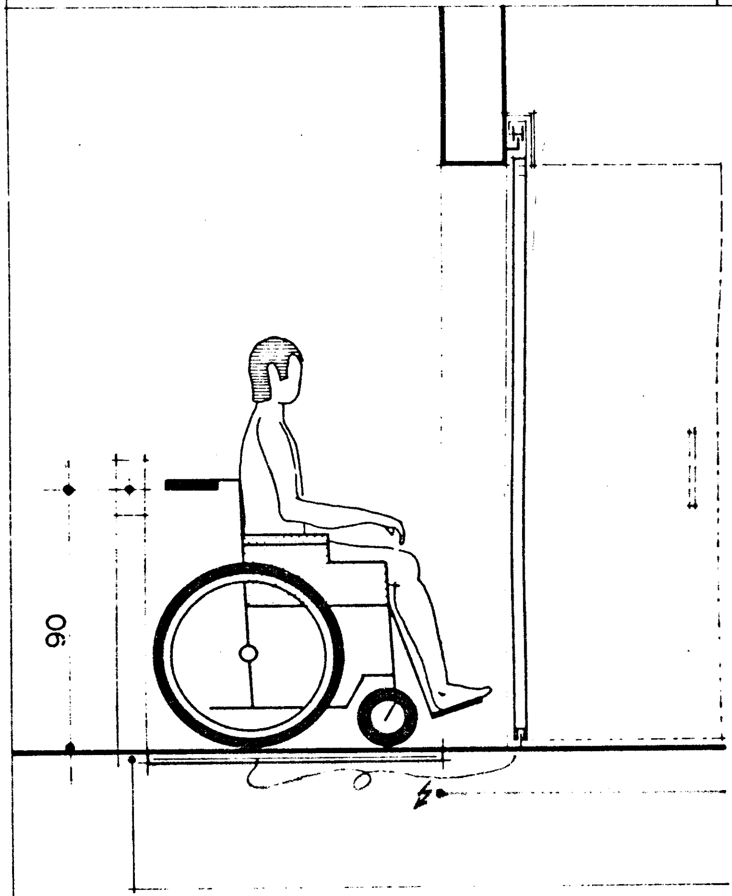
accessibility

automatically-opening sliding and
pivoted doors

2.1.1



sliding door with
automatic action
(pivoted door dotted)

clear width minimum
85 cm (= door width
90 cm)

where pivoted doors
are used, these should,
wherever possible,
swing away from the
direction of approach

level floor without
floor rails

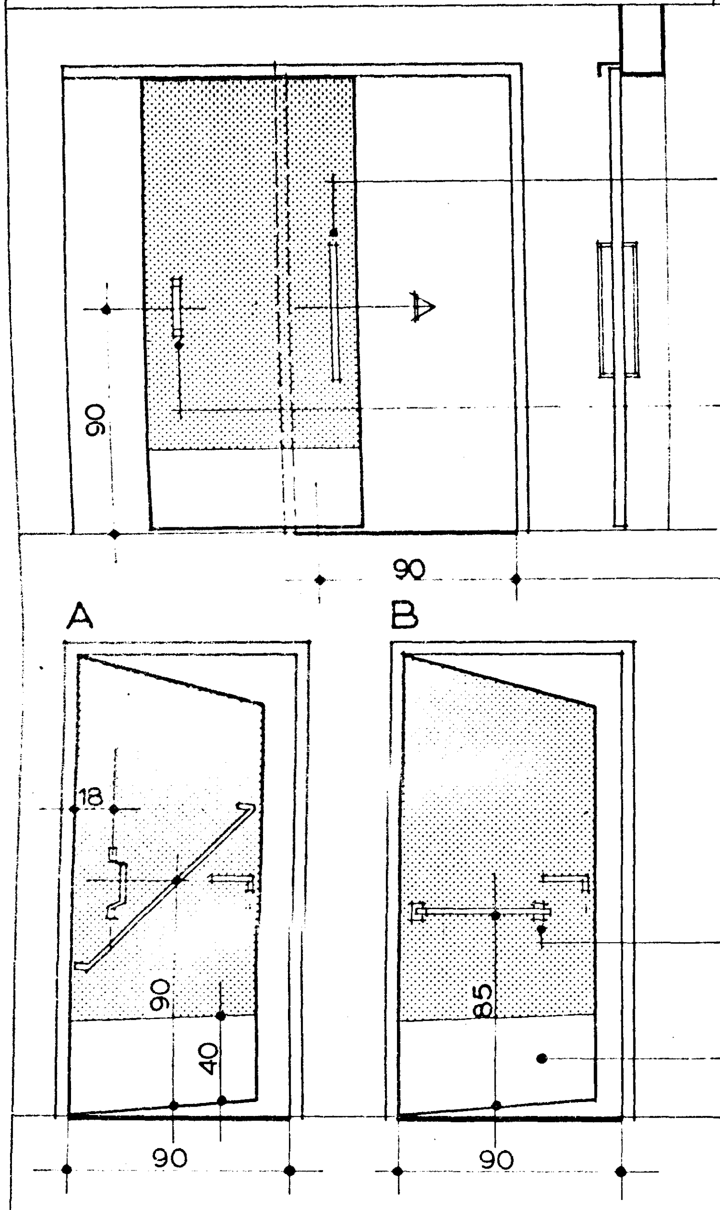
electrical contact
under rubber floorma
or electric eye or
column with button
at sufficient distance
of door

no coconut doormats
should be used becau
they impede locomotion and slip easily

N

accessibility
sliding and pivoted doors

2.1.2.



sliding door of non warping material with mountings for smooth easy movement

large and firm handle

extra handle for closing the door

level continuous floor

clear width minimum 85 cm (= door width 90 cm)

pivoted door

frame in contrasting colours for persons with poor vision

impact-resisting frame to withstand mechanical damage, up to 100 cm

two possibilities for handles

protective strip for knocks and scratches

clear width minimum 85 cm (= door width 90 cm)

make provisions for fixing handles when doors are hollow

NVR

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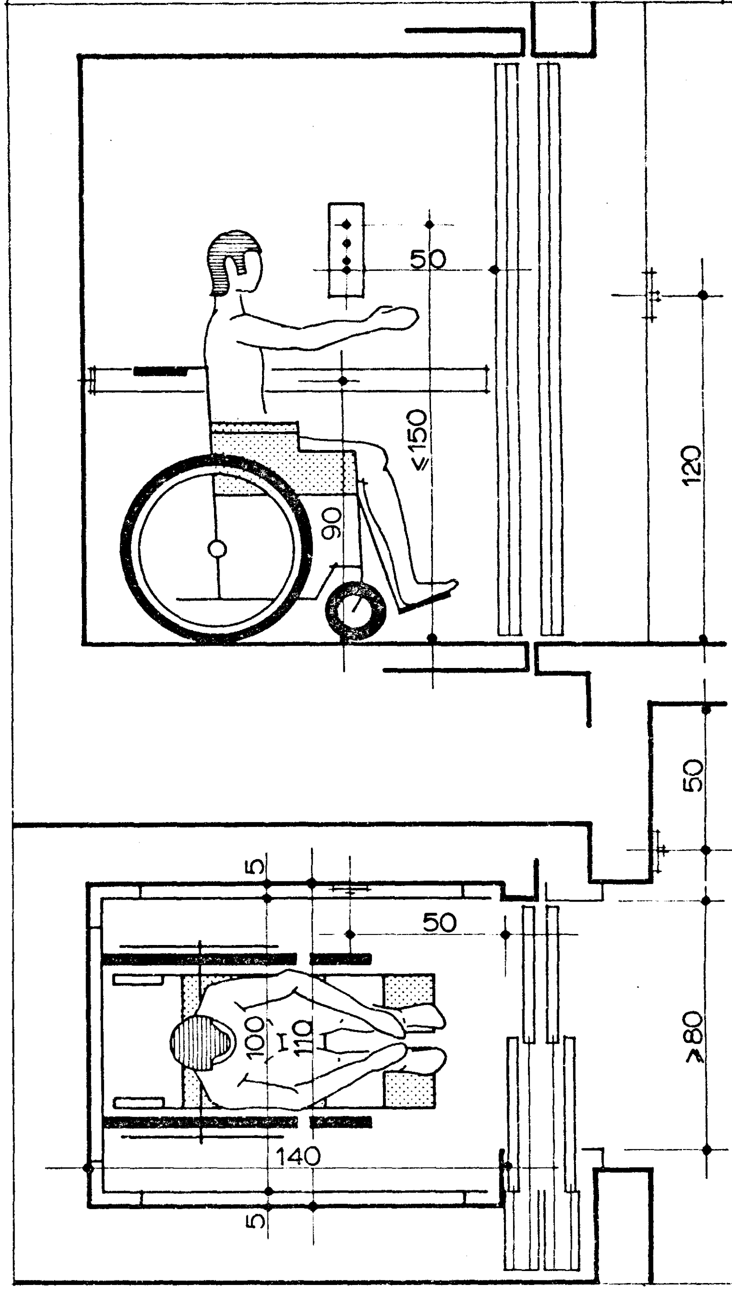
accessibility
lifts

2.1.5.1



lift: minimum dimensions for wheelchair with attendant 110 x 140 cm, automatic sliding door

correct position for control panel

handrail at 90 cm on three sides

alarm signal device 100 cm above floor, preferably telephone

gap between lift car and floor max. 2 cm

accuracy of stopping max. 2½ cm

button

inside dimensions: 110
140 cm

dimensions between handrail and wall of lift car = 5 cm

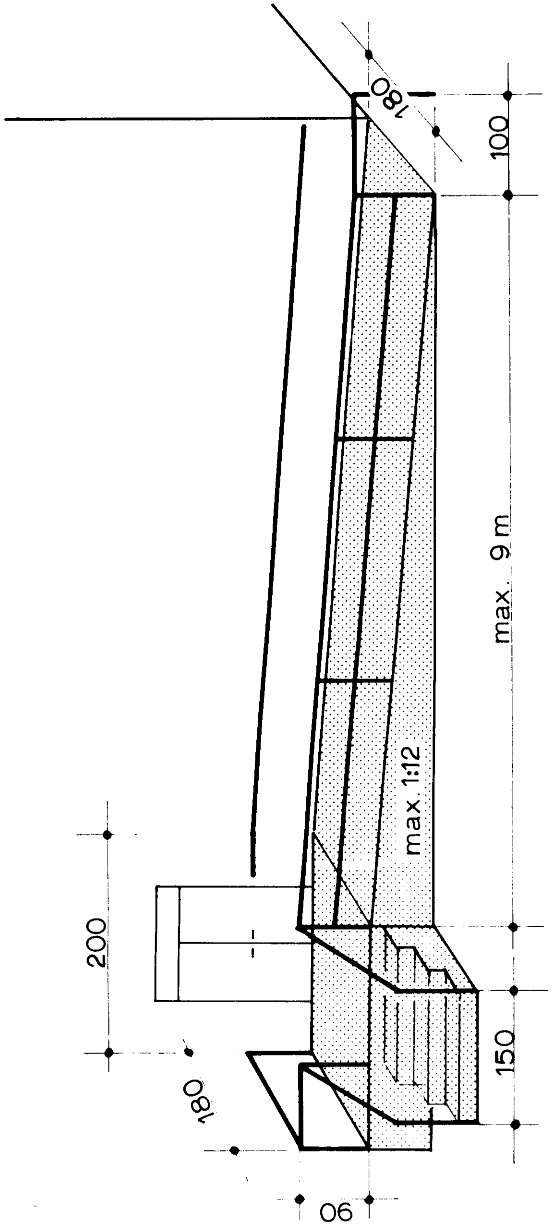
dimensions between railings = 100 cm

n.b.
for nursing homes etc. special large buttons possibly in horizontal arrangement

NV

accessibility
ramps for buildings

2.1.6.1.



person in wheelchair can travel on ramp independently and without using handrail

handrail on both sides of ramp

width: 180 cm for passing. If not necessary total width 130 cm

long ramps should be provided with intermediate landings at least every 900 cm

length of landing 200 cm minimum 150 cm

if available space permits: slope of ramp preferably 1 in 20 to 1 in 15 maximum: 1 in 12

for ramps steeper than 1 in 20 (5%): indicate percentage of slope

ramp should be completely horizontal in transverse direction

section see 2.1.6.2.

also provide normal access steps, these can often also be used by persons using a stick see 2.1.8.

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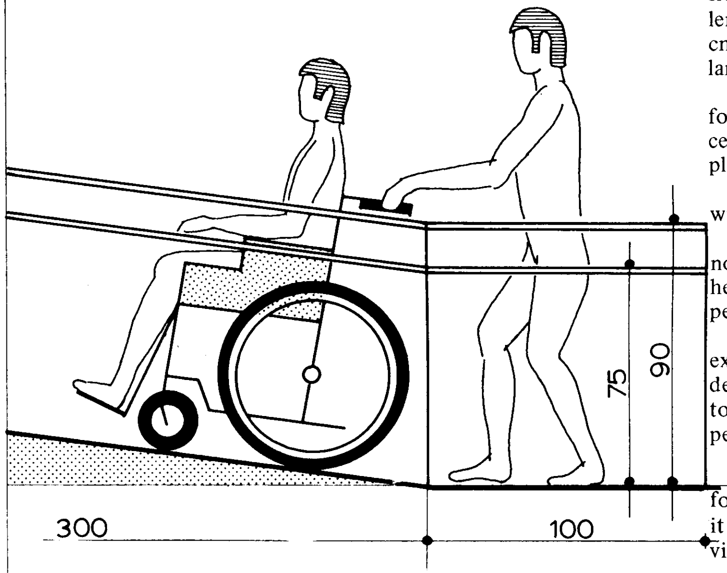
accessibility
ramps for **private use**

2.1.6.2.



slope maximum 1 in 8 at length of maximum 300 cm if longer intermediate landings are necessary

