Designing Functional Residential Interiors for Wheelchair Users

BY

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B.Sc (H.Sc.)

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CERTIFICATE

MANISHA MOHANTA has satisfactorily prosecuted the course of research and that the thesis entitled **"DESIGNING FUNCTIONAL RESIENTIAL INTERIOR FOR WHEELCHAIR USER'S"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by her for a degree of any university.

Date: **(Dr. (Mrs.) MAHALAKSHMI V. REDDY)**

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DECLARATION

I, MANISHA MOHANTA, hereby declare that the thesis entitled "**DESIGNING FUNCTIONAL RESIDENTIAL INTERIORS FOR WHEEL CHAIR USER'S",** submitted to Acharya N.G. Ranga Agricultural University for the degree of **MASTER OF SCIENCE IN HOME SCIENCE** is a result of original research work done by me. I also declare that any material contained in the thesis has not been published earlier.

Date: **(MANISHA MOHANTA)**

Place:

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(MANISHA MOHANTA)

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ABSTRACT

Barrier-free environment is a phrase to depict the accessibility for people with disability as a vital aspect to independence; which can substantially increase the options for establishing one's own routine of daily living and working activity without additional assistance. The present scenario of increasing number of population with locomotive disabilities emphasizes the importance of creating a built-environment for conducive living. Builders, architects and interior designers who are the ultimate providers of barrier-free environment in buildings should ensure building standards and guidelines in the design to meet the needs of users.

Given their history of segregation and isolation, the right to full participation in the community is one that people with disabilities value very highly. However, in order to participate in the life of the community, a person needs to get around. Hence the present study on "Designing functional residential interiors for wheelchair users." was proposed with the following objectives:

1. To observe the existing residential building design features in the homes of wheelchair users.
2. To explore the views of wheelchair users on the functionality of the existing design features
3. To evolve appropriate interior design solutions through computer graphic models for the wheelchair users.

Hyderabad city, the Capital of Andhra Pradesh was identified for conducting the research. The ex-post facto research design was used to progress in research. Ten adult wheelchair users were selected as respondents through purposive random sampling technique for conducting case-studies. An interview cum observation sheet was developed to explore the views of wheelchair users on the functionality of existing design features in residential buildings. The data was collected through direct personal interview and observation, was analyzed to evolve appropriate design solutions.

Findings of the study indicated that, there were an equal number of male and female respondents in this study. Respondents who were affected with polio and victims of accidents were four each and another two were sufferers of cerebral palsy or paralysis. All of them had problem with lower limbs and six among them also had problems with upper limbs and deformed facial bones. Polio and cerebral palsy affected members had prolonged disability period while the rest were for less than 10 years.

Among the 10 respondents, seven were young adults in the age group of 20-30 and four were married. All of them had the support of either parental or conjugal family except one who opted to live independently. All the respondents had formal education, except one. Five among them have completed either graduation or post graduation, while two more are pursuing post-graduation. Two of the respondents were engaged in managing their own family enterprise while one respondent was employed outside the home. Except one respondent, all of them belong to middle or upper-middle income group. Regarding management of their daily chores, seven of them needed assistance in toilet activities and clothing management, while four persons looked-for assistance in activities like bathing and grooming, cooking and home management.

Equal number of respondents lived in Independent houses and apartments. All the participants reported their partial satisfaction with adaptations introduced in the home. Everyone had problem in accessing toilets bath area, personal room, kitchen and approach area outside the house. Detail analysis of every feature in the home revealed their dissatisfaction with provisions like ramp, curb ramp, door design, kitchen counter, storage shelves, circulation path, toilet, bath, position of faucet and due to the problems like difference in floor level, presence of threshold, narrow doorways, inaccessible storage areas, switch controls and kitchen counter and faucets, inaccessible toilet and bath area. Respondents of the study gave their personal suggestions to overcome these barriers in their homes. Most of the suggestions were for improving conditions in bath and toilet area, kitchen, approach area to home and accessibility to storage provisions and switch controls in all the rooms.

It was observed that the selected residential buildings did not possess many design features as per standards and guidelines meant for wheelchair users. So, design guidelines and standards suggested by various authors and authorities were considered, for evolving design solutions to overcome the problems expressed by the respondents. Design solutions suggested in this study are presented in the form of computer graphical drawings in AutoCAD 2007. Necessary plan and perspectives for each functional area of the house were evolved independently by incorporating the design solutions and these were unified to create a model residential house plan.

From the present study it can be concluded that residential buildings should ensure accessibility features to meet the needs of end-users. The design solutions proposed in this research can be incorporated in any residential building to improve functionality. There are several ways of humanizing the residential buildings like - altering an existing house with suitable modification, building an additional portion or buying a new home to provide a satisfactory and self-dependent life.

CHAPTER I

INTRODUCTION

Social security is an important issue for everyone in the society. It implies one to be free and lead life with self- esteem and dignity and this has a special significance to the persons who are disabled. The right of disabled persons to social security is a constitutional category which binds the country to guarantee social rights to disabled persons in accordance with the principle of equal opportunities. The right of disabled persons to independence, their inclusion in society, and co-operation in the life of the community is particularly worth stressing

Disability may occur during a person's lifetime or may be present from birth. It is a phenomenon that affects not only others only, but a phase that all of us pass through in the cycle of time. The meaning of disability includes not only people with physical impairment, but also the temporarily infirm, senior citizen, pregnant women and people carrying children or luggage, etc.

The problem of disability is gaining more and more importance all over the world. According to World Health Organization (WHO) around 10 per cent of the world's population, or 650 million people, live with a disability. In India, 2.13 per cent of the total population is disabled as per 2001 statistics. As per the National Sample Survey Organization (NSSO) 58th round data 57.50% disabled were having loco motor disability, 10.88% were blind, 4.39% were having low vision, 16.55% were having hearing impairment, 11.65% had speech disability, 5.37% were mentally retarded and 5.95% were mentally ill. The proportion of disabled

persons has shown a significant decline for disability types like visual, hearing and speech. However, the magnitude and proportion of the loco motor disability has increased during 1991- 2002. Its share has gone up to 57.50% in 2002 from 55.30% in 1991 (NSSO, 2002).

The problem of disability is putting a great restraint on accessibility to various areas and facilities. Accessibility to anything and everything is a matter of right for all of us. The concept of 'accessibility' points towards designing of spaces and products, such that even the people with special need can use them easily. For a person using wheel chair or crutches, the impediments are in the form of slippery floors, change of level, steep slopes, steps and stairs, hand space rails, width of doorways and corridors, door swings and accessories, counter height, as well as a range of control panels. People with visual impairment face further impediments. Their barriers include absence of poor intimation of the path ahead, lack of Braille or tactile signage, inadequate illumination, or unchecked protruding objects in the way. Barrier Free Environment is one which enables people with disabilities to move about safely and freely and to use the facilities within the built environment. The goal of barrier free design is to provide an environment that supports the independent functioning of individuals so that they can get to, and participate without assistance, in everyday activities such as procurement of goods and services, community living, employment, and leisure. The fundamental principles that have been followed in developing standards/norms for various facilities to buildings, health care institutions, are to meet the standards of disabled people for safety, convenience and usability.