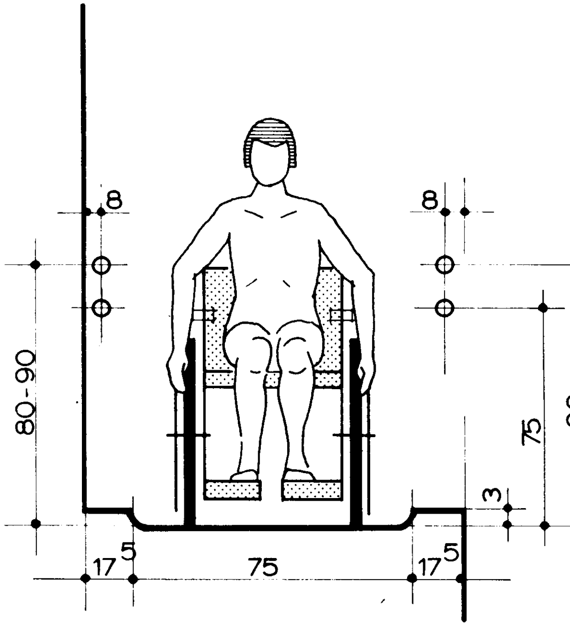
for considerable differences in height use lifting platforms

width of ramp: 85-95 cm

normal handrail at 90 cm height for non-disabled persons and stick users

extra handrail for independently ascending the ramp to be used on slopes steeper than 1 in 12

for persons using a stick it is necessary also to provide steps



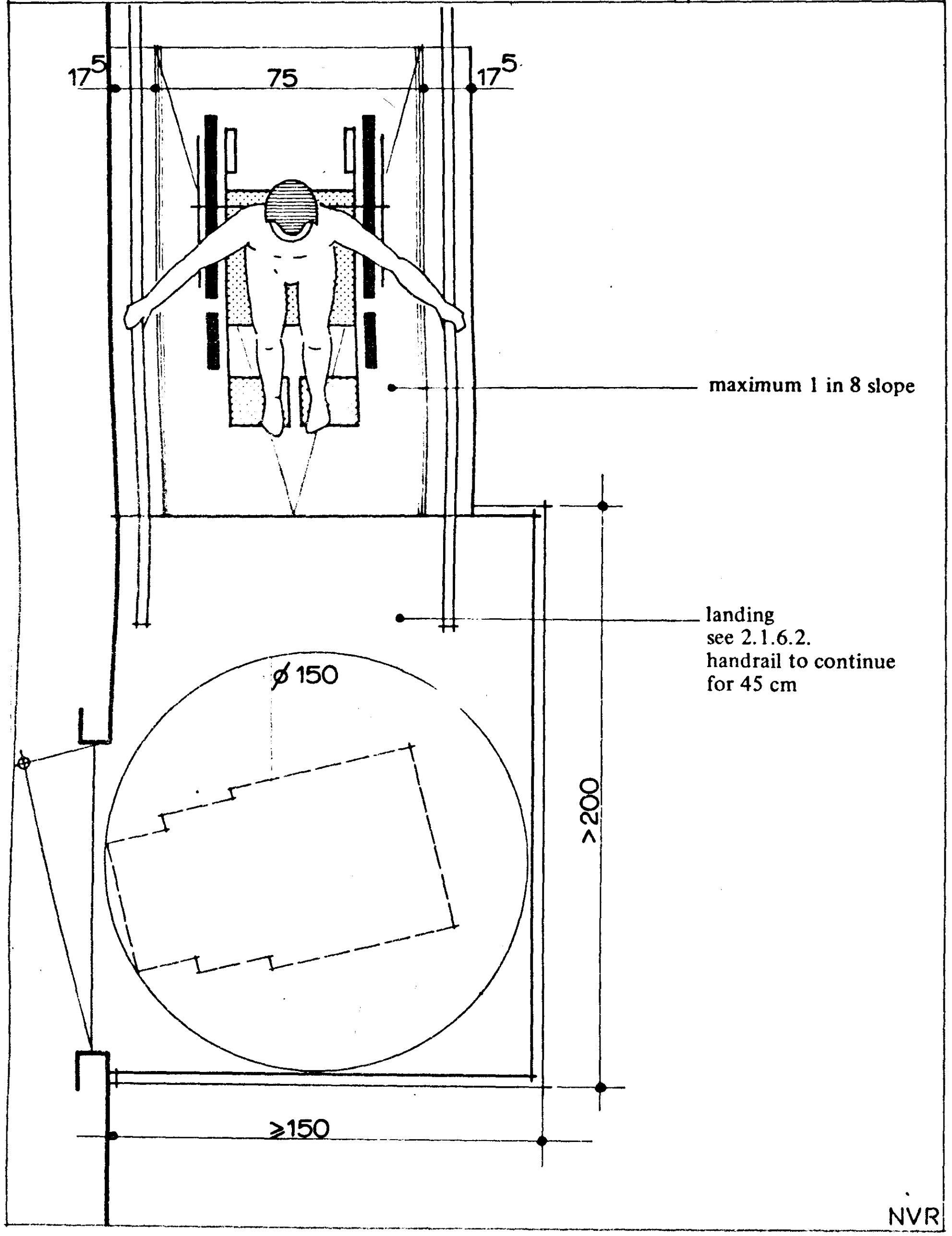
a handrail height of 80-90 cm is recommended

if it is necessary to use a higher handrail, it is advisable to install a second handrail at 75 cm. This handrail is needed for use without help at gradients steeper than 1 in 12

accessibility

landings on ramps
manoeuvring space for landing for **private use**

2.1.7.1.



maximum 1 in 8 slope

landing
see 2.1.6.2.
handrail to continue
for 45 cm

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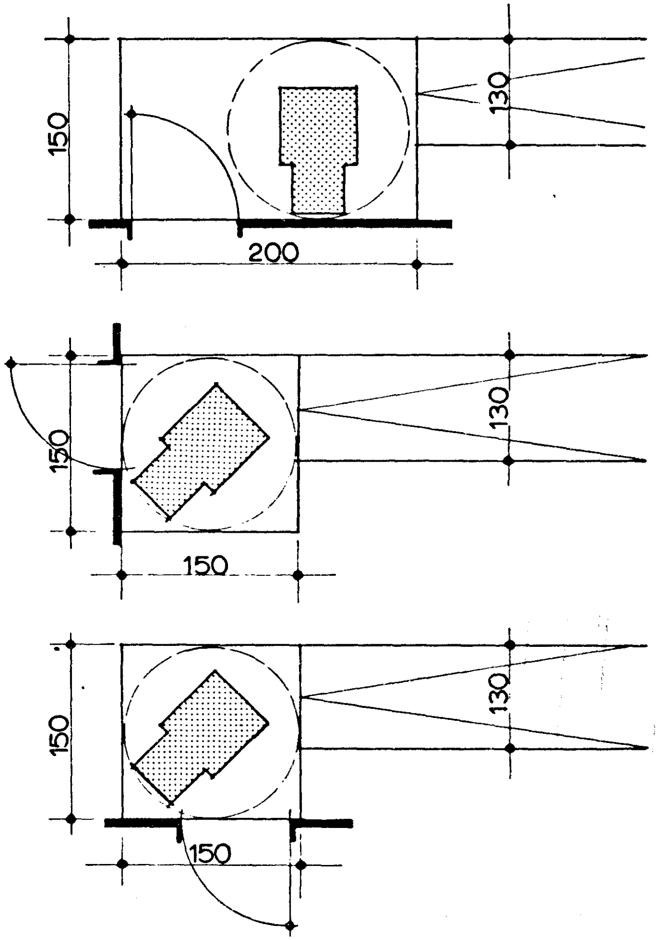
accessibility

landings on ramps
manoeuvring space for landing for general use

2.1.7. 2.

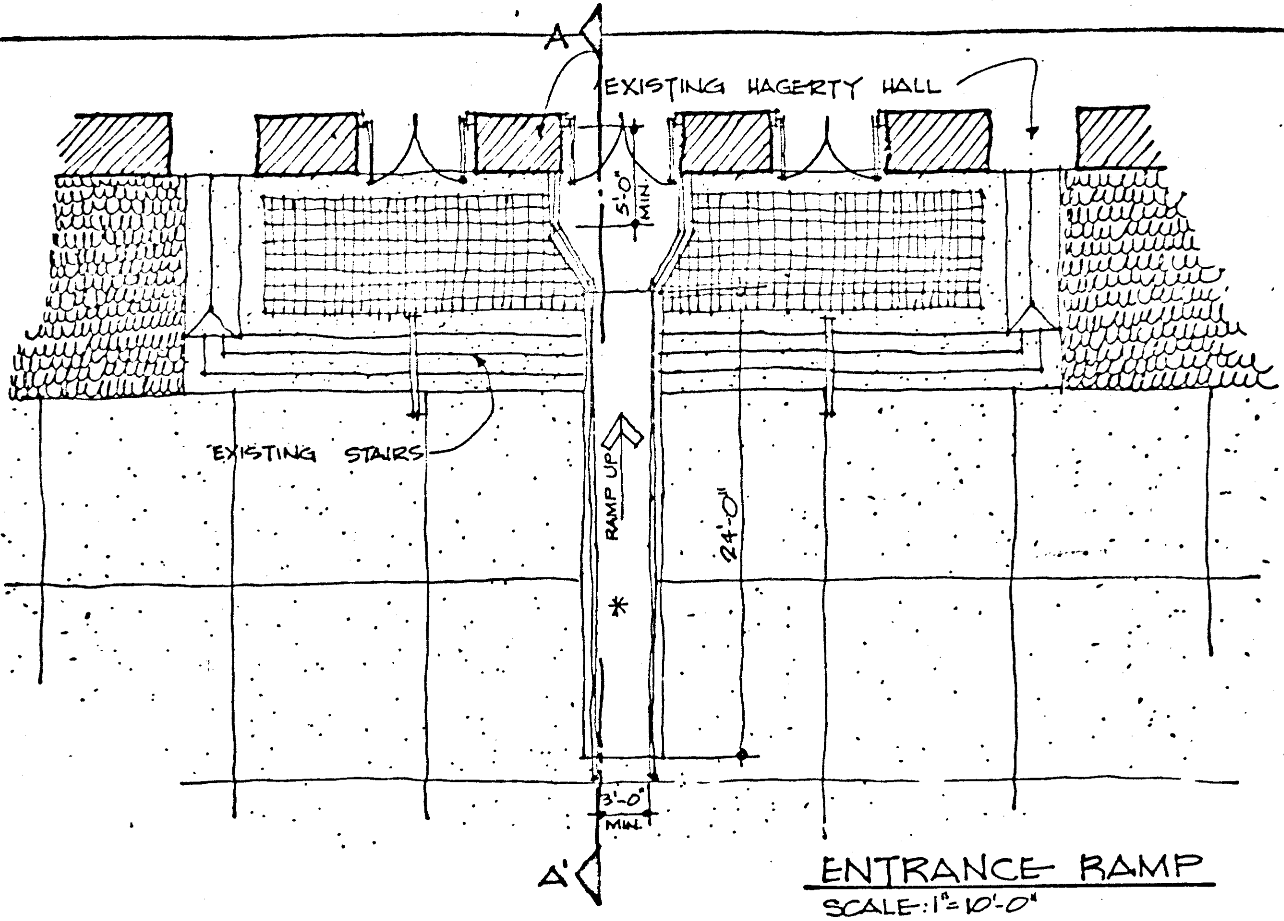


landing of sufficient
size to enable wheel-
chair to be manoeuvre

steps should also be
provided, in addition
to ramp

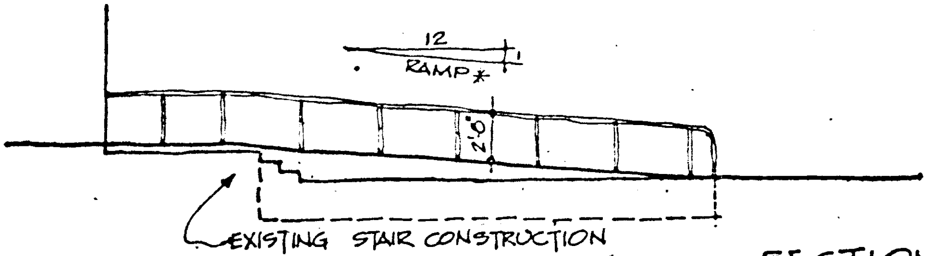
intermediate landings
to be provided on ram
more than 900 cm in
length

N\



ENTRANCE RAMP

SCALE: 1" = 10'-0"

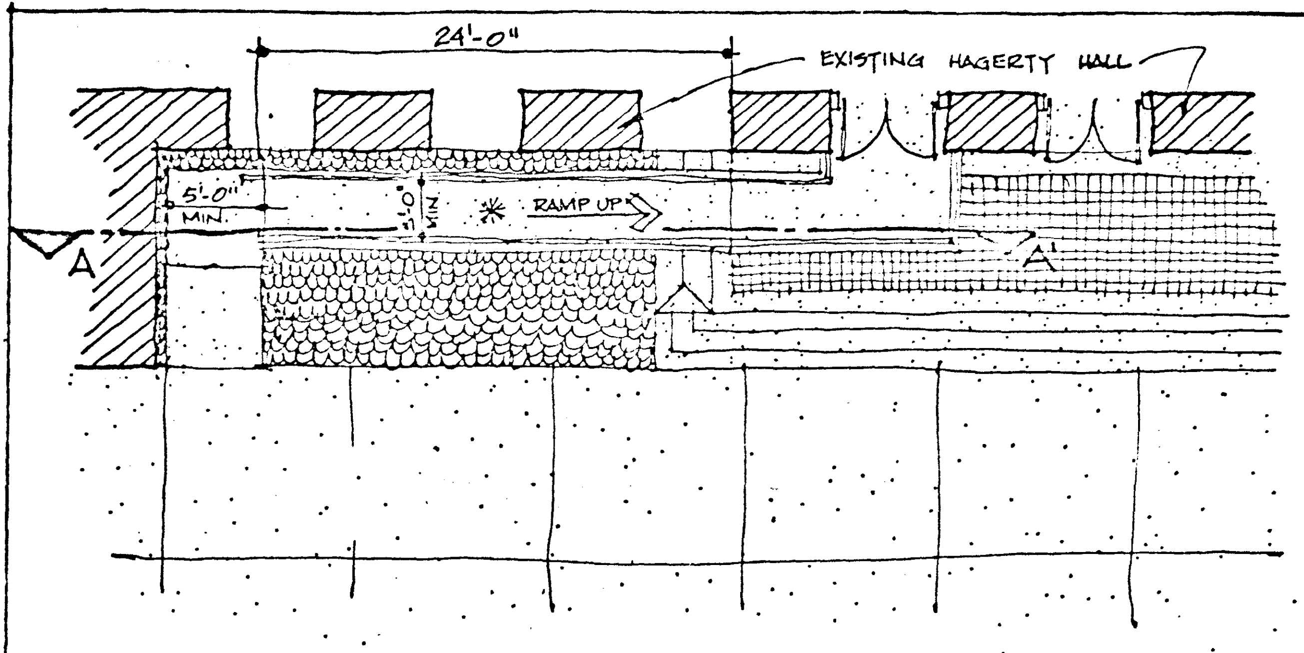


SECTION A-A'

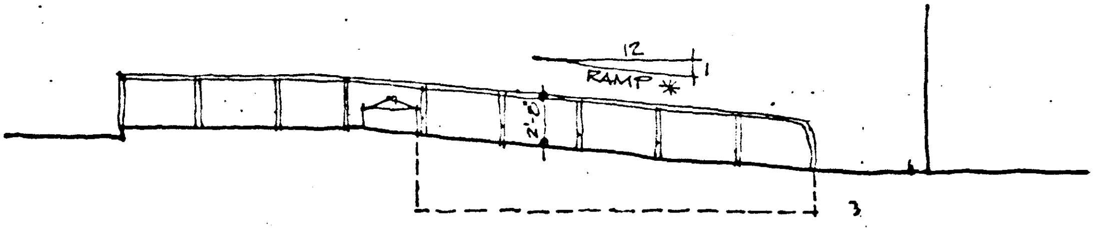
SCALE: 1" = 10'-0"

* RAMP TO BE CONCRETE WITH A NON-SKID SURFACE, MAXIMUM SLOPE 1:12

ESTIMATE OF COST: $1400.



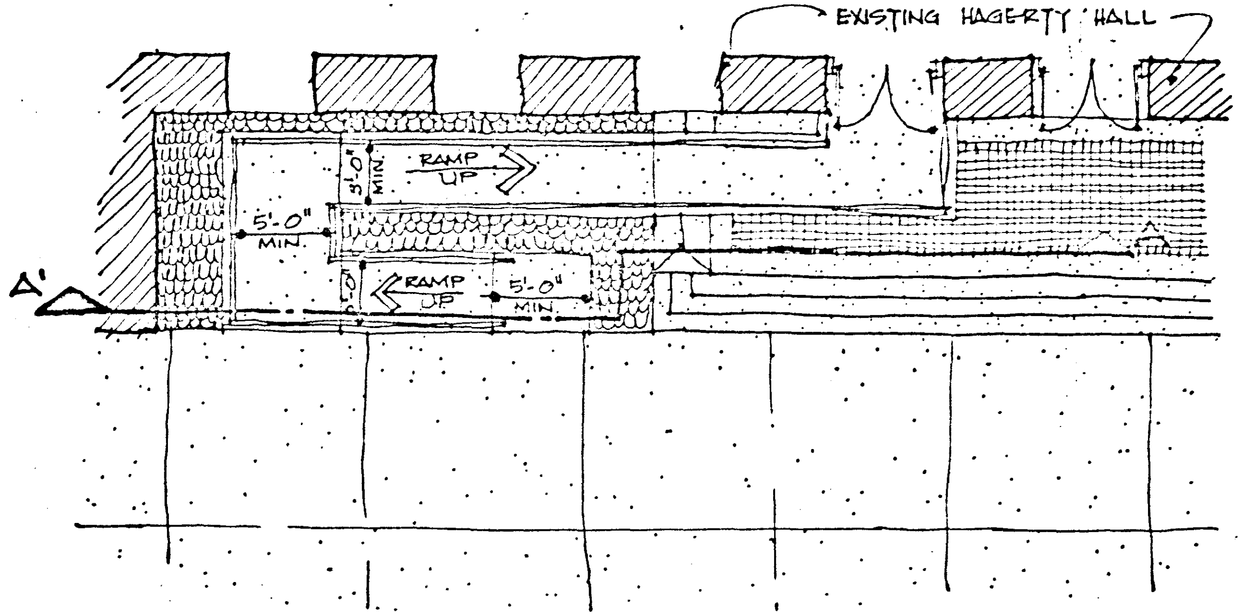
ENTRANCE RAMP
SCALE: 1"=10'-0"



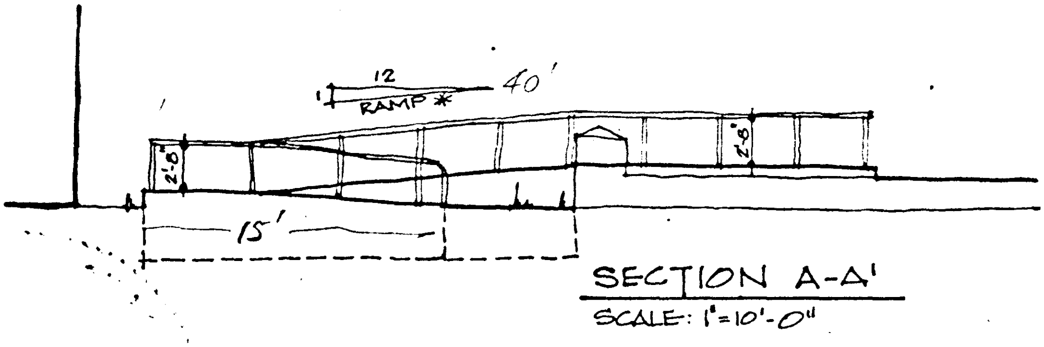
SECTION A-A'
SCALE: 1"=10'-0"

* RAMP TO BE CONCRETE WITH A NON-SKID SURFACE, MAXIMUM SLOPE 1:12

ESTIMATE OF COST: $1300.



ENTRANCE RAMP
SCALE: 1"=10'-0"



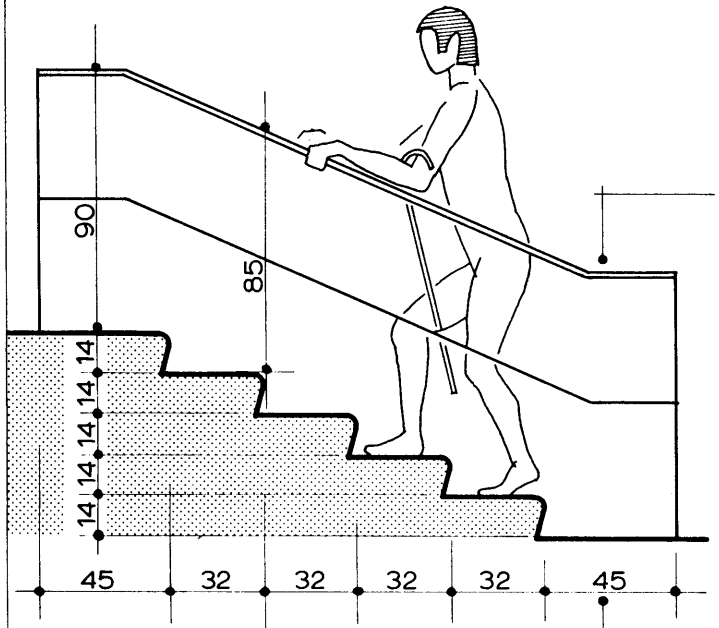
SECTION A-A'
SCALE: 1"=10'-0"

* RAMP TO BE CONCRETE WITH A NON-SKID SURFACE, MAXIMUM SLOPE 1:12

ESTIMATE OF COST: $1500.

accessibility
staircases

2.1.8.



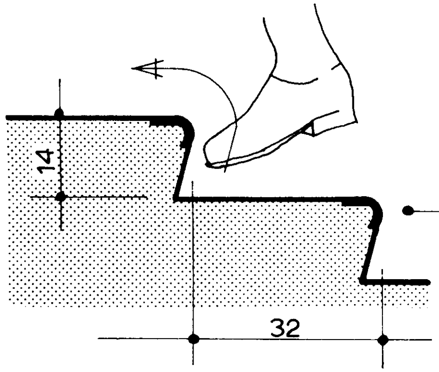
handrail to be securely fixed because of abnormal load acting in different direction

width of stairs:
if possibility of passing is required: 120 cm
for leaning on two handrails: 90 cm

riser:
recommended 14 cm
minimum 8 cm

tread:
recommended 32 cm

handrail to continue beyond upper and lower end of stairs; this does not apply to landings when protruding freely into space



anti-slip strip

riser and tread in contrasting colours

for blind persons:
different floor material on approach to stairs over a length of 120 cm

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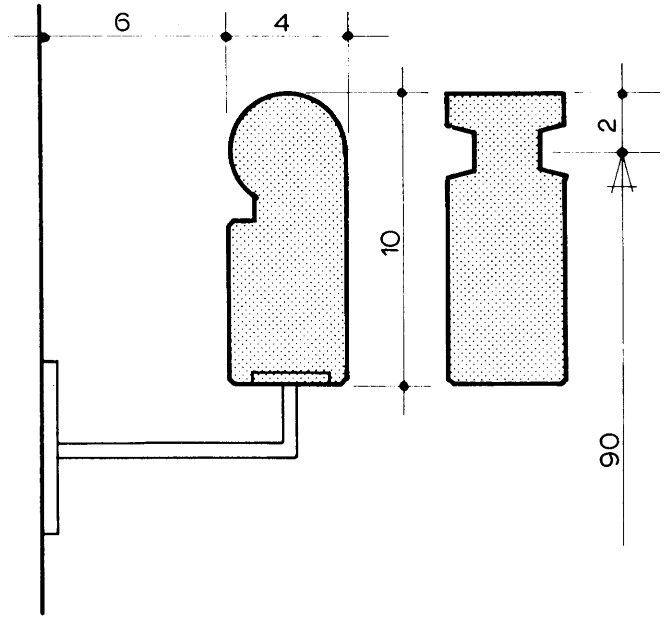
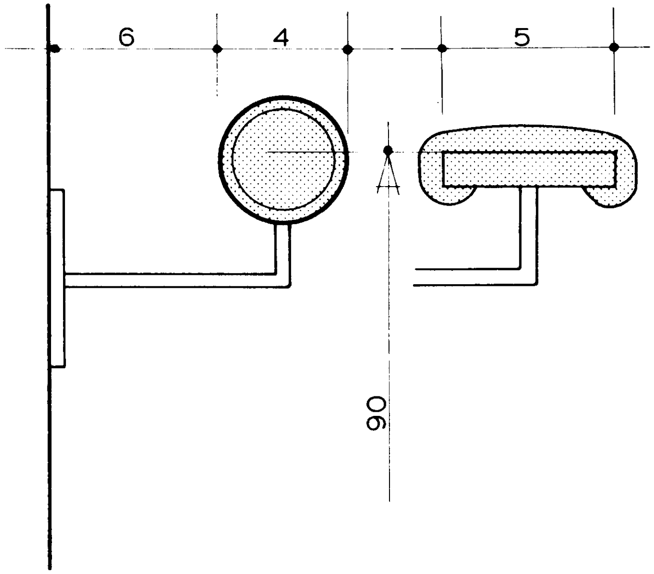
accessibility
handrails

2.1.9.



sections for wooden handrails

hand should be able to enclose rail properly; sharp edges should be rounded



sections for metal handrails

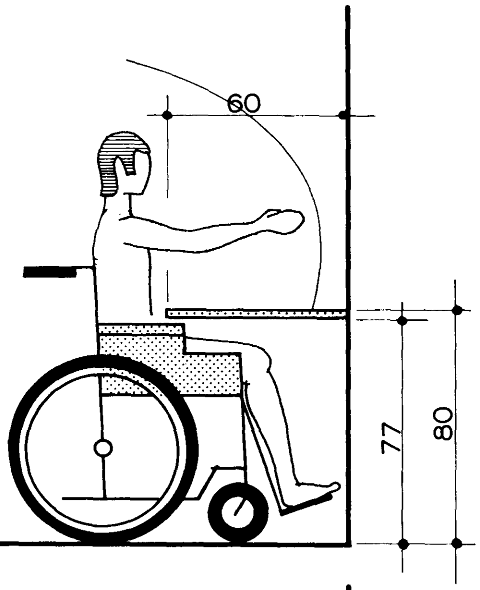
handrails to be covered with plastic

utility

working surface, table, kitchen work top

2.2.1.

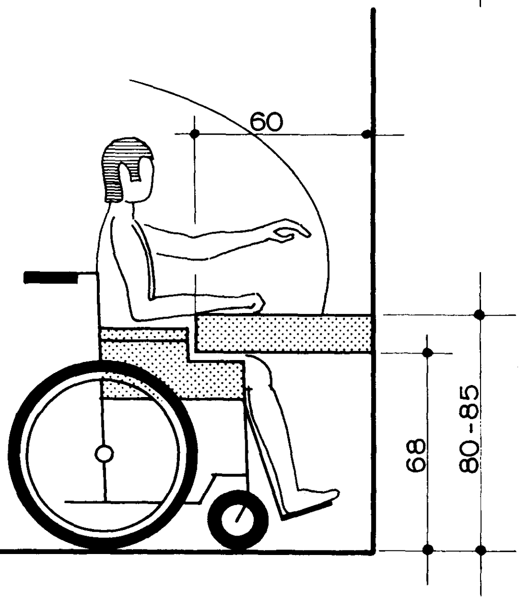
working surface/table



minimum space under board or table top 77 cm to enable wheelchair to go under it

recommended height of leaf or table top: 80 cm

useful dimensions are between 77 and 85 cm



kitchen work top essentially adjustable

minimum dimensions are indicated

waste discharge to be located as far back as possible

discharge pipe to be screened as protection against risk of burns to legs

space under work top: app. 68 cm
maximum height: 85 cm

NVR

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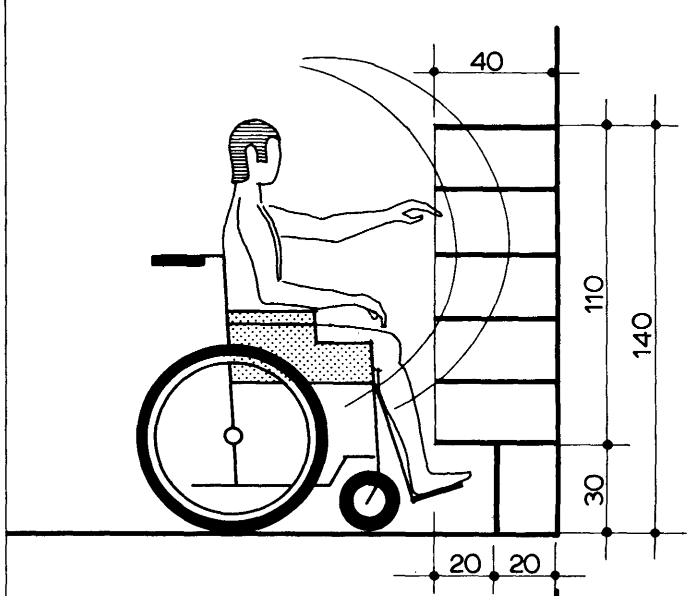
utility

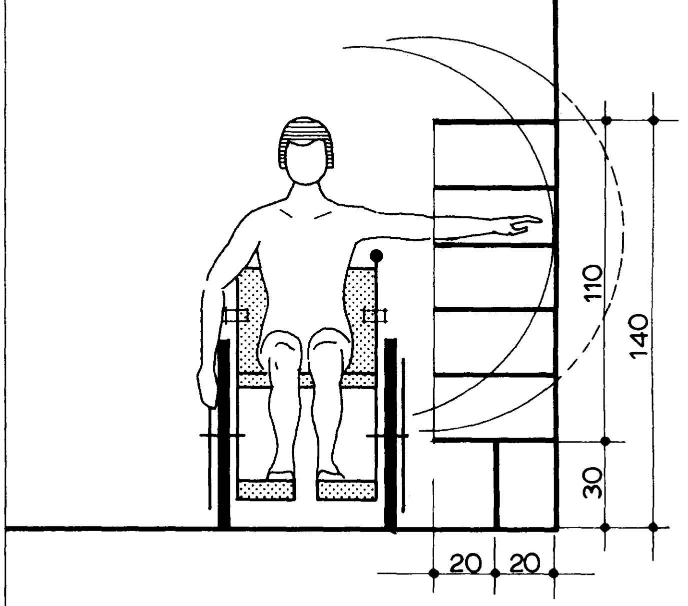
cupboards and shelves

2.2.2.



cupboard can be reached from front

minimum clear space under cabinet: 30 cm



cupboard can be reached from the side: gives deeper reaching range

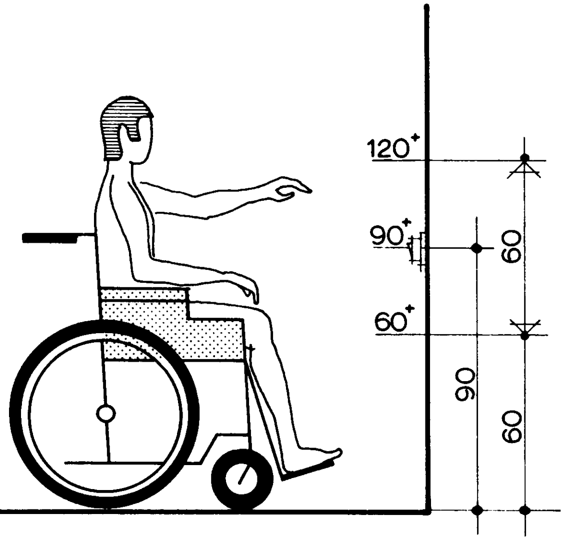
cupboard doors: wide pivoted doors to be avoided
preference for rolling shutter doors or up-and-over doors

NVR

utility

positioning of electrical switches, etc.