Whether or not a home is barrier free depends upon the nature and extent of one's disability. As a practical matter, a barrier free home is one which enables an individual to do what he or she needs and desires to do as independently as

possible. These requirements are found in state, local and model building codes, and regulations such as National Building Organization (NBO) – Disabilities Act 1995, Central Public Works Department Ministry of Urban Affairs & Employment India (CPWD) 2000. These laws dictate standards, dimensions, and characteristics for such features as door widths, clear space for wheelchair mobility, audible and visual signals, grab bars, switch and outlet height, and more. The accessibility standards regulate the accessibility of buildings and facilities provided within them.

Though the problem of disability is gaining more and more importance all over the world, providing accessible environment for living has been one of the most neglected issues in the disability sector (Sharma and Kumar 2004). People with disabilities do require proper attention to a myriad of details for their house or apartment: price range, location, aesthetics, overall floor space, the number of bedrooms, and more.

To conceptualize ‘Accessible Design’ into habitat it is important to recognize that habitat is a conglomerate that is dependent upon the needs of the people who inhabit it while at the same time ordering the environment in which they exist. In short, it is a unique combination between man and his environment where both are interchangeably the 'creator and the created. The other important fact is that of the correlation between disability and habitat and the need to understand the requirements of disabled persons in the context of habitat as a lifestyle and not simply as a physical entity. Accessible Design therefore has to incorporate an understanding of the emotional hierarchy of needs arising out of the interpersonal dynamics of disabled people with the family, the community and available resources for education, livelihood, and recreation, health care and so on (Bhagat, (2000).

For the world to be accessible to all, it requires the will and commitment on the part of authorities to vigilantly enforce the provision of barrier free design. It is achievable and affordable only if the thought is integrated right from conceptualization and planning stage of any space or building. It would also have to clearly take into account a respect for the topography, attitudes, general development and societal structure of the area. Professionals have the responsibility to integrate these as inherent features of architectural designs, so that society readily accepts these changes.

Rationale for the study

Social security is of special importance for disabled persons. Thus the right of disabled persons to social security is a constitutional category which binds the country to guarantee social rights to disabled persons in accordance with the principle of equal opportunities. But in reality, people with disabilities are overshadowed by the need for housing to be accessible.

A home is more than a building: it is a state of mind, an expression of personality. If a house is inadequate for the needs of the people living in it, it never quite becomes a home. For people with disabilities, a dwelling must be fully accessible to become a home. In practice the wheelchair users are living in a variety of settings, from their own homes in various tenures to residential building settings. Finding a home that is universally-designed for wheelchair-accessibility can be more difficult. Since there is no law that checks on the construction of barrier-free homes, growth in this segment is sporadic and driven by the individual home owner's needs. Thus, there is no guarantee that a home that accommodates wheelchair user, meets the requirements. A dwelling is adaptable, if it is accessible

and if it permits modifications at low cost for the benefit of disabled people in wheelchairs.

A number of research studies have been conducted on barrier free housing, and product design for wheelchair users, but all of them had focused on the need of further research while designing 'Dwellings for Wheelchair Users'. When occupational therapists applied design guidance (Goldsmith: 1996) which was considered best practice at time (Quilgars ,2000) to situations where wheelchair users needed personal assistance to transfer from a wheelchair, there was often insufficient space for the movement of the caretaker and equipment. These practical issues highlighted the need for supplementary research in this area. Hence, the present study on "Designing functional residential interiors for wheelchair users" was proposed with the following objectives.

1. To observe the existing residential building design features in the homes of wheelchair users.
2. To explore the views of wheelchair users on the functionality of the existing design features
3. To evolve appropriate interior design solutions through computer graphic models for the wheelchair users.

Delimitations of the study

The study on designing functional residential interiors for wheelchair users has the following delimitations:

1. The study is limited to residential building design solutions only.
2. The sample selection was purposive and random.
3. The study is restricted for wheelchair users only.
4. The study is conducted as case study with only 10 respondent

CHAPTER II

REVIEW OF LITERATURE

The review of related literature provides guidelines to formulate the problem precisely. It helps in making the study either innovative and provides some additional findings of studies conducted during past for they provide a strong base for planning, conducting and evaluating the study. Hence the literature search was done from different sources to provide a theoretical base for the study on “Designing functional residential interiors for wheelchair users” and is documented under the following heads:

2.1. Population with special needs

2.2 Importance of Barrier Free Design

2.3. Need for Barrier-free residential buildings

2.4. Specific design needs of wheelchair users in residential buildings

2.5. Recommended standards and guidelines for barrier free residential buildings for wheelchair users

2.1 Population with special needs

The United Nations Organizations (2003), Public Works Department Act (1995) and World Health Organization (1990) defined population with special needs as persons with disability suffering from not less than forty per cent of any disability as certified by a medical authority. American Disability Act, (1998) and Pugh, (2001) termed disability as a physical or mental impairment that substantially limits one or more of the major life activities of such individual. Mitchell (2002) articulated that “Disability is not an outcome, rather it's an input. It is a demographic variable - just like age, gender, racial ethnicity, socio-economic status - and it needs to be seen that way, as opposed to a negative health

outcome". Jonkers (2003) avowed that disability is not easily conceptualized and it cannot be defined in any exhaustive way; it is influenced by differing cultures, social institutions, and physical environments. As per Graham (2004), Disability is a way of identifying another risk factor that contributes to lessened participation in common activities like going to school, working, voting, participating in community life.

According to World Health Organization (WHO, 1990), there are 600 million people with disabilities in the world i.e. 10 per cent of the world's population is disabled. United Nations Development Program (UNDP, 2000) reveals that, 80% of people with disabilities live in developing countries. Carol (2000) stated that as per World Bank estimates, 20 per cent of the world's poorest people are disabled.

India’s disability census report (2001) and the National Sample Survey Organization (NSSO, 2002), points to a disability percentage of 2.13% among the total population. However, the office of Chief Commissioner for persons with Disabilities (CCD) estimates that about 5% of the Indian population is disabled.

The NSSO 58th round conducted in 2002 depicts that out of the total disabled population, 57.50% disabled were having loco motor disability, while 10.88% were blind, 4.39% were having low vision, 16.55% were having hearing impairment, 11.65% had speech disability, 5.37% were mentally retarded and 5.95% were mentally ill. The proportion of disabled persons has shown a significant decline for disability types like visual, hearing and speech (Choubey, 2003 and Paul, 2005).