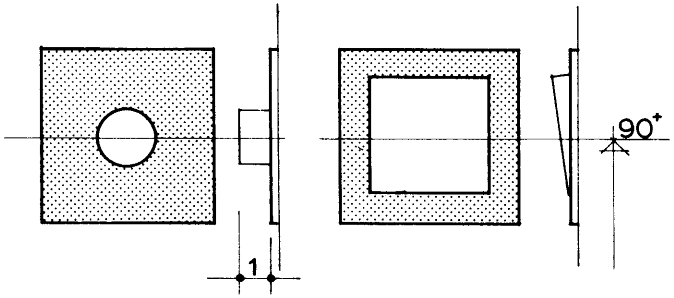
2.2.3



recommended height limits for switches and wall sockets: approx. 90 to 120 cm

limiting dimensions for switches

limiting dimensions for wall sockets



right: *pad switch*

left: *push-button*

pull switches are of importance for some persons

for severely handicapped persons remote control by radio

NVR

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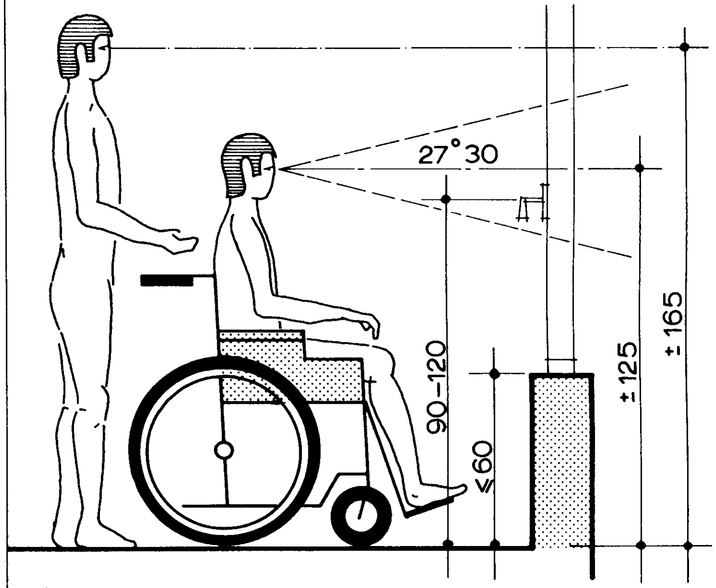
utility

positioning of window controls

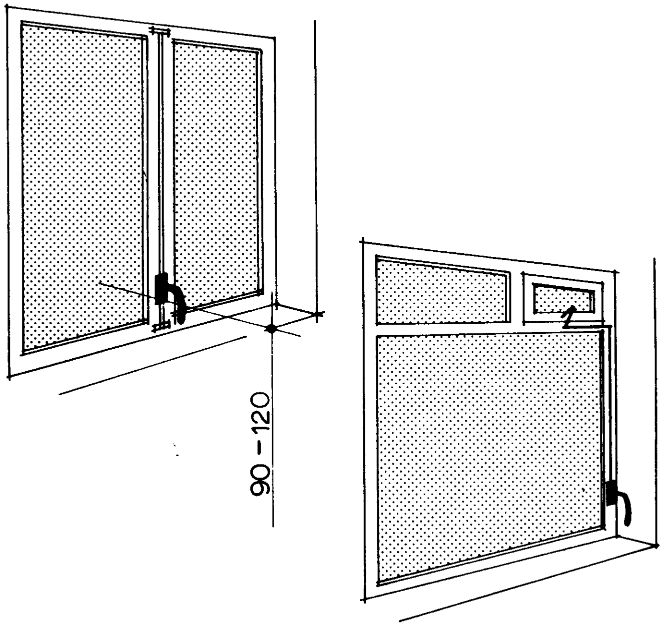
2.2.4.



allow for different eye level with regard to transcoms and window parapets

height of window sill preferably 60 cm, possible max. 85

good ventilation possibilities are essential of long sojourn indoors



ensure correct positioning and possibility of properly operating the locking mechanism; consider where furniture will subsequently be placed

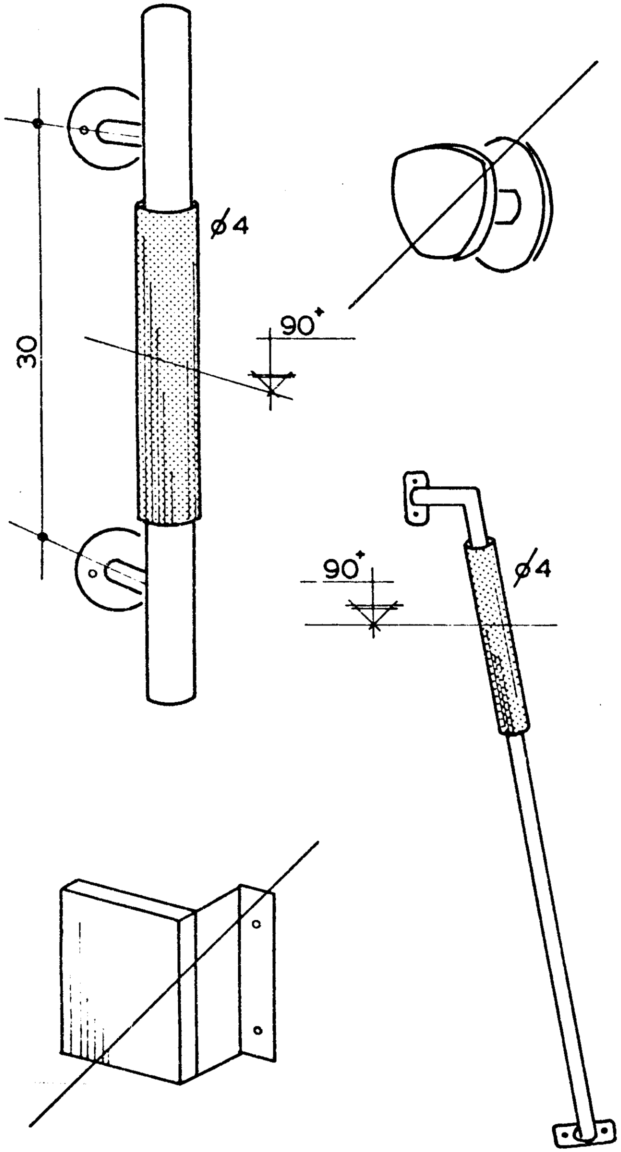
handles which the hand can properly enclose, height approx. 90-120 cm

NVF

utility

hinges and locks
handles for frontdoors

2.2.5.1



hand should be able to enclose handles and knobs easily

NVR

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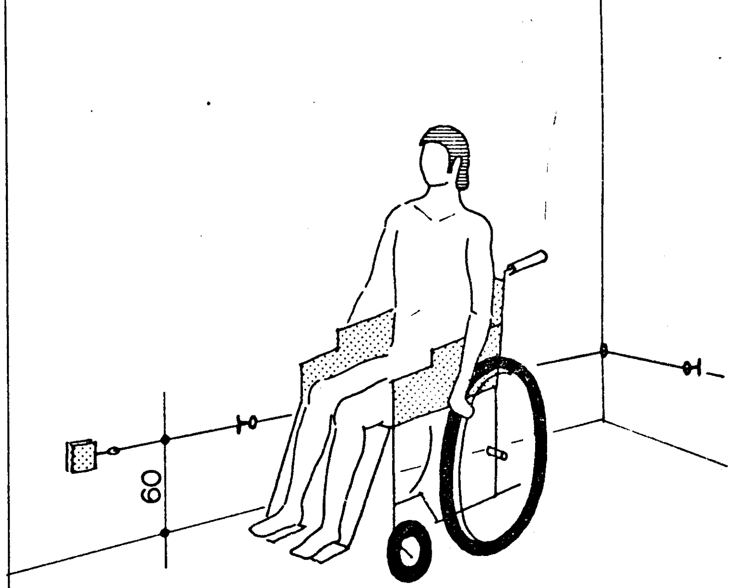
utility

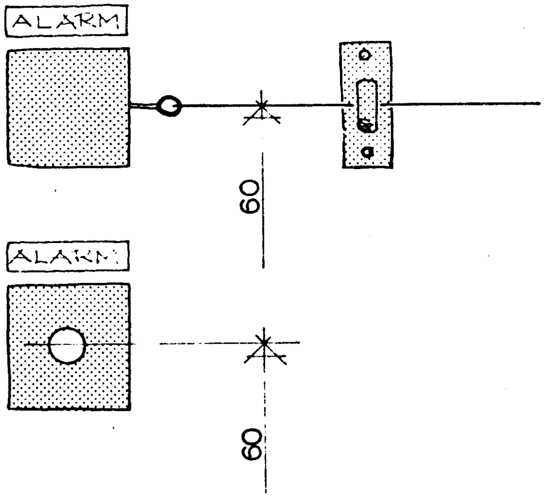
alarm installation for use in lavatories, shower rooms etc.

2.2.6.



alarm installation:
pull switch connected
with orange or red co
extending all round t
room at height of 60

alternative: easily
reachable push-butto



pull switch with cord

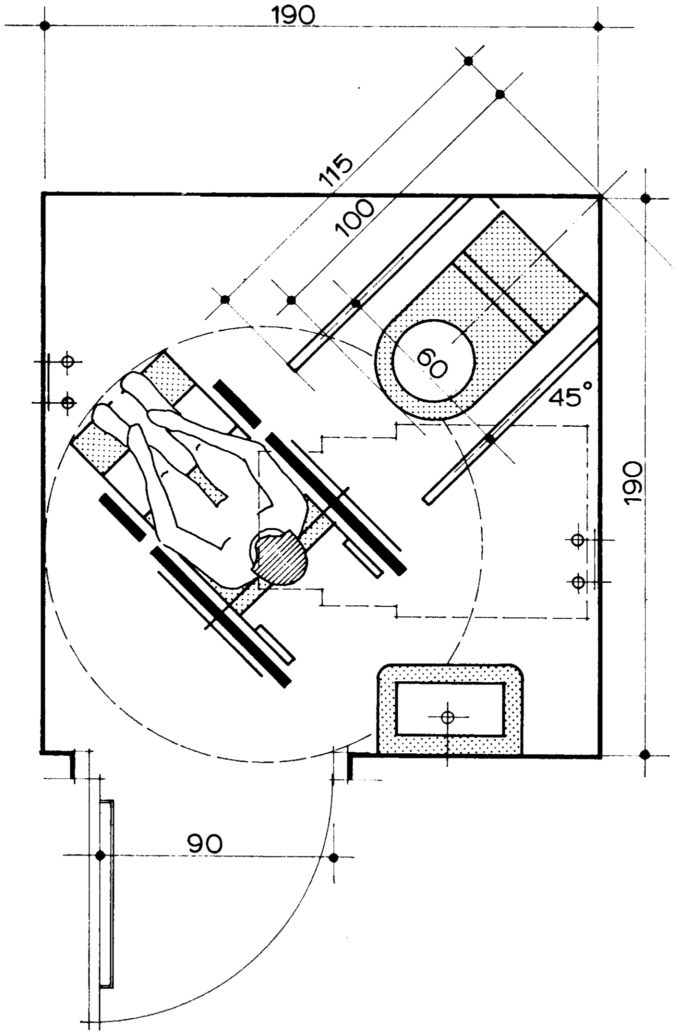
push-button: should
be reachable even wh
lying on the floor

N

buildings

lavatory minimum size 190 x 190 cm

3.1.1.1.



acceptable plan for a lavatory where limited space is available

for universal lavatory see 3.1.1.3.

siphonic closet see 3.1.1.4.

swing-up double arm rests see 3.1.1.5.

hooks for clothing at 120 cm height

wash basin, size 30 x 50 cm with bracket and mirror

lock: opening from outside should be possible

alarm installation see 2.2.6.

n.b.
waste bin should be available

also a sliding door can be recommended

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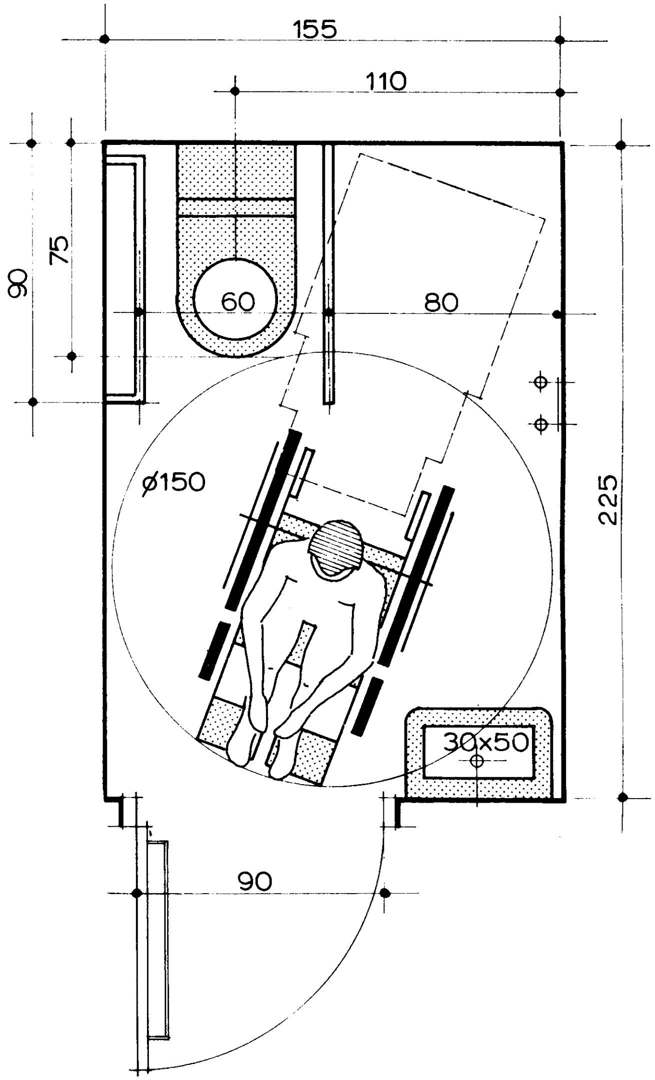
buildings

lavatory minimum size 225 x 155 cm

3.1.1.2.



acceptable plan for a lavatory where limited space is available

for universal lavatory see 3.1.1.3.

siphonic closet see 3.1.1.4.

swing-up arm rest, slanting bar fixed to wall

hooks for clothing at 120 cm height

wash basin, size 30 x 50 cm with bracket and mirror

lock: opening from outside should be possible

alarm installation see 2.2.6.

n.b.
waste bin should be available

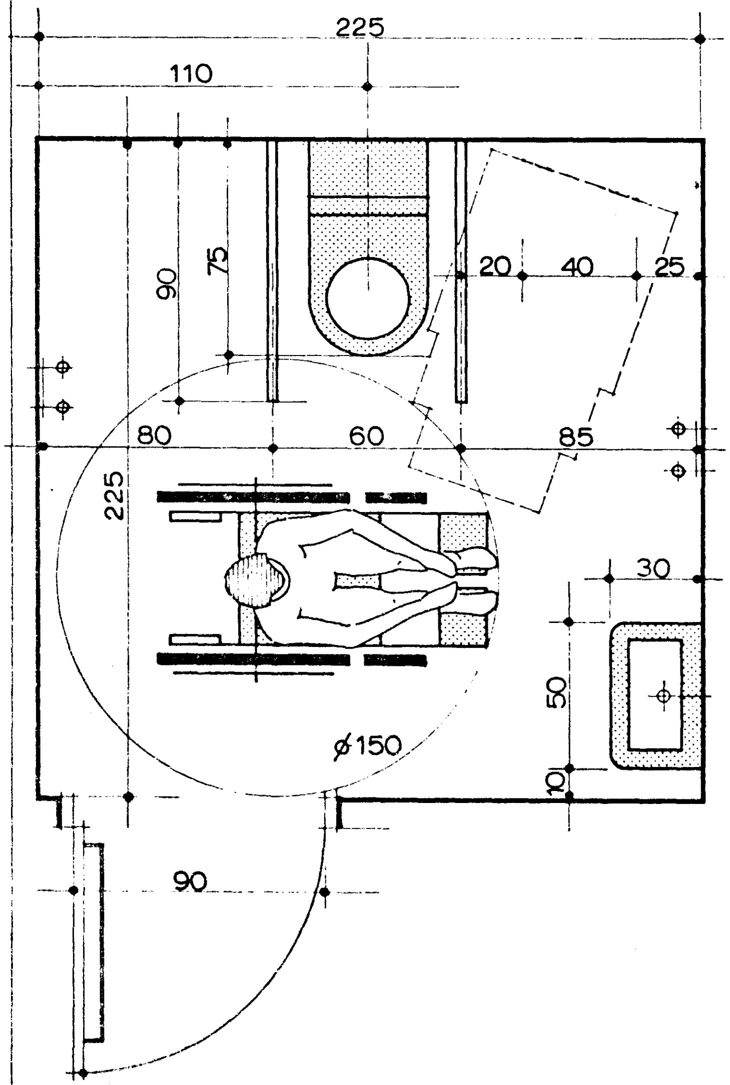
also a sliding door can be recommended

buildings

universal

lavatory minimum size 225 x 225 cm

3.1.1.3.



universal plan which allows for space for assistance by helper

siphonic closet see 3.1.1.4.

swing-up double arm rests, see 3.1.1.5.

hooks for clothing at 120 cm height

wash basin, size 30 x 50 cm with bracket and mirror

lock: opening from outside should be possible

alarm installation see 2.2.6.

n.b.
waste bin should be available

also a sliding door can be recommended

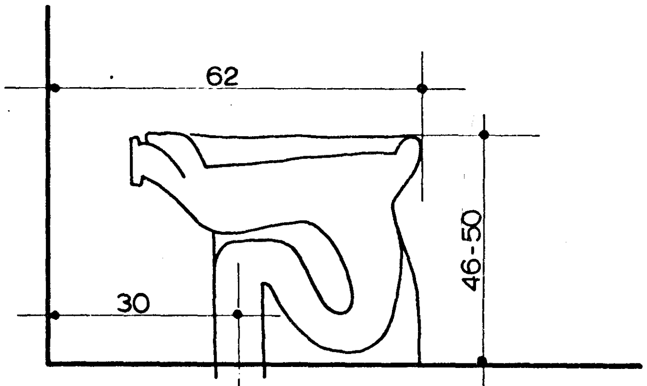
---

buildings

lavatories

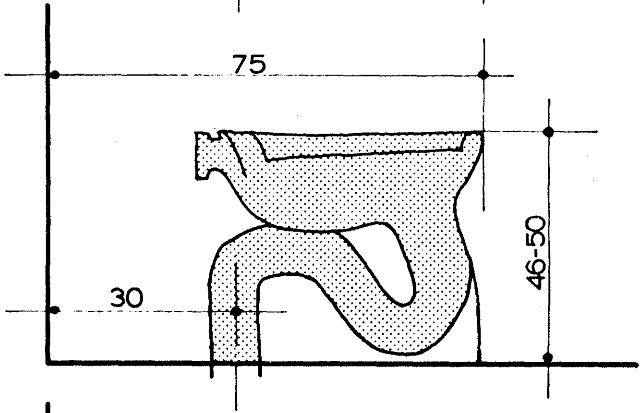
siphonic closets

3.1.1.4



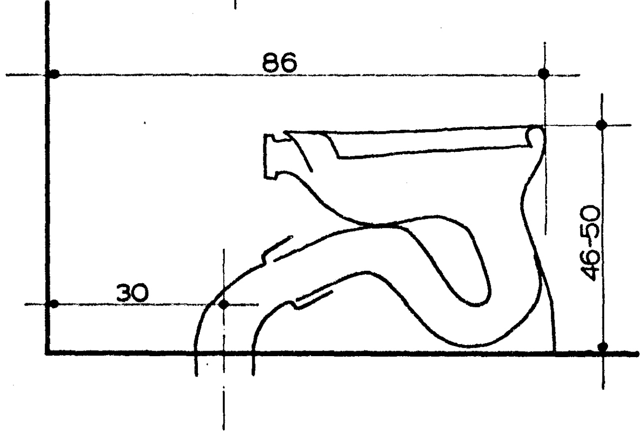
when discharge pipe is placed 30 cm from wal a normal as well as an adapted siphonic pan can be installed

height of closet 46 to 50 cm



for general use in lavatories this pan, mounted 75 cm from the wall, is preferred

seat: use an unbreakab seat



cistern: a low-level cistern with lever or button may be used or an ordinary high-level flushing cistern with pull cord

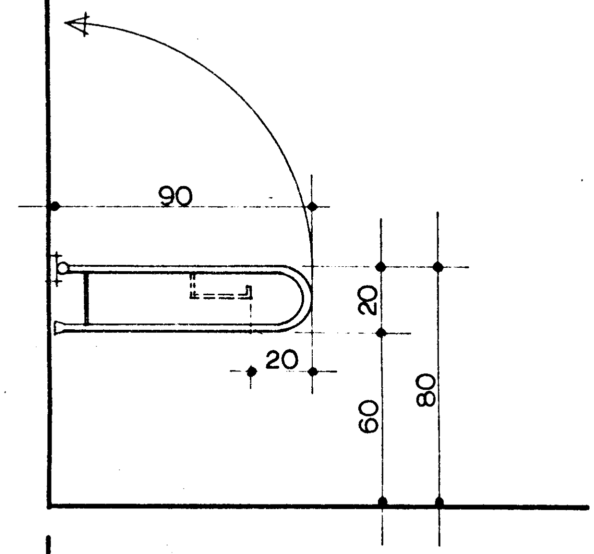
n.b.
for individual use, adaptation to handica can be necessary

buildings

lavatories

swing-up double arm rests

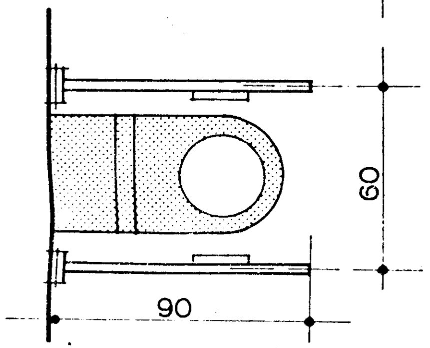
3.1.1.5.

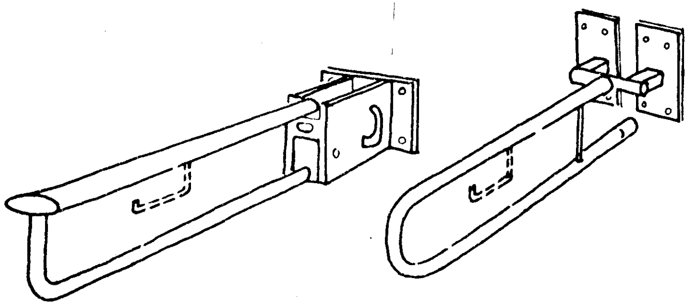


examples of arm rests, with and without hook for toilet roll

for special cases arm rests can be used combined with back rest

wall sufficiently thick and firm to withstand a heavy load





left: arm rest can be fixed in vertical position

right: arm rest, when in vertical position, is held by a magnet

NVR

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buildings

lavatories

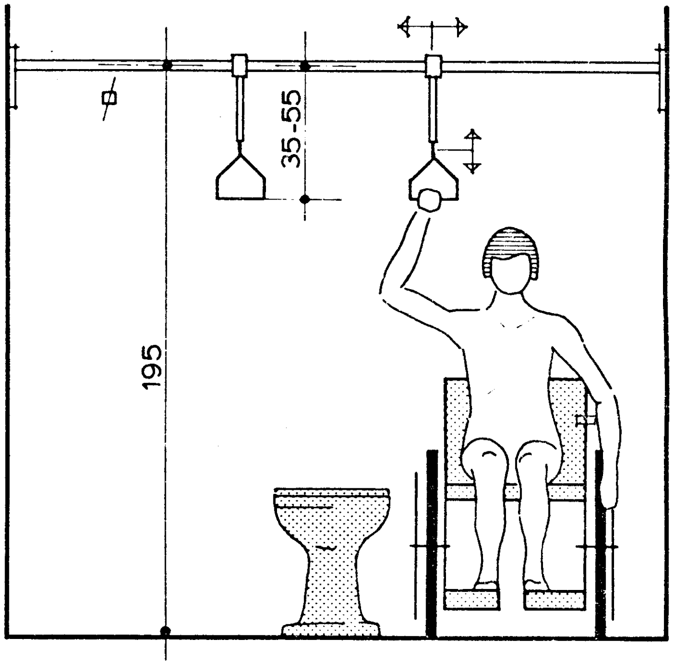
triangles

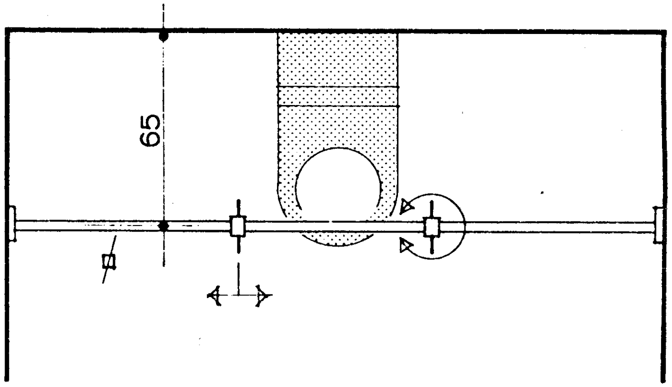
3.1.1.6.

triangles: square ste
bar with two sliding
small bars with han
grip in triangle form

grip can be raised a
lowered

by pulling, handica
person can move ov
onto lavatory



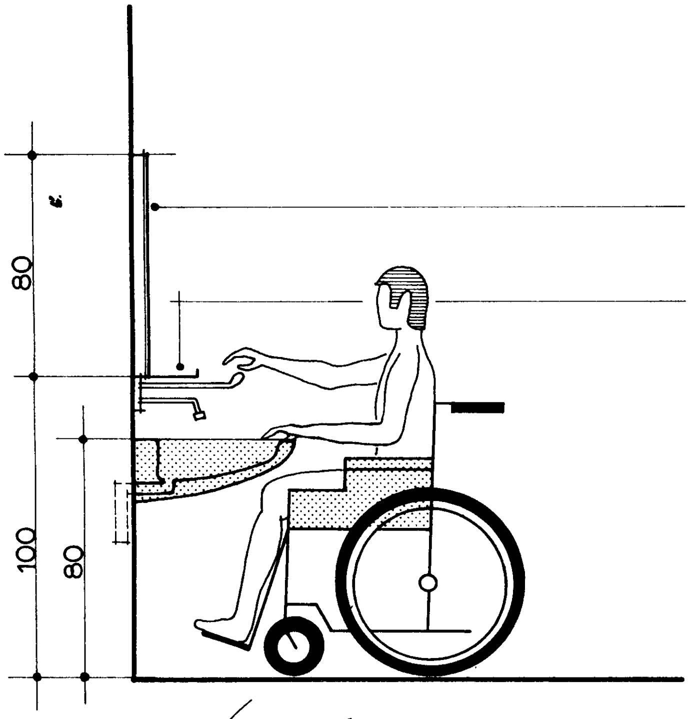


n.b.
a triangle is prefer
to swing-up arm re
by some handicap
people because pul
needs less effort th
pushing oneself up

triangles to be use
in individual cases
as an extra fitting i
buildings where m
handicapped peopl
the adapted lavato

buildings
lavatories
wash-basin

3.1.1.7.



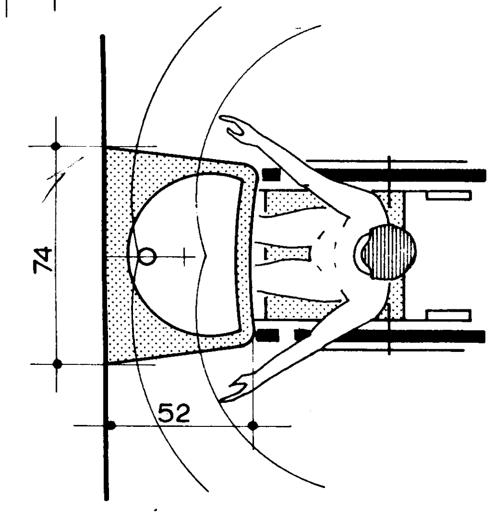
inclined mirror,
125 cm height to centre,
or straight mirror
100-180 cm

fixture for disposal
of bandages etc.

mixing tap with lever
control, thermostatic-
ally safeguarded

wash-basin for wheel-
chair users: fixed very
firmly as some people
will lean on it

discharge pipe at rear
or as close as possible
to wall and off-centre



special wash-basin,
hollow at front

depending on available
space, smaller basins
can be used

n.b.
waste bin near basin
with opening at approx.
80 cm

attention to correct
height of towels etc.
grasping height approx.
100 cm

NVR

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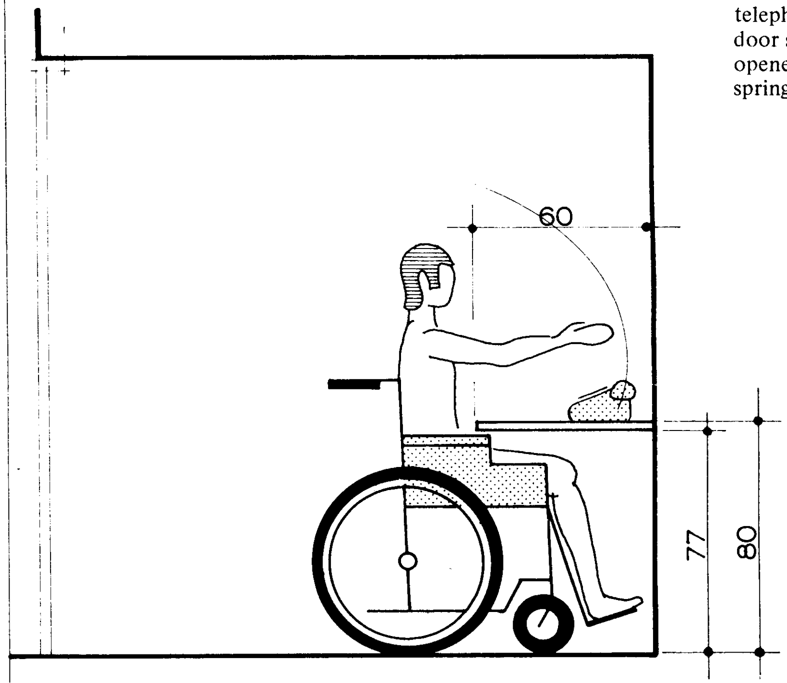
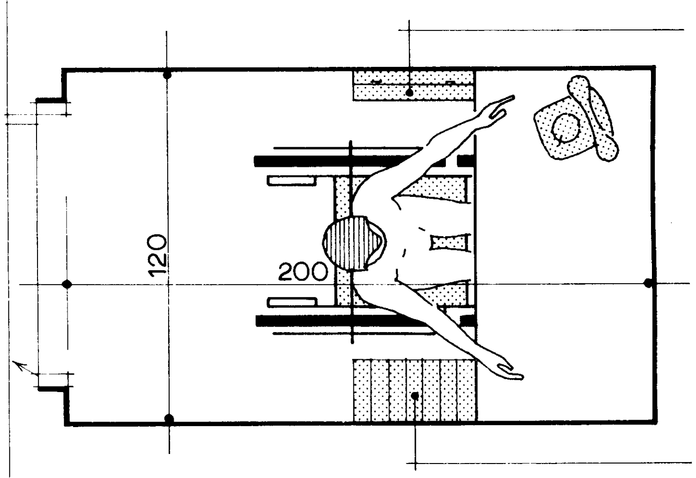
building
telephone booth