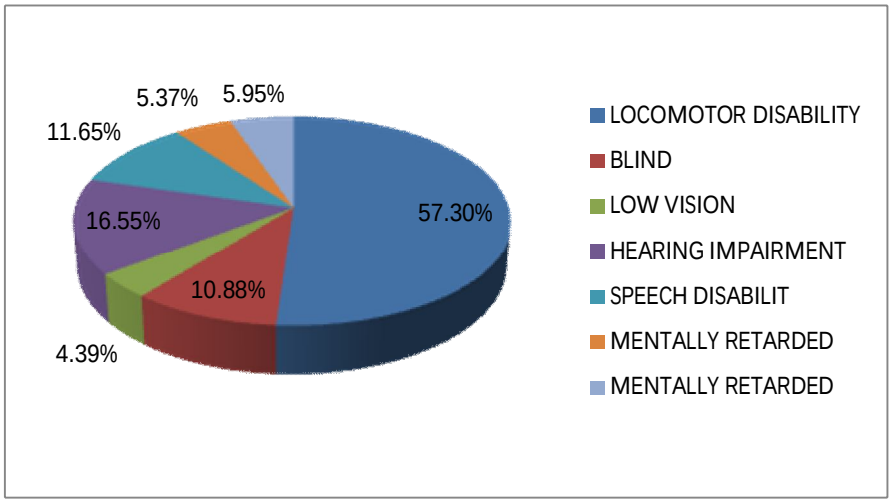


Fig-2.1 Estimates of Disability by the NSSO 58th Round (2002), National Sample Survey organizations

Arora, (2003) stated that no systematic, scientific and precise information is available on the prevalence, degree and kind of disability, the few discrete sample surveys available indicate that 50 million persons are suffering from some disability. The number is larger than the population of many developed European nations. The incidence of disability is more among the weaker and poorer sections.

The NSSO Report (2002) cited that among the recorded 18.49 million disabled persons, 10.89 million were males and 7.59 million were females, again constituting 59% and 41% of males and females respectively. This report also stated that, a significant proportion of disabled persons (77%) were dwelling in the rural areas. The prevalence rates have shown declining trends both for rural and urban areas, up to the age group of 14 years in 2002 as compared to 1991, but the age group of 15-44 years have registered increase both for rural and urban areas in 2002 as compared to 1991. Increase in disabled population is highly correlated with low education, poverty, low resources, communities and individuals with low resources Batshaw (2004).

The gender disparity, of the Census 2001 indicates 58:42 and the NSSO 58th round 2002 indicates 59:41 male: female ratio. There is a general preference for male children in India for which girls are often neglected and receive less attention than boys. They are also less likely to be educated. If girls and women in general are not valued, then disabled girls and women are likely to be even less so. In addition, studies reveal that where men and women have similar impairments, women are more likely to continue working and carrying out household tasks, less likely to seek medical treatment and see themselves as disabled (Erb and White 2004).

Though the incidence rates for disabled women recorded declining trends in 2002 as compared to 1991, Andhra Pradesh recorded higher women disability incidence rate among the rural areas. While on the other hand Madhya Pradesh, Bihar, Jharkhand and majority of Eastern states recorded significant decline in the incidence rates for women in 2002 as compared to 1991(NSSO,2002).

In India nearly 10.6 million persons constituting 57.50 % of all the disabled population (18. 49 million) were loco motor impaired. The reported loco motor impaired persons as per the Indian Census 2001 and NSSO 58th round December (2002) survey have shown a significant increase from 8.93 million in 1991 to 10.6 million in 2002. The increase could be probably due to increase in traumatic impairments especially accidents due to increasing vehicular traffic movement, industrial accidents and other occupational hazard accidents. The proportion of loco motor disabled persons to all disabled persons has also marginally increased from 55.3 % in 1991 to 57.50% in 2002. Of the total loco motor-impaired persons nearly 37.61% were females and the rest 62.39% were males in 2002. Gender variation in the loco motor impairment could be explained to the nature of work undertaken by the males, which have more potential of

accidents. Hence loco motor impairment caused by occupational and traffic accidents are gender specific, in particular more likely for males in India. With such a high rate of challenged population we need a lot of research in the field of barrier free to develop an inclusive design for the excluded group.

These surveys have also looked into the causes of disability. The causes of disability can be broadly classified into three groups: genetic/hereditary factors, biological (including age-related) factors and accidents. Polio was the cause of loco motor disability in about 30 percent of the disabled population. Accidents were the cause of nearly 40 percent of the disabled population. Leprosy, Paralysis and other illnesses caused disability among 20 per cent people. Genetic / hereditary factors, birth time disorder were the major reasons for 10 percent of the disabled population (Bhanushali, 2007).

Human rights Ombudsman, Annual Report 1999 stated that respecting the personal dignity of disabled persons requires that regardless of their age or the nature and origin of their disability they are guaranteed the effective exercising of their right to independence. The most effective way that the state can do this is by increasing the possibilities for disabled persons to lead an independent life, so that it enables them to be included and co-operate equally in all areas of life and work.

Article 14 of the Indian Constitution applies uniformly to every legal citizen of India, whether they are healthy or disabled in any way (physically or mentally) and guarantees a right of justice, liberty of thought, expression, belief, faith and worship and equality of status and of opportunity and for the promotion of fraternity. To safeguard the interests of the disadvantaged sections of the

Society, the Constitution of India guarantees that no person will be denied `equality' before the law (Human Rights Watch (March, 2002).

The Persons with Disabilities (PWD) Equal Opportunities, Protection of Rights and full Participation Act, 1995, which came into enforcement on February 7, 1996, ensures equal opportunities for the people with disabilities and their full participation in the nation building. The Act provides for both the preventive and promotional aspects of rehabilitation like education, employment and vocational training, reservation, research and manpower development, creation of barrier-free environment, rehabilitation of persons with disability, unemployment allowance for the disabled, special insurance scheme for the disabled employees and establishment of homes for persons with severe disability etc.

The National Trust for Welfare of Person with Autism, Cerebral Palsy, Mental Retardation and Multiple Disabilities Act, 1999 has set the following objectives towards the welfare of this section of population such as,

- Enable and empower persons with autism, cerebral palsy, mental retardation and multiple disabilities to live as independently and as close as possible to the community to which they belong.
- Provide support to the persons with disability so that they may be able to live with their families.
- Extend support to the registered organizations so as to enable them provide need based services during the period of crisis deal with the problems of persons with such kind of disability that lack a family support.
- Promote measures for the care and protection of such disabled persons in the event of a death of their parent or guardian.

- Evolve procedures for the appointment of guardians and trustees for persons with disability requiring such protection.
- Facilitate the realization of equal opportunities, protection of rights and fullest social participation by such disabled persons.

Information on the current living arrangements of the disabled persons reveals that about 3% disabled persons were living alone and 6-7% were staying with relations or non-relations. Only 5.5% disabled people were staying only with spouses and another 32% were staying together with spouses and others. Significantly nearly 38-40%-disabled persons were staying with parents without spouses. Hence these disabled persons are vulnerable to exploitation or are left to themselves at the mercy of community after the death of their parents. This information demonstrates immediate need of rehabilitation homes for the disabled persons with support from government or civil society organizations. (Zutshi, 2004)

World Program of Action Concerning Disabled Persons (United Nations document, 2003) stated that Persons with disabilities often are excluded from the mainstream of the society and denied their human rights. Discrimination against persons with disabilities has a long history and takes various forms. They range from invidious discrimination, such as the denial of educational opportunities, to more subtle forms of discrimination, such as segregation and isolation because of the imposition of physical and social barriers. Effects of disability-based discrimination have been particularly severe in fields such as education, employment, housing, transport, cultural life and access to public places and services. This may result from distinction, exclusion, restriction or preference, or denial of reasonable accommodation on the basis of disablement, which effectively nullifies or impairs the recognition, enjoyment or exercise of the rights

of persons with disabilities. Appropriate measures are required to address existing discrimination and to promote thereby opportunities for persons with disabilities to participate on the basis of equality in social life and development.