3.1.2.1

telephone booth:
door should be easily
opened. No heavy
springs





tip-up seat, height
50 cm

minimum size can be
110 x 140 cm

for special cases
telephones with soun
box are available

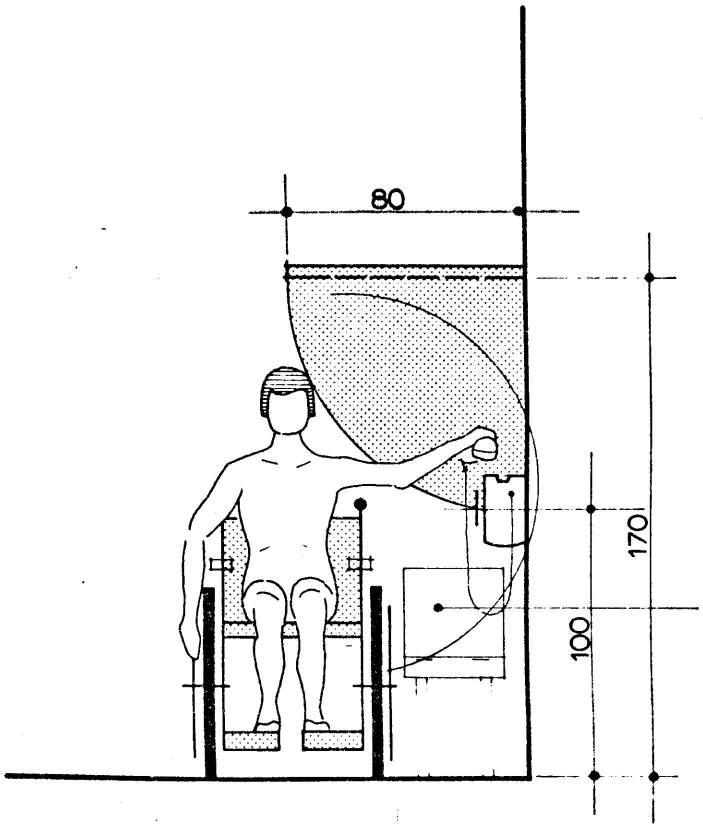
official telephone
guides

NV

buildings
telephone hood

3.1.2.2.

telephone
can be used seated



dial and coin box at
approx. 100 cm

tip-up seat, height
50 cm

NVR

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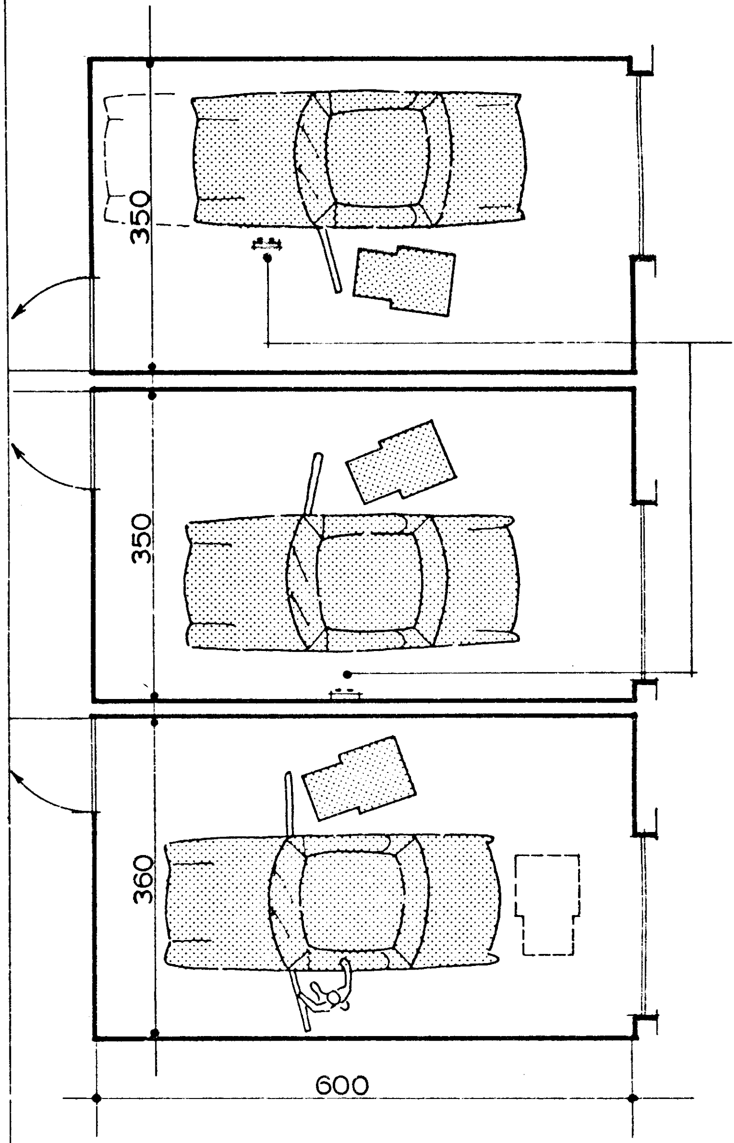
buildings
garages (for car length up to 400 cm)

3.2.10.



garage for wheelchair
user who drives car
wheelchair remains
in garage (*a*)

approx. 300 cm in
front of garage:
post with electric do
opener, height appro
100 cm

pendant controls for
light and electrically
operated tilting door

garage for wheelchai
user who drives car
wheelchair taken in
the car (*b*)

garage for wheelchai
user who is passenge
in car
space required for
manipulating wheel-
chair to put it in the
car boot (*c*)

general: if possible,
direct access from
building or house

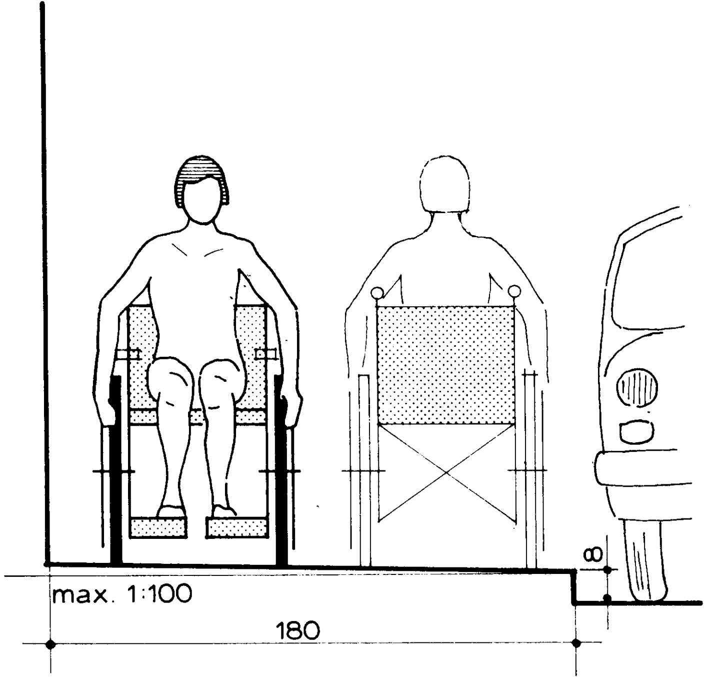
attention to space an
loading equipment f
electric wheelchair l
Amp., when required

N

town planning arrangements

pavement, footpaths

4.1.1.



pavement (footway)

minimum width: 120 cm if local extra width for passing is provided

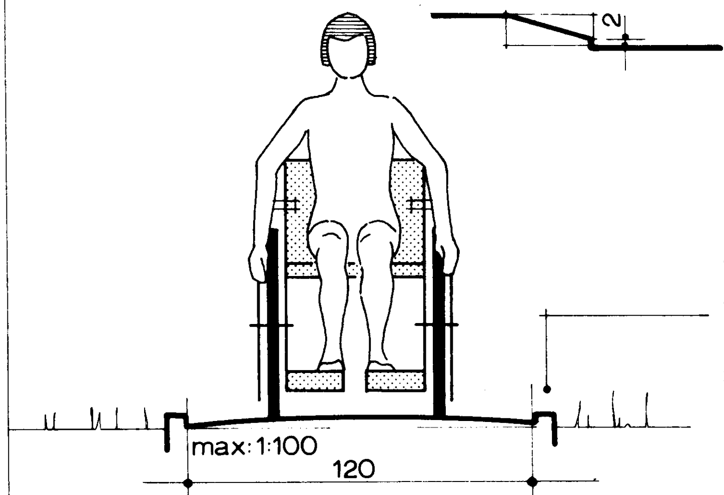
recommended width: 180 cm

longitudinal gradient: not steeper than 1 in 20

maximum cross-fall: 1 in 100

kerb preferably not higher than 8 cm

locally lowered kerb (rounded, 2 cm high) in places where wheelchair has to leave the pavement



footpath

material: preferably paving with closed-texture surface

minimum width: 120 cm if local extra width for passing is provided
recommended width: 180 cm
maximum longitudinal gradient: 1 in 20

distinct separation of path from border

maximum cross-fall: 1 in 100
n.b.
pavement and footpath: on long gradients horizontal rest areas ('landings') should be provided.

NVR

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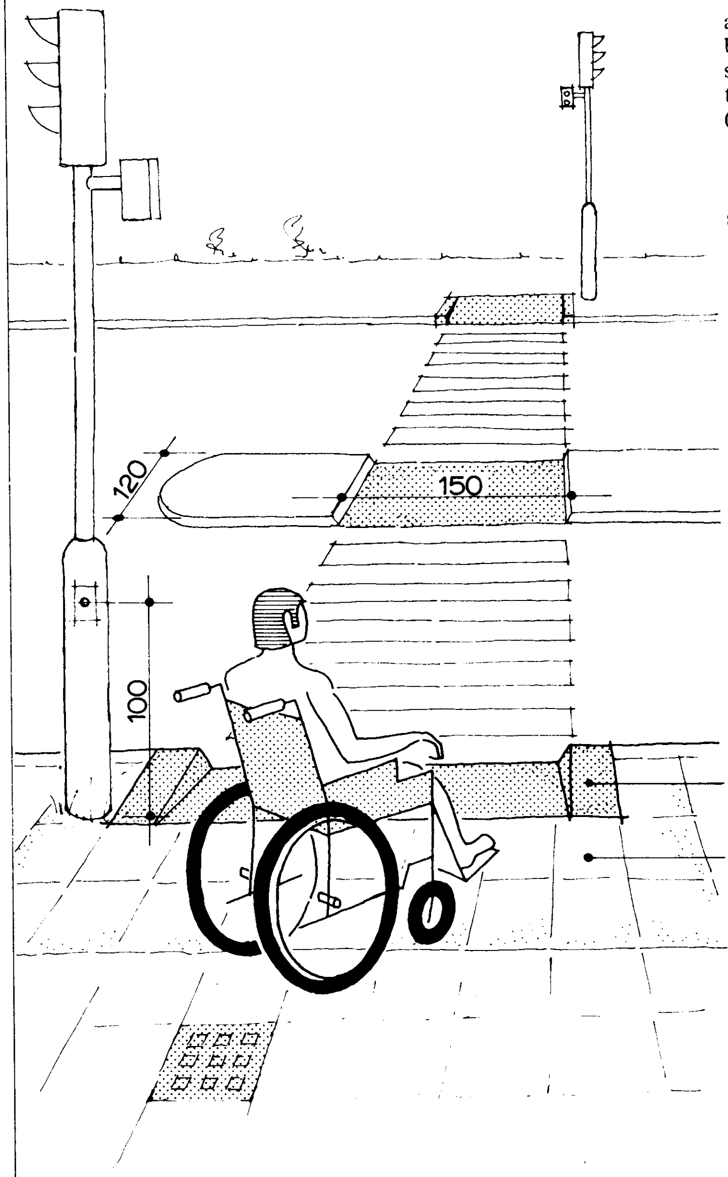
town planning arrangements

pavements, pedestrian crossings

4.1.2.



pedestrian crossing

at busy crossings a buzzer should sound so long as the pedestrians' light is at 'safe' (for blind persons)

sufficient time to allow safe crossing (speed 1 m/5 sec.)

passage through traffic island should be 150 cm minimum width and flush with roadway