2.2 Importance of Barrier Free Design

Everyone in this world has something to contribute for the growth of our country, however the general feeling is, people from the vulnerable groups are not considered to be productive citizens and hence most often there are either no provisions or investments made to ensure access. (Mahesh 2007).

A barrier free design is one that contains no obstacles to accessibility and usability by disabled people. Its standards should satisfy anyone who is hampered in his mobility of functioning (as compared with a non disabled person) as a result of obstacles put in his way by the design of a building, the choice of hardware and equipment, and the arrangement of outside space. (Swaroop, 2000)

There are many products that are essential for facilitating independence. These include domestic appliances; food and household provisions; clothing; communication devices; forms and bank statements etc.; and lighting. All these products, and many others, are an integral aspect of life for the whole population. However, most are designed and marketed with only the able-bodied user in mind. In an attempt to encourage product developers to consider the wider population the inclusive design cube was conceived

The inclusive design cube (Keats and Clarkson, 2005) highlights the different design approaches which can be used to develop products appropriate for a given range of capabilities (Figure 2.2) and has the following characteristics:

- The volume of the cube, or a part of the cube, represents the whole or a part of a population;
- The axes of the cube currently represent motion, sensory and cognitive capabilities with one apex of the cube representing a fully capable individual;
- The individual parts of the cube represent the populations which may be served by a particular design approach.

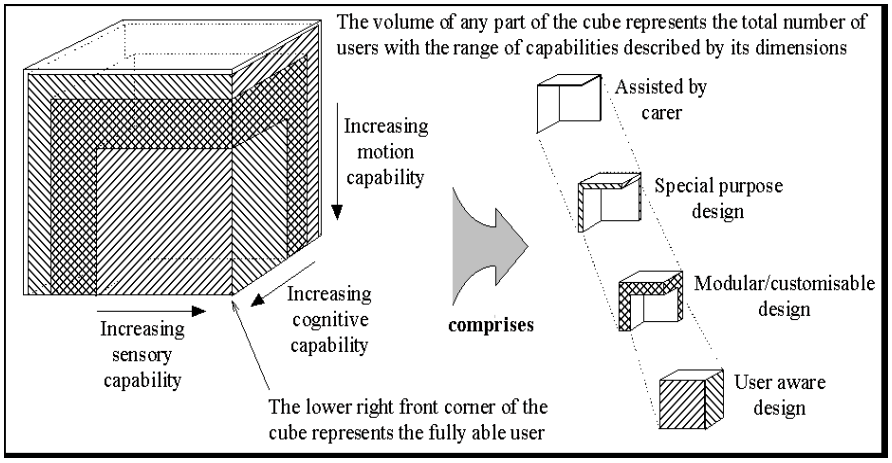


Fig. 2.2 The inclusive design cube

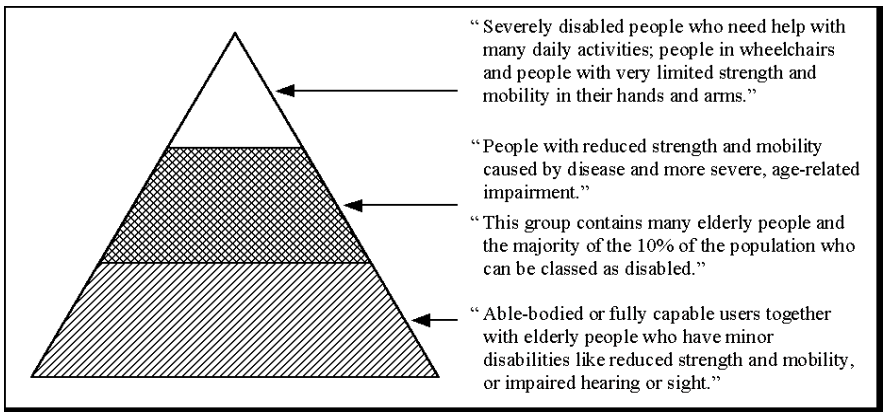


Fig. 2.3 The user pyramid

The cube in its current form has qualitative axes ranging from full capability to no capability. The motion axis represents such factors as strength and co-ordination capability; the sensory axis covers audio and visual capability; while the cognitive axis recognizes the range of intellectual capability. At the low capability end of each scale, it is likely that many of the needs of daily living will be met by caretaker. As capability increases, special purpose design will provide products to suit specific needs, for example wheelchairs, walking frames, hearing aids and spectacles where such products are not intended for general use by the whole population. Modular or customizable design allows for variations in product user interfaces to accommodate a wider range of abilities than a standard interface. Finally, user aware design is intended to result in products which appeal to as wide a range of capability as possible. The cube is essentially an extension of the user pyramid proposed by Benktzon and shown in Figure 2.3.

During the past 20 years, considerable advances have been made in the fields of designing for the disabled or older user, with different approaches reflecting local cultural, political and historical situations. In the USA, the concept of ‘Barrier-Free’ design was developed in response to the demands of the disability movement. This led to Section 504 of the Rehabilitation Act (1973), prohibiting discrimination against people with disabilities; The Fair Housing Amendments Act (1988); and the Americans with Disabilities Act (1990), assert the individual’s right to use products and services on an equal access basis.

Chapter VII of the "Persons with Disabilities (Equal Opportunities, Protection of Rights and Full Participation) Act, 1995,India, Sections 44 to 46 deal with non-discrimination in transport on the roads and in the built environment. It enjoins upon the governments and local authorities to ensure

within their economic capacity provision for installation of auditory signals at red lights in the public roads for the benefit of persons with visual handicaps, curbs and slopes to be made in pavements for the easy access of wheel chair users, devising appropriate symbols of disability as warning signals at appropriate places.

Hobson, and Molenbroek, (1992) studied on Anthropometry and Design for the Disabled: Experiences with Seating Design for the Cerebral Palsy Population. Ninety-four variables were obtained from each subject in a sample of 133 cerebral palsied individuals. Both qualitative and quantitative factors were assessed and measured. The study emphasized on the anthropometric needs of individuals with disabilities which are different from individuals without disabilities. It also aimed to develop an anthropometric data resource that can be used in the design of seating and mobility devices for a population with a specific disability.

Bernardi, et.al, (1995) studied on Ergonomics of Paraplegic Patients Working with a Reciprocating Gait Orthosis. The aim of the study was to evaluate the energy demand (O2), and cardiopulmonary load (HR and E) imposed on the subject by different working tasks while sitting in a wheelchair, and standing with the aid of an RGO. Subjects without disabilities were used as controls. The use of RGO produced a dramatic improvement in subjects' mobility and reach space in the workplace. The energy demand and the cardio respiratory load imposed on the subjects using the RGO did not differ from those observed while sitting in a wheelchair. Nor did they differed from those observed in the controls. The energy demand slightly exceeded the values typical of light work and was, thus, compatible with the duration of a normal working day.

Becker, and Thakor, (1994) studied on the Range of Motion of Human Fingers with Application to Anthropomorphic Designs .The human hand serves as a model for anthropomorphic manipulators and prosthetic devices. In order to better guide the design of these devices, a study of the range of motion of human fingers was taken up. The role of tendons in the actions of human fingers is modeled and is experimented on the range of motion of fully functioning fingers. Further study of persons with hand disabilities reveals constraints imposed by deficient tendon mechanisms. The basic investigation of persons with and without hand disabilities guides the design of tendon-based actuators for mechanized fingers.