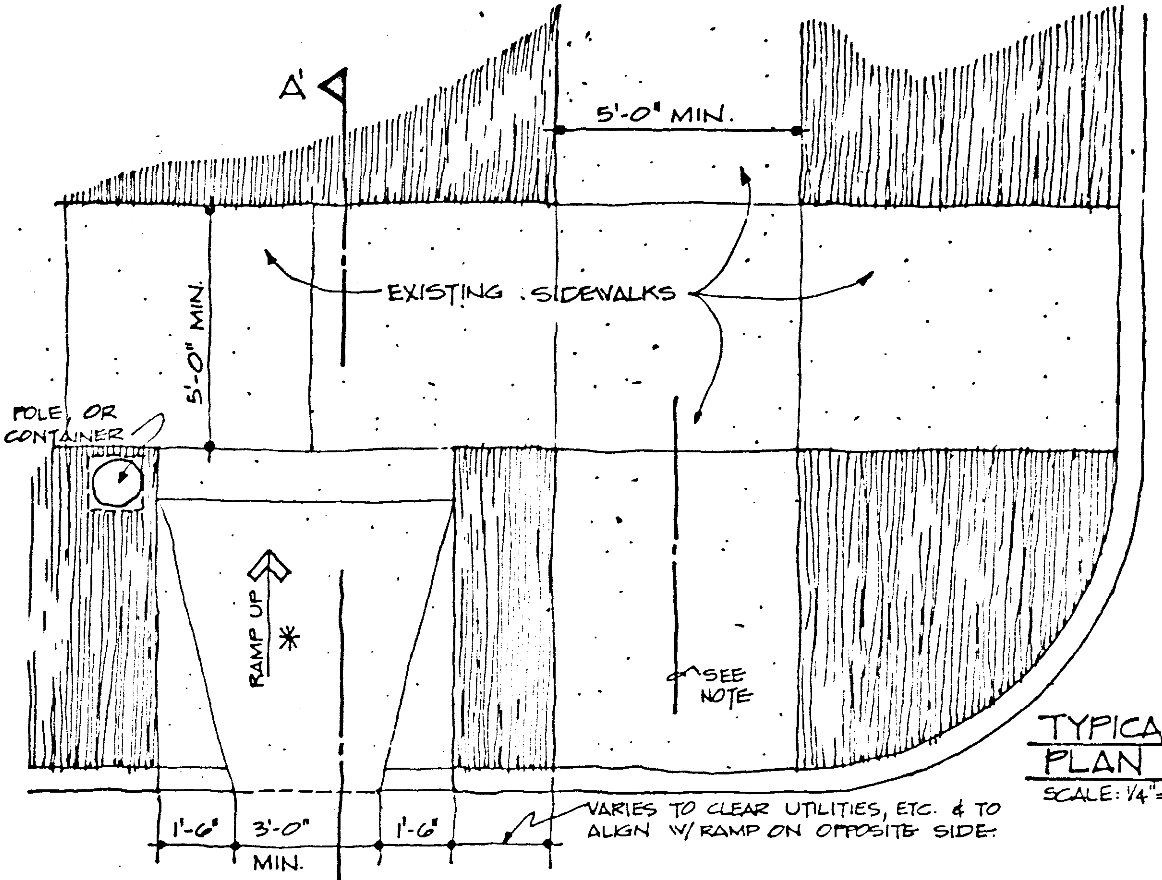
push-button in contrasting colour

concrete ramp, 90 cm min. width

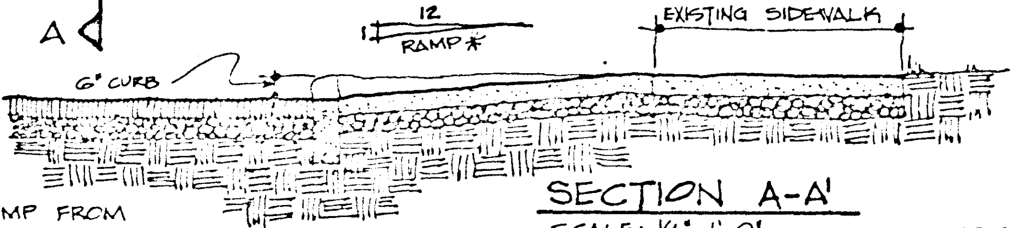
different paving materia to warn blind and semi-blind persons; may also extend across full width of pavement

grid openings max. 2 cm for stick users

NVI



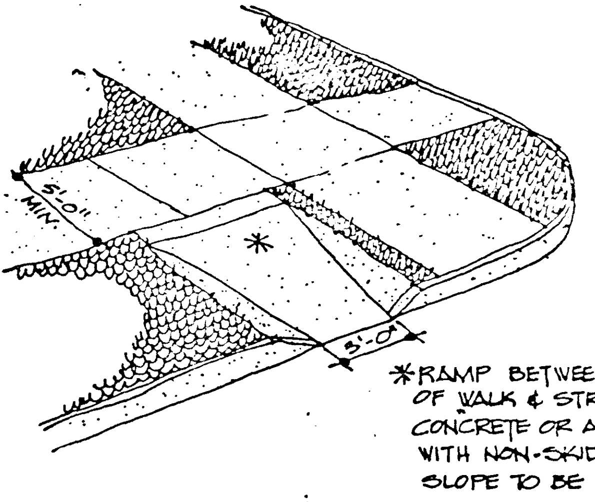
TYPICAL PLAN
SCALE: 1/4"=1'-0"



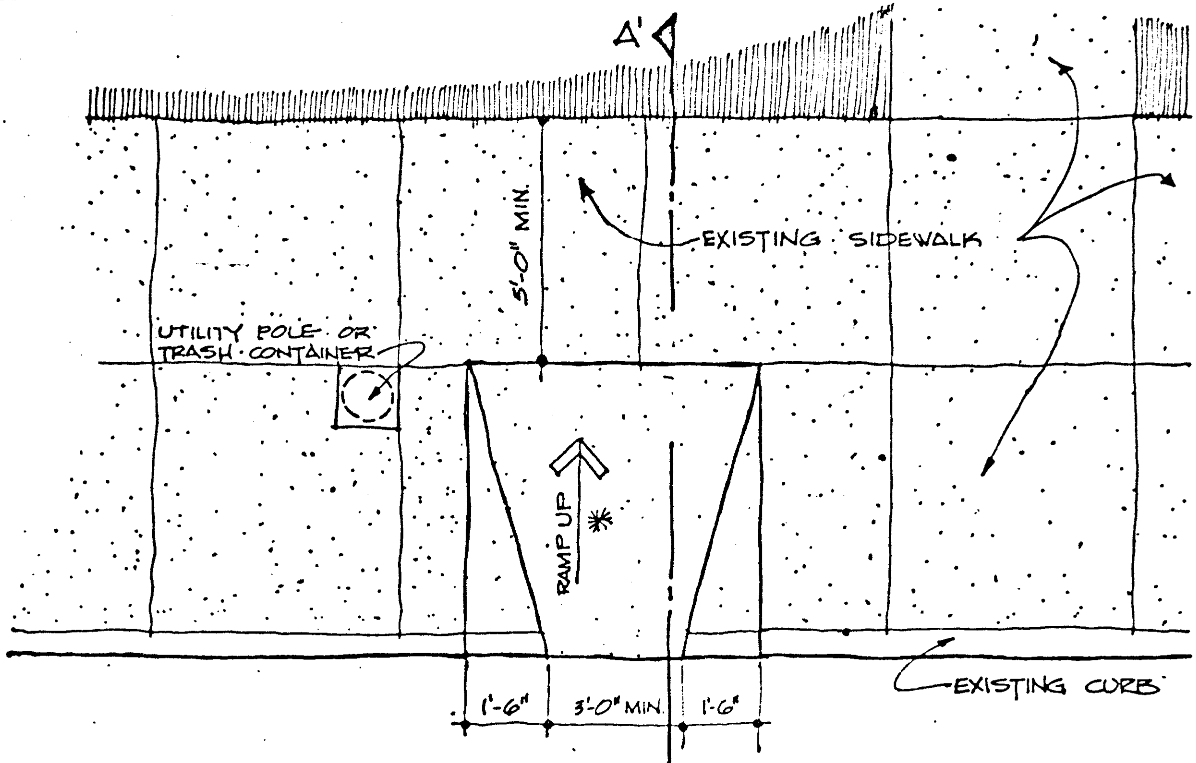
SECTION A-A'
SCALE: 1/4"= 1'-0"

NOTE: OFFSET RAMP FROM SIDEWALK AXIS TO PRESERVE CURB ORIENTATION FOR BLIND PEDESTRIANS.

ESTIMATE OF COST $75



*RAMP BETWEEN GRADES OF WALK & STREET TO BE CONCRETE OR ASPHALT WITH NON-SKID SURFACE; SLOPE TO BE 1:12 MAX.

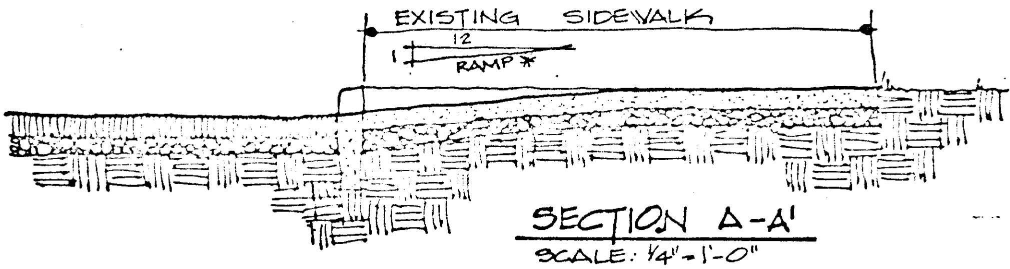


ESTIMATE OF COST: $ 80

Cane Traveler

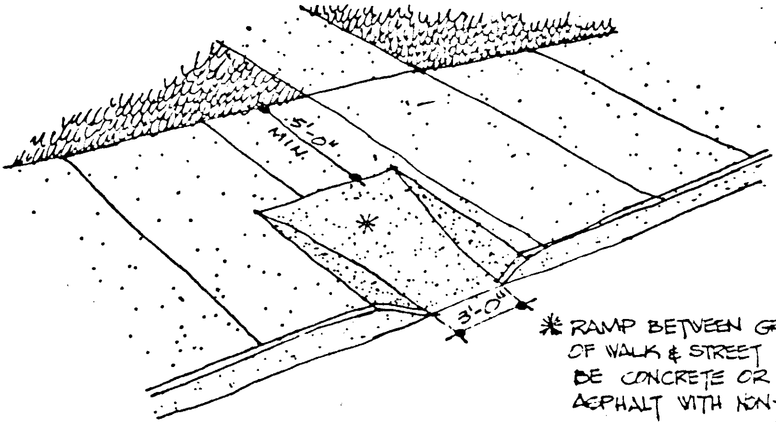
TYPICAL PLAN

SCALE: 1/4" = 1'-0"

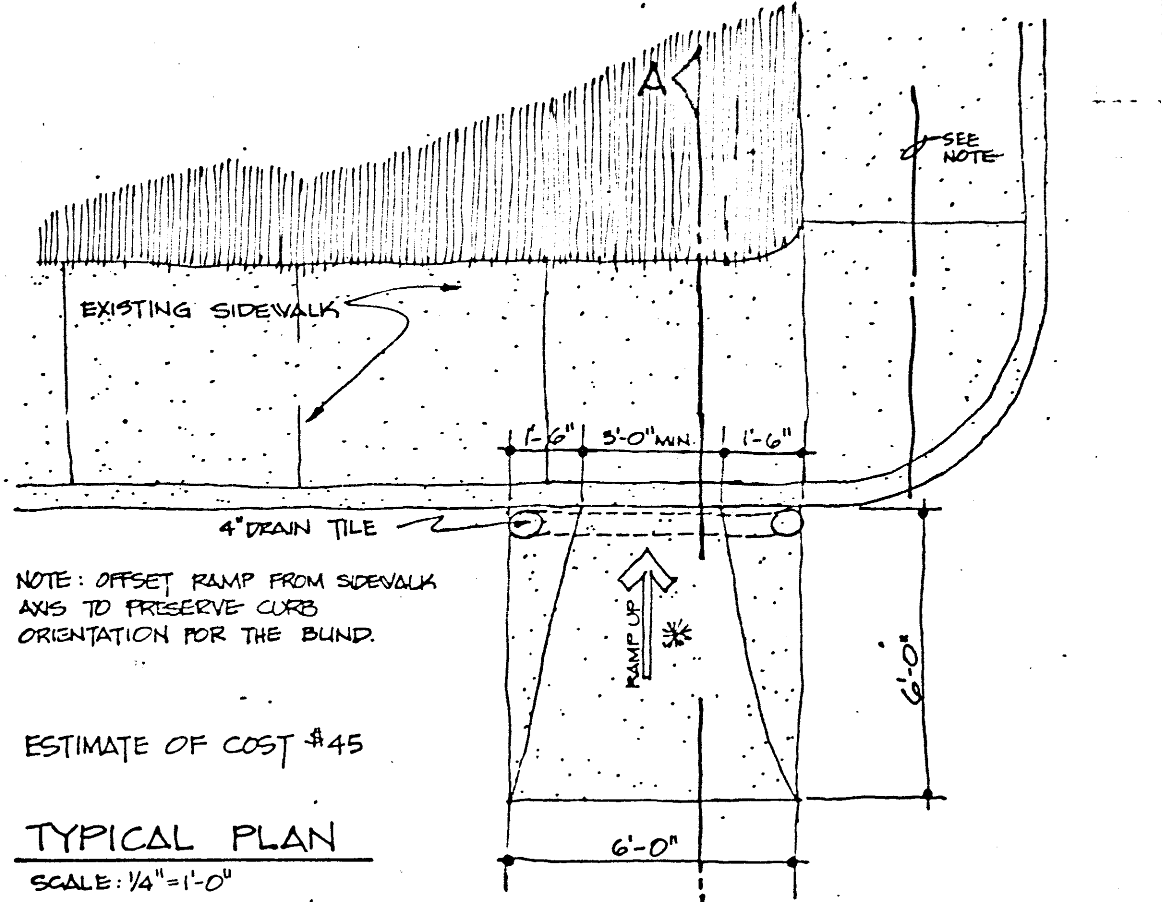


SECTION A-A'

SCALE: 1/4" = 1'-0"



* RAMP BETWEEN GRADES OF WALK & STREET TO BE CONCRETE OR ASPHALT WITH NON-SKID SURFACE, SLOPE TO BE 1:12 MAX.

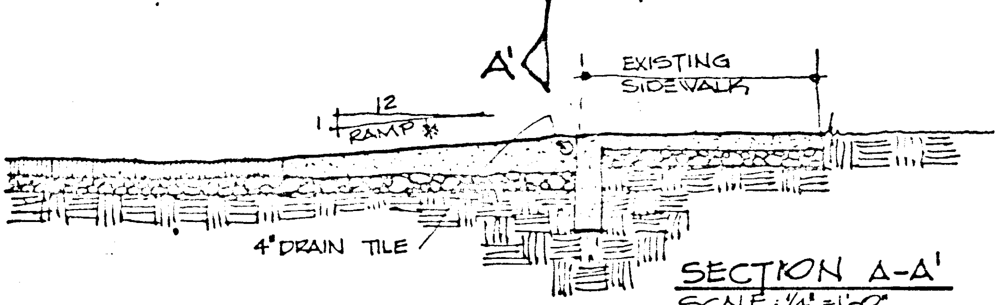


NOTE: OFFSET RAMP FROM SIDEWALK AXIS TO PRESERVE CURB ORIENTATION FOR THE BLIND.