Petzall, (1995) studied the Design of Entrances of Taxis for Elderly and Disabled Passengers. This study aimed at determining suitable dimensions for the entrances of cars used in taxi service for people with disabilities. Eleven ambulant people with disabilities and six wheelchair users participated in the trials. Travelers with disabilities have found it difficult to enter and leave homes due to the narrow doorways. In the study the subjects got into and out of a mock-up homes whose entrance could be altered by changes to the width and height of the doorway, the height of the sill, and the angle to which the door opens. Results showed that, in large part, more or less the same entrance dimensions are required both by people confined to wheelchairs and ambulant people with disabilities.

Hobson. et.al (1997) studied on Anthropometric Data for Design of Specialized Seating and Mobility Devices. The data collected have been analyzed for 12 variables considered to be of immediate interest. The study described the importance of obtaining critical anthropometric data that can be used by designers for improving the quality of body support in wheelchairs and

other mobility devices for people with disabilities. This has been made necessary because existing data from the non-disabled population is often inappropriate for designing for people with disabilities.

Goldsmith,.et.al. (1992) studied on the designing a Public Convenience for the Disabled .In this study five separate designs for lavatory compartments were studied through practical tests with 28 patients. The suitability of shape and size of the cubicle, door fittings, sanitary fittings, and grab rails were analyzed. Two possible designs were presented as a basis for further trials. The authors stressed the importance of accessibility of public conveniences in all buildings likely to be used by people with disabilities.

According to Albrecht and Selman (2003), an individual with limited mobility could be at a great disadvantage in any society yet if that same person lived in a society with advanced services, supports and technology, he/she might encounter only few challenges. The individual's disability can substantially impede the ability to live independently in conventional housing. More suitable housing conditions with inclusions of barrier free designs can enhance the individual's possibilities for living more independently.

2.3 Need for barrier free residential buildings

A home is more than a building: it is a state of mind, an expression of personality, the one place where it is possible simply to be. If a house is inadequate for the needs of the people living in it, it never quite becomes a home (Dragonfly, 2007). Understanding the needs of special and vulnerable populations requires commitment on the part of officials and planners, advocacy groups and relevant agencies. This is particularly significant, given findings that disabled people's self-respect and feelings of independence can be significantly improved by a

feeling that they are in control of their home and housework (Lund and Foord, 1999; Quilgars, 2000).

The concept of designing barrier free residence for physically challenged first appeared in Northern European countries. The United States began to explore this concept as part of continuing care for special need communities in the early 1980s. However, midway through the decade barrier free residential facilities were also being developed as freestanding residences (Frank, 2002). Accessibility is a general concern, an economic good or attribute that most households value, irrespective of the physical conditions of their members.

Christophersen (2006) studied on whether universal design of new dwellings in the ordinary housing stock can accommodate the extensive requirements that homes for people with severe disabilities have to meet. Four case studies were used to illustrate the range of needs and ways to provide for them. One was a small child born with extensive brain damage. The other three were accident victims. Among the three, two of them had brain injuries affecting both motor and cognitive functions, while the third suffered a broken neck causing extensive paralysis. All four had considerable needs for assistance due to mobility problems, cognitive difficulties or both, and needed homes that were specially adapted to their needs. The study confirmed that necessary adaptation and extensions in construction works were essential in the new construction.

Fernando (2002) studied the benefits of a barrier-free building: a contingent valuation of accessibility as an attribute of housing. This study focuses on the social benefits of barrier-free building which has always required indirect solutions, such as calculating the savings in social services, hospitalization or adaptations made possible by the increase in accessibility.

This research uses the Contingent Valuation Method to gain a direct appraisal of the benefits from barrier-free housing. When comparing two similar dwellings, with the only difference being their accessibility conditions, the 1,007 randomly chosen households that answered the direct survey would pay, on average 12.5 per cent more for being barrier-free. None of the different appraisals made on accessibility costs reaches 5 per cent. This confirms the social profitability of building without barriers and shows the potential size of the private market for those housing developers that meet the demand.

Malassigne, (1991-1992) studied on the Design of Bathroom Fixtures and Controls for the Able-Bodied and Disabled. The research has illustrated the serious lack of data concerning body dimensions and reach characteristics of the population with disabilities. Such a lack of pertinent data indicated the need for a limited anthropometric study of certain body measurements of people with as many types of disabilities as necessary to project the range of the disability. The study sought to do the following: (1) document body sizes and reach capabilities of the whole population with disabilities, illustrating the range of dimensions by percentile; (2) show specific disabilities of the whole population and the range of dimensions by percentile; (3) determine the existence and extent of any deviation present when the anthropometry of the population with disabilities is compared with identical measurement data from the population without disabilities; and (4) provide designers with information that would assist in sizing bathroom fixtures and seating areas, and locating controls, accessories, and grab surfaces. Twenty-one female and 61 male students from the Woodrow Wilson Rehabilitation Center participated in the study. Eighty-two types of disabilities were represented in the sample. The results indicated that differences in body measurements between people with and without disabilities appear to

exist; however, future research should increase the number of people with disabilities in the sample and include disabilities not represented in the first study.

Fox, (1995) conducted research on Environmental Modifications in the Homes of Elderly Canadians with Disabilities. This study was performed to (1) determine whether the use of architectural modifications in the homes of the elderly with disabilities can reduce the level of disability, (2) estimate the degree of need for environmental modifications, and (3) determine the predictors of the use of architectural modifications. The degree of need was estimated using data from 8,895 respondents (55 years and older) from the Canadian Health and Disability Survey (1983-84). A subgroup of 1,520 respondents who needed architectural modifications was selected to determine the need for architectural modifications and the extent to which those needs are being met. These data were analyzed using multiple linear regressions. Approximately 37.9% of the elderly with disabilities required at least one modification of their homes. About 40% did not have the architectural modification that was needed. Income was found to be a predictor of the use of architectural modifications. Users of architectural modifications were more independent in performing instrumental activities of daily living than non-users. The author concluded that there was a substantial need for environmental modifications in the homes of the elderly with disabilities. Furthermore, architectural modifications should be made available at a low cost.

2.4. Specific design needs of wheelchair users in residential buildings

It is not uncommon for able bodied people to underestimate challenges that wheelchair users face when accessing private and public areas. They take accessibility for granted, so much so that they may not even be aware of the difficulties that their fellow countrymen in wheelchair face when commuting between two places. An accessible built environment is a core element for the realization of a society based on equal rights.

Wheelchairs are basically means of movement for persons with physical disabilities. As a result of the aging of society in recent years and the development of the infrastructure, social and psychological barriers faced by the disabled are being eroded, people are increasingly willing to go out by wheelchair, and the number of wheelchair users is growing (Wheelchairs, 2000). The various kinds of wheelchairs available can be broadly classified into two types: hand-powered or manual wheelchairs, and electrically powered wheelchairs. Manual wheelchairs include wheelchairs pushed by hand (with the help of an assistant), travel (front-wheel drive) chairs, standard (rear-wheel drive) chairs, chairs operated one-handed, chairs operated using one leg, wheelchairs pedaled one-handed, three-wheeled chairs, standing-up chairs, seat lifting chairs, and highly-maneuverable chairs designed especially for use in sports such as basketball and marathons. The most common types of wheelchair are self propelled as powered wheelchairs cost much more. The user pushes the wheelchair forward by turning on the outer rims of the wheels. To make turns, the user simply has to control the direction and speed of both wheels to make the desirable maneuver.

Sanford, et.al. (1996) studied on Accessibility Requirements for Ramp Slope. This study aimed at evaluating the usability of the range of ramp slopes allowed under the current ADA accessibility guidelines. One hundred seventy-one subjects of all ages, using different types of mobility aids, traversed a 30-foot ramp varying in slope from 1:8 to 1:20. Data were recorded for pulse rate, energy expenditure, and rate of travel, distance traveled, and the location of rest stops. Findings showed that only a few manual wheelchair users had difficulty traversing all 30 feet in ascent, even on slopes as steep as 1:8.

Sweeney et.al (1999) studied on portable ramps for wheelchair users. This paper described a study on establishing values for gradients which could be achieved by wheelchair users, while using two different lengths of otherwise identical portable ramps. Sixty subjects each tested gradients between 1:14 and 1:6 on portable ramps of 1 meter and 1.8 meters in length. The results demonstrated that the majority of attendant-propelled, self-propelling, and powered wheelchair users could negotiate gradients of 1:8 and 1:6.

Das and Kozey, (1994) studied on Structural Anthropometry for Wheelchair Mobile Adults. The purpose of this study was to develop a reliable and accurate anthropometric database of paraplegic adults in wheelchairs. Data were collected on 42 males and 20 females. The dimensions recorded indicate that designs based on individuals without disabilities would not be suitable for this population. Data collected included seated stature; eye, shoulder, forearm, knee, toe, and maximum reach height; overhead, normal, and maximal reach; radial and overall arm length; trunk depth, and bi-deltoid and acromion width.

Floyd, et.al. (1996) studied on the Space Requirements of Wheelchair Users. In this study ninety-one male and 36 female paraplegic and tetraplegic

patients at the National Spinal Injuries Centre, Stoke Mandeville, England, were the subjects of a study to determine the body dimensions and space requirements of wheelchair users with spinal cord lesions. Apparatus was designed to measure nine anthropometric body dimensions, including head, eye, shoulder, and elbow heights; shoulder and thigh widths; and lower leg length. Measurements were taken with the subjects sitting upright in their usual chairs and relevant details of age, time spent in chair, level of spinal cord lesion, whether complete or incomplete, and the type of wheelchair used were recorded. In making measurements of reaching distances for 76 male and 26 female paraplegic subjects with full use of their arms, the aim was to determine the boundaries of a three-dimensional shell which would outline the space in which wheelchair users could manipulate objects and use equipment around them. Comfortable and maximum reaching distances in various directions were measured and a total of 35 reaching measurements for each subject was recorded. The data obtained were analyzed by computer to derive means, standard deviations, and 5th and 95th percentile values for males and females.

Jarosz, (1996) studied on determination of the Workspace of Wheelchair Users. In this a sample of 101 men and 69 women with impairments in the lower extremities requiring the use of a wheelchair were tested. Eighteen anthropometric dimensions were measured in the sitting position. The results of the study constitute a set of basic anthropometric data for the design of workstations and home interiors for this group of users. These data can also be used by wheelchair designers. The graphic method used for determining maximum extremity reaches showed that the workspace accessible to this population was smaller than that available to the population without disabilities.

Young-Jun et.al (2000) conducted a study on Development of Kitchen Models for Wheelchair Users, Yongin Songdam College Department of Industrial Design. This study revealed that many wheelchair users in Korea remodeled their kitchens to solve the inconvenience of using their kitchens; most of them are not satisfied with the results. In relation to this, some people complained about the difficulty in finding proper materials when remodeling kitchens and pointed out that some kitchen elements, remodeled using foreign materials, did not meet the conditions of Korea. Also some wheelchair users said that their family members even felt inconvenienced when using kitchens after remodeling them, while they felt the kitchens became a little more convenient.

Berg (2001) worked on the research entitled “wheelchair users at Home: Few Home Modifications and many injurious falls” to describe the prevalence of specific structural modifications in the homes of wheelchair users in the community and to examine the relationship between home modifications and the occurrence of injurious falls. In total, 525 respondents met the study selection criteria of being 18 years and older. The prevalence of 5 structural modifications was relatively low. Only 4% had all 5 accessibility features and 36.4% had none. A higher percentage of the injured fallers (47.7% vs 34.0%) reported that none of the modifications were examined here. Overall, 37.9% of wheelchair users fell at least once in the past 12 months, and 17.7% suffered a fall-related injury (46.7% of fallers). The study is an important step in highlighting access and safety problems in the homes of wheelchair users. Home environments that facilitate independence and that make it easier to move around should be considered a basic need for disabled persons.

Steinfeld, Schroeder and Bishop, (1999) studied on accessible Buildings for People with Walking and Reaching Limitations. The study reported data on the following topics: eye level and reach limits for ambulant, semi ambulant, and wheelchair bound persons; wheelchair maneuverability; maximum travel distance for people with limitations of stamina; push- pull forces against windows and doors; ramps (maximum slopes); toilet stalls (dimensions, use of grab bars, need for seat); showers (dimension of shower stalls, usability of wheel-in showers and those with a curb); bathroom layouts; kitchen layouts (dimensions, heights of shelves and work surfaces); doorways; elevators (size, location of control panels, timing of elevator doors); public telephones, and public mailboxes.

All areas of newly designed or newly constructed buildings and facilities and altered portions of existing buildings and facilities shall comply with a minimum of accessibility requirements of wheelchair users.

2.5. Recommended standards and guidelines for barrier free Residential buildings for wheel chair users

The Building Standards and Regulations control accessibility to the built environment. The aims of the regulations are to ensure 'that as far as possible reasonable and practicable, buildings should be used by people with disabilities' (O'Herlihy 2004; NDA 2004). The Regulations are set out as a series of requirements each addressing an aspect of design, construction or building alterations. Regulations focus on access for people with disabilities. The goal of barrier free design is that a building plan should be comprehensive and functional for individuals who use the space, e.g., the young, elderly, individuals with permanent and temporary loco motor disabilities. Efforts to address the

restricting effect of an inaccessible environment have taken place both at national and international level.

There is an absence of a singular and well-defined regulation, which makes it mandatory for all buildings, whether public or private, to be completely accessible to people with disabilities. The onus, therefore, falls on various construction companies and real estate developers to ensure their buildings incorporate the principles of universal design. While the phrase ‘within the limits of their economic capacity’ can, on occasion, throw a spanner in the works, the Act has been effective over all, says the Deputy Commissioner for Persons with Disability, Dhariyal (2000).

The advent of Universal Design approaches (Preiser, 2001) had a major impact on the planning for accessible housing. There is a ‘quest’ to design a mainstream house type, which will meet the needs of all users. This quest has proved to be elusive. The advent of adaptable homes has been heralded as a move in this strategic direction, in that the design features either reduce the need for, or ensure more cost effective adaptations when needed. Blythe et al, 2002 reported on the research to evaluate Adaptable Homes and the study showed that adaptable homes cannot always be adapted cost effectively for assisted wheelchair users. Adaptable homes have the potential to meet the needs of short-term wheelchair users or people who use wheelchairs for outdoor mobility only. However, Adaptable Homes have real limitations in meeting the needs of everyday wheelchair users particularly those who require personal care and equipment.