ESTIMATE OF COST $45

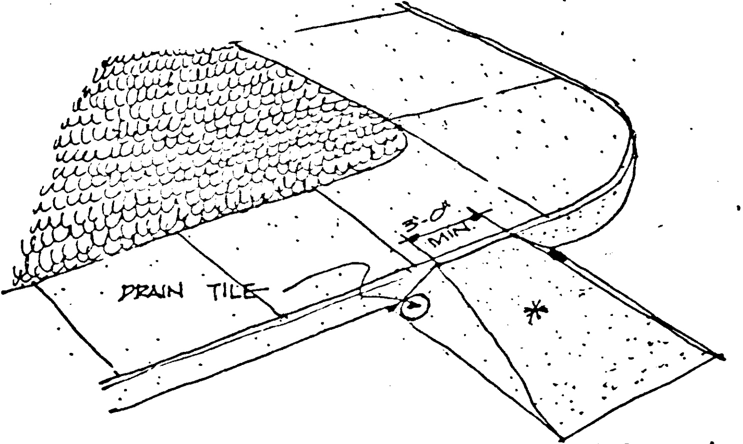
TYPICAL PLAN

SCALE: 1/4"=1'-0"

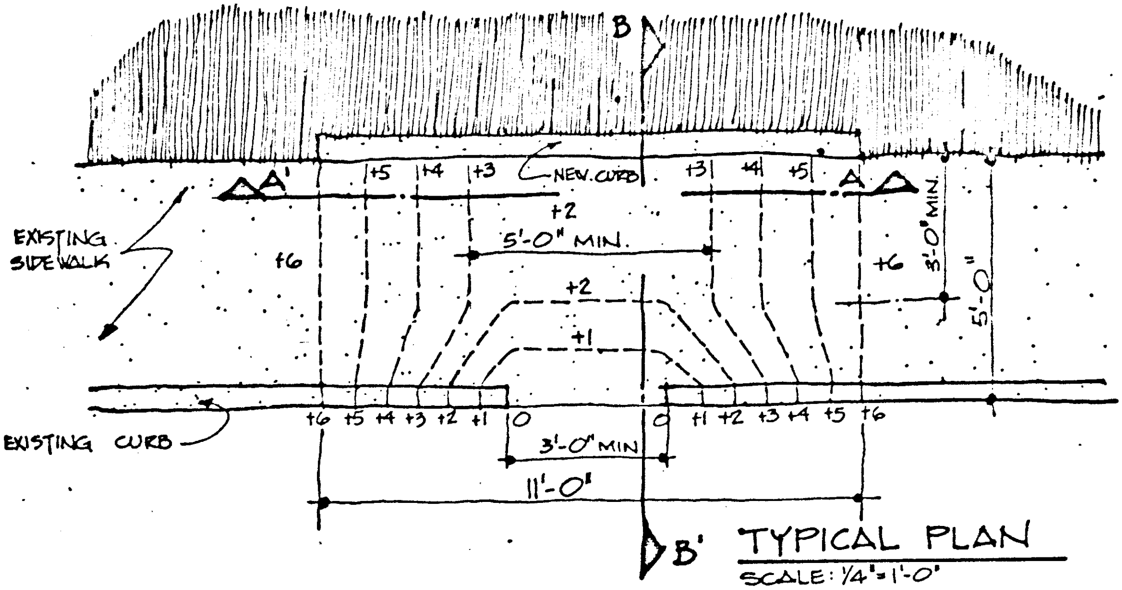


SECTION A-A'

SCALE: 1/4"=1'-0"

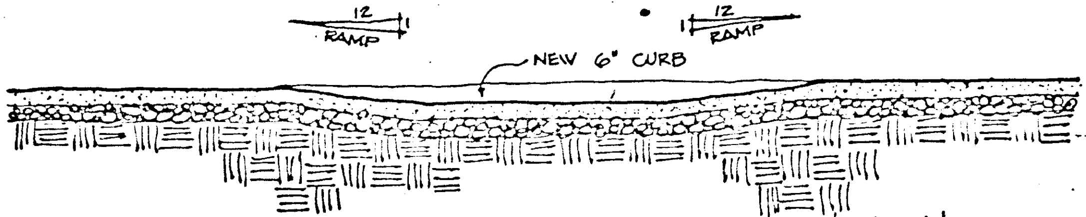


✻ RAMP BETWEEN GRADES OF WALK & STREET TO BE CONCRETE OR ASPHALT WITH NON-SKID SURFACE SLOPE TO BE 1:12 MAX.



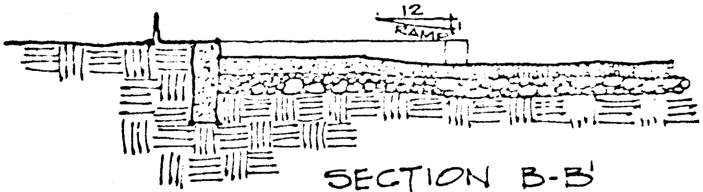
TYPICAL PLAN

SCALE: 1/4"=1'-0"



SECTION A-A'

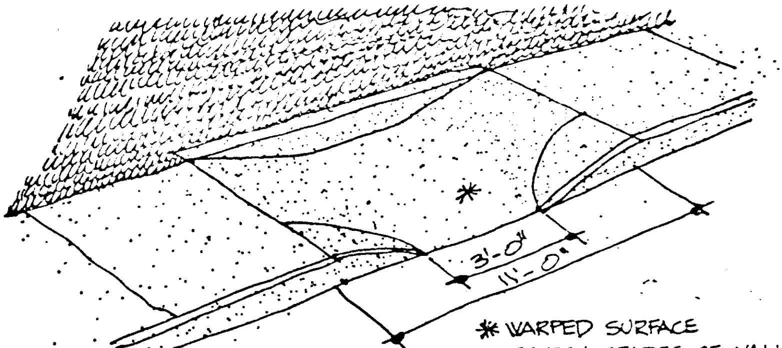
SCALE: 1/4"=1'-0"



SECTION B-B'

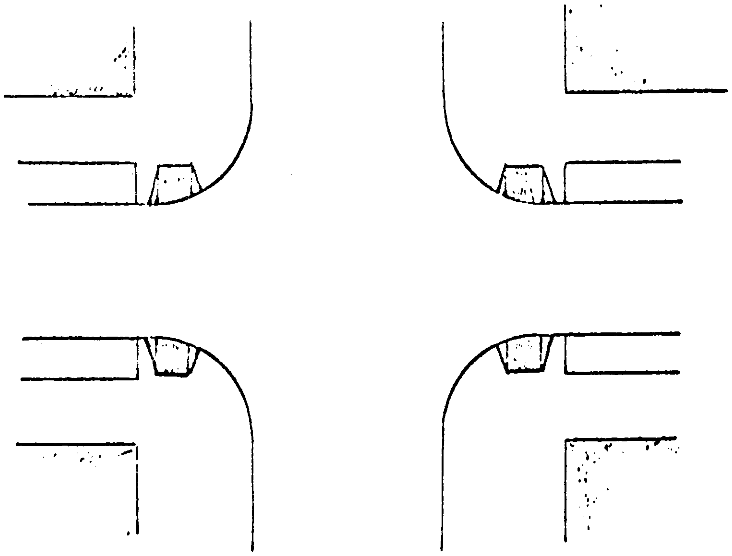
SCALE: 1/4"=1'-0"

ESTIMATE OF COST $200.

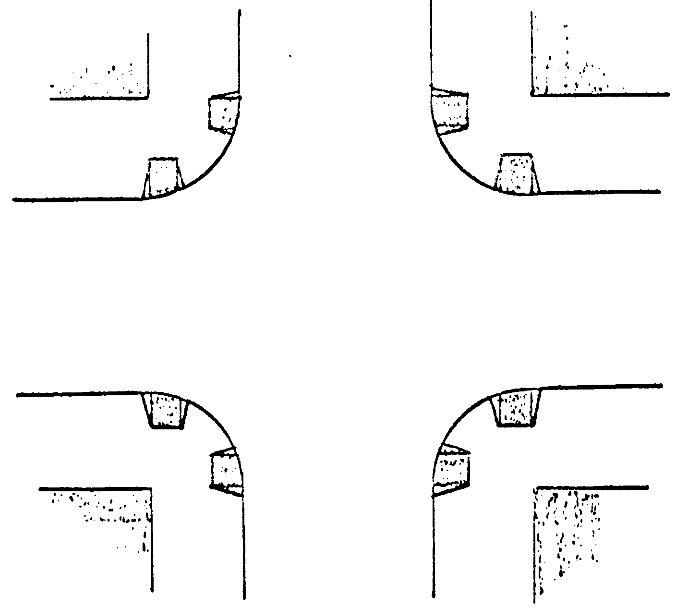


* WARPED SURFACE BETWEEN GRADES OF WALK AND STREET TO BE CONCRETE OR ASPHALT WITH A NON-SKID SURFACE, 1:12 MAX. SLOPE

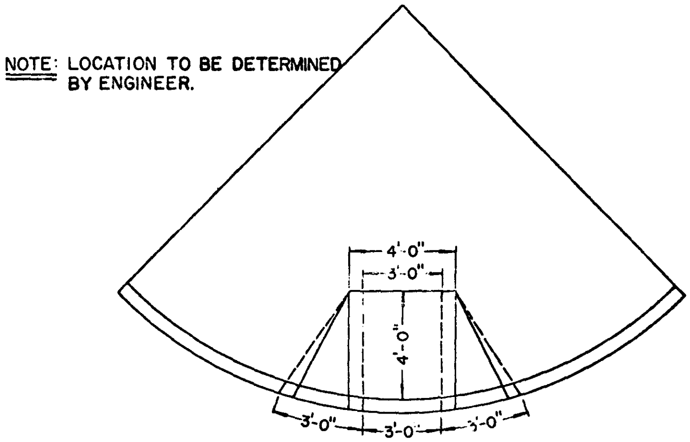
B. RESIDENTIAL - Arterial

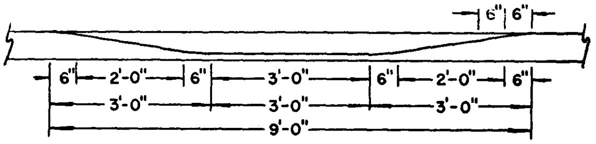


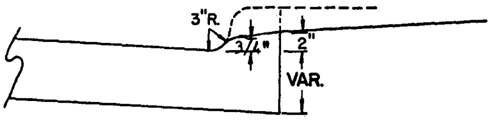
C. ARTERIAL - Arterial

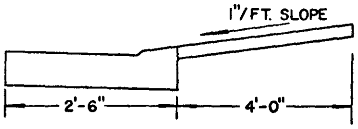


Courtesy of the Planning and Design Division, Department of Public Works, City of Minneapolis, and the Minnesota Society for Crippled Children and Adults, Inc. (MiSCCA)
April 24, 1969









PEDESTRIAN RAMP FOR THE HANDICAPPED

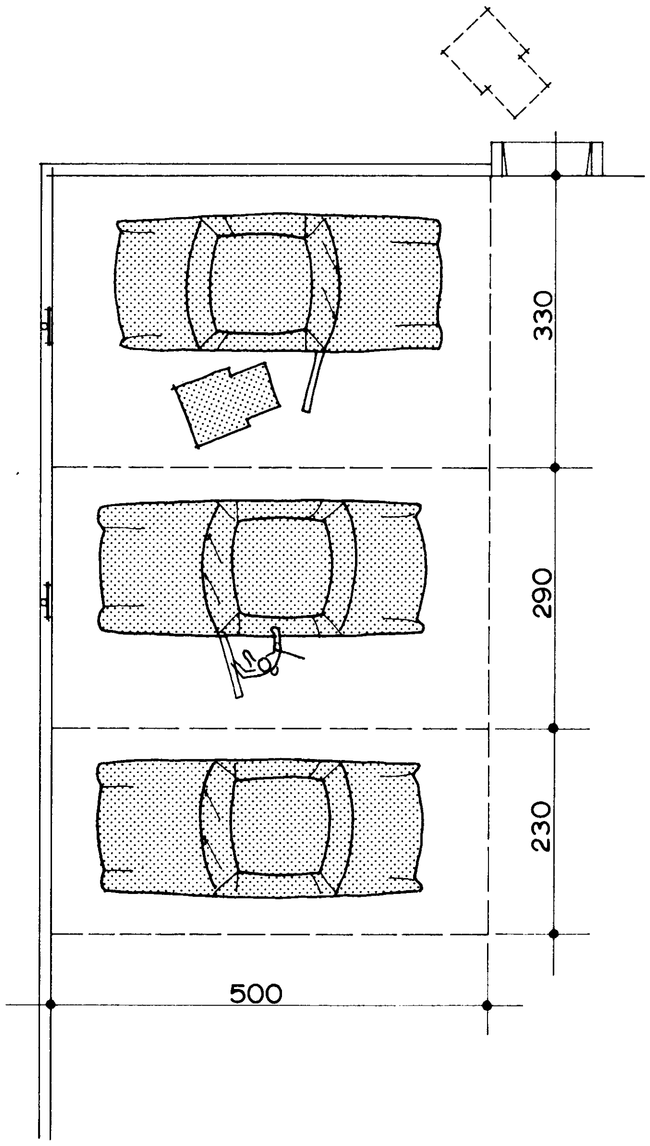
PLANNING AND DESIGN DIVISION
DEPARTMENT OF PUBLIC WORKS
CITY OF MINNEAPOLIS

DATE: 4/8/68
SCALE: NONE
NO.

Courtesy of the Planning and Design Division, Department of Public Works, City of Minneapolis, and the Minnesota Society for Crippled Children and Adults, Inc. (MiSCCA)
April 24, 1969

town planning arrangements
car parks (dimensions apply to European cars)

4.1.3.



pavement
(footway)
with locally lowered
kerb

notice board:
'no parking except
for invalids'

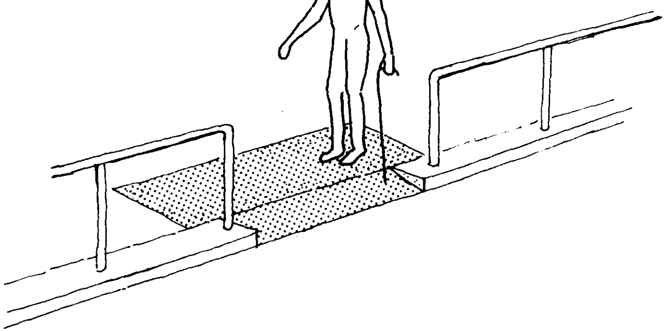
parking bay for stick
users

ordinary parking bay

NVR

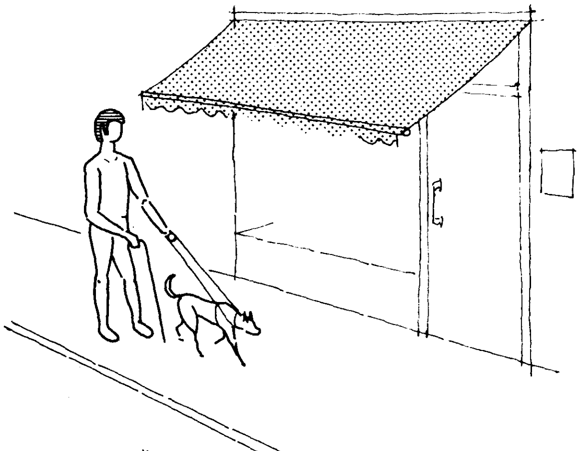
persons with sensory disabilities
persons with impaired vision

5.1. 2.



safety barrier with conspicuous distinctive colour

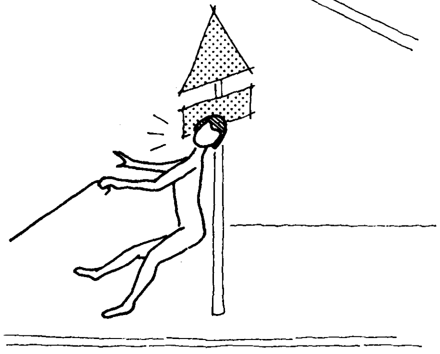
different paving material at pedestrian crossing, see 4.1.2.



no protruding obstacles lower than 200 cm

name-plate with embossed lettering installed within reach

door frame in contrasting colour



road signs should be installed at safe height

posts in conspicuous colours, preferably yellow/black

n.b.
where necessary, the arrangements for visually handicapped persons should be incorporated in the drawings

NVR

BIBLIOGRAPHY

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