2.5.1 Anthropometry of Wheelchair Users

Anthropometry is the branch of ergonomics that deals with body shape and size. People come in all shapes and sizes so you need to take these physical characteristics into account whenever you design anything that someone will use.

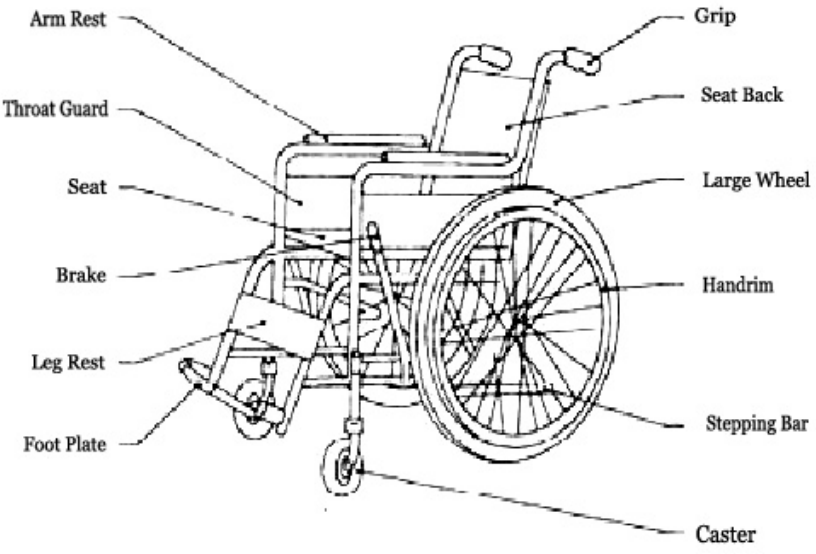
Anthropometry is the study of the dimensions and abilities of the human body. Static anthropometry is the measurement of body sizes at rest and functional anthropometry is the measurement of abilities related to completing tasks. In the case of wheeled mobility, static anthropometry includes measurement of people and their devices. Functional anthropometry includes measurement of reaching abilities, maneuvering and other aspects of space and equipment use from a wheeled mobility device (IDEA Centre, 1999).

Goswami,(1997) studied on Anthropometry of People with Disability which included body size variables as well as strength, reach, and mass measurements. A consensus finding among the studies is that body dimensions of persons with disabilities are smaller than those of persons without disabilities except for dimensions of the shoulder region.

In a recently published review of the anthropometry of people with disabilities (Kumar, 1997), Goswami(1998) examined six international studies of people with lower limb disorders and discovered that, for a combined total of 58 body size descriptors measured in the studies, not a single dimension was found in common. However, lack of anthropometric information about many disability groups severely limits the design of environments and products that are usable by as many as possible (Steinfeld and Paquet, 2004).

For the people using wheelchairs the dimensions and characteristics of these are essential for making the environment barrier free (Mahesh, 2007). The length of conventional wheelchairs is 1.1–1.25 m, width of 0.6–0.7m and the height of 0.9 -1.1m. The maneuvering space needed for wheelchair turning is a circle of 1.5 m diameter as shown in .The reach of persons in a wheelchair is restricted to a zone less than 0.400 m from room corners and between 0.7 and 1.2 m above the floor. These measurements are based on a wheelchair design widely used by those who can afford it. Simpler designs are however frequently used in some countries (Tenebaum, 2007). A common model has small wheels and is a rudimentary rolling board. Maneuvering space requirements will be same or even less. However, the height of reach is 0.3–0.4m less than the conventional wheelchairs. To suit all kinds of wheelchairs-switches and other implements should thus be placed at a height of 0.9 m and at least 0.4 mm from inside corners (Lars, 1994)

Fig. 2.4 Details of a wheelchair



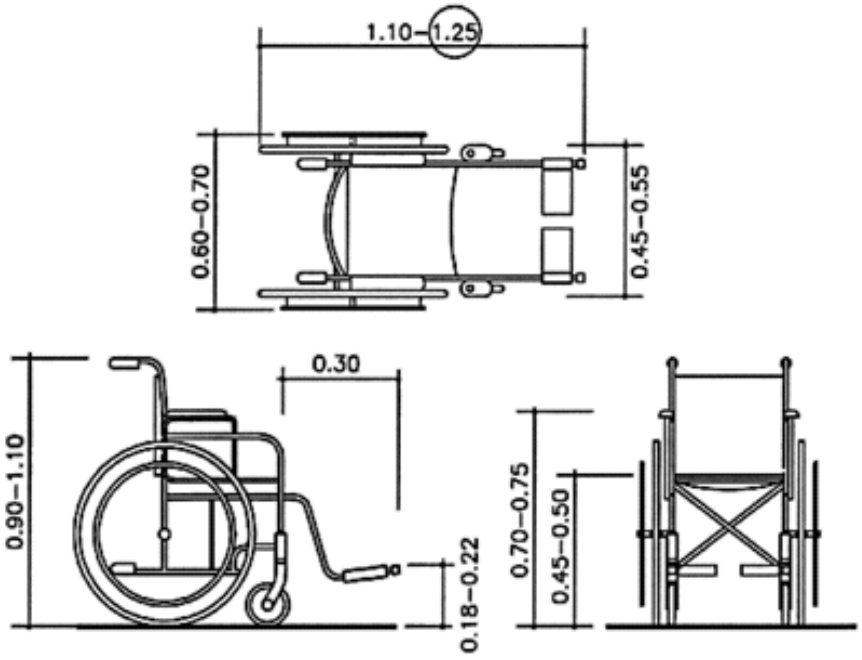


Fig 2.5 Details of a wheelchair parts and dimensions

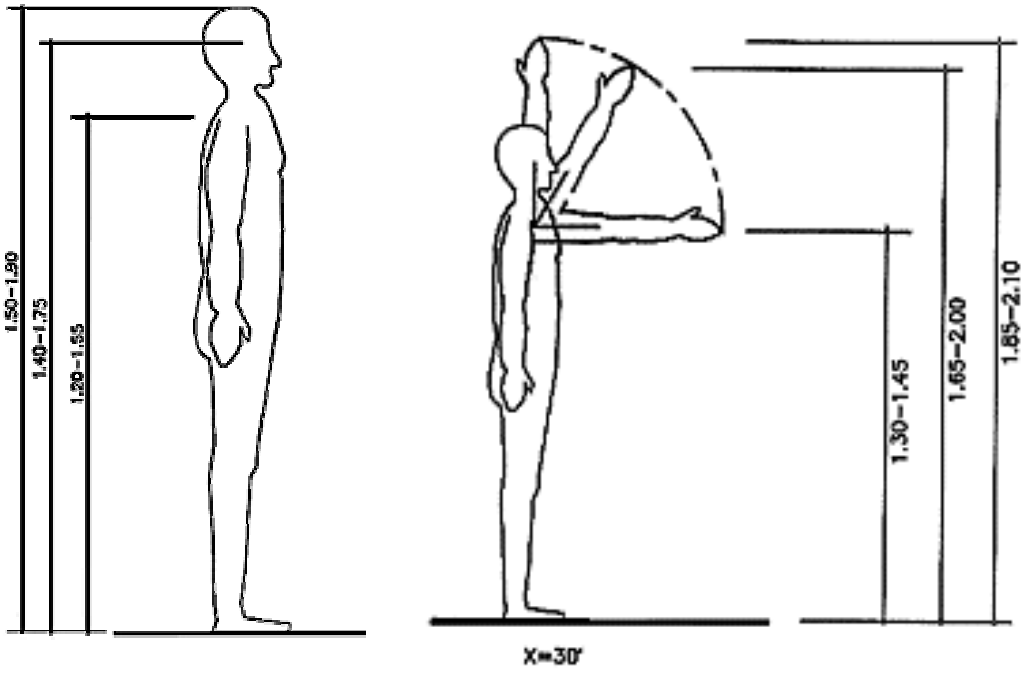


Fig 2.6 Dimensional data and Vertical reaching zones of Normal Person

As per the national statistics on disability there are 8 million potential wheelchair users in India (National Sample Survey Report 2002). Dimensional data varies from one person to another, and the average dimensions vary from one country to another. The dimensions of the individual human being vary with age, gender. The given measurements take into consideration the size variation between males and females as well as between different persons of the same gender. (Mona 2000), Cannale et.al. (1999) , Cappozo et.al. (2001) Dimensional data and vertical reaching zones of normal person shown in Fig 2.2 is the height 1.50 m - 1.90 m from floor level, height of the eye1.40 m - 1.75 m from floor level, height of the shoulder1.20 m - 1.55 m from floor level. And also maximum reach Up1.85 m - 2.10 m, oblique reach Up1.65 m - 2.00 m, onward reach1.30 m - 1.45 m and .The dimensional data of a wheelchair user is shown in fig.2.2. Vertical and Horizontal reaching zones of a wheelchair user is shown in fig 2.3 and fig 2.4 are the height 1.25 m - 1.45m from floor level, height of the eye1.16 m - 1.33 m from floor level, height of the shoulder 1.99 m - 1.14 m from floor level, And also maximum reach Up1.47 m – 1.79m, oblique reach Up1.28 m – 1.49 m, forward reach 0.99m -1.08 m.

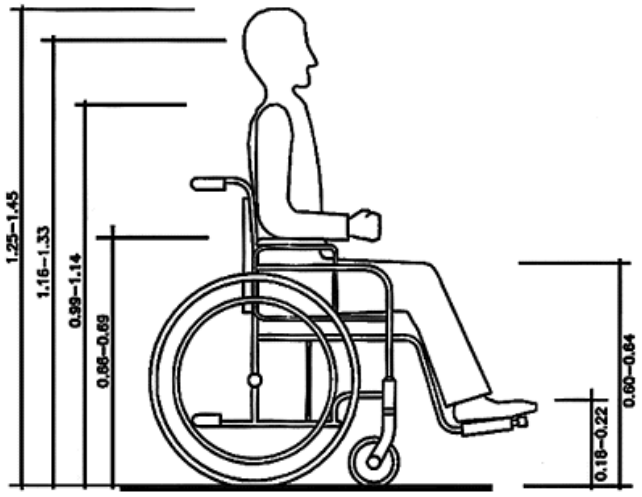


Fig2.7 Dimensional data of a wheelchair user

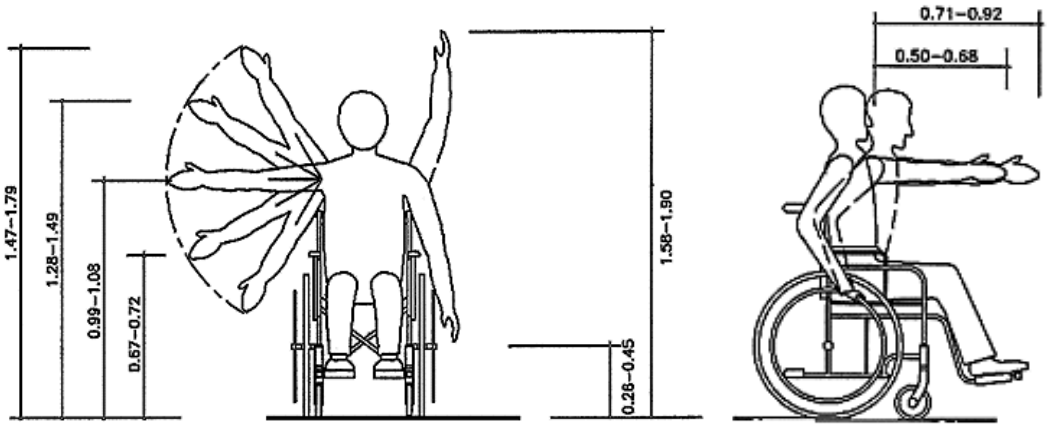


Fig 2.8 Vertical and horizontal reaching zones of a wheelchair user

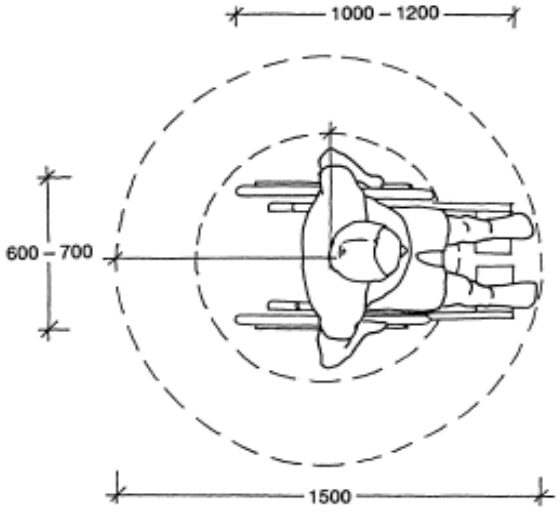


Fig 2.9 Space allowance needed for maneuvering a wheelchair

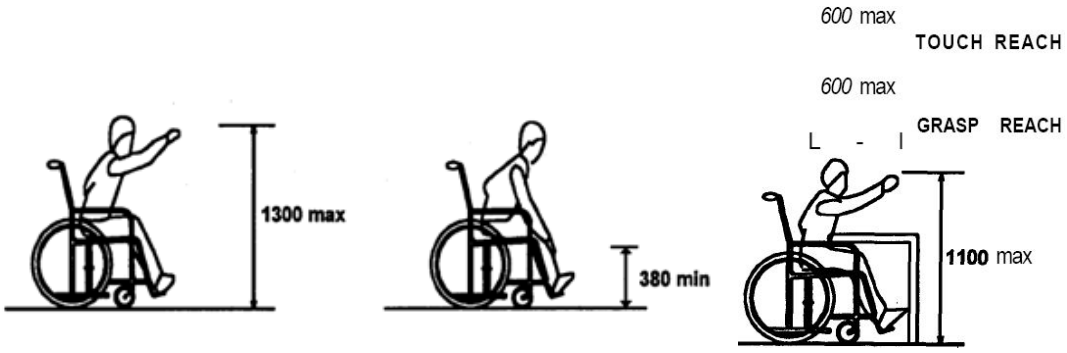


Fig.2.10 forward reach without obstruction and over obstruction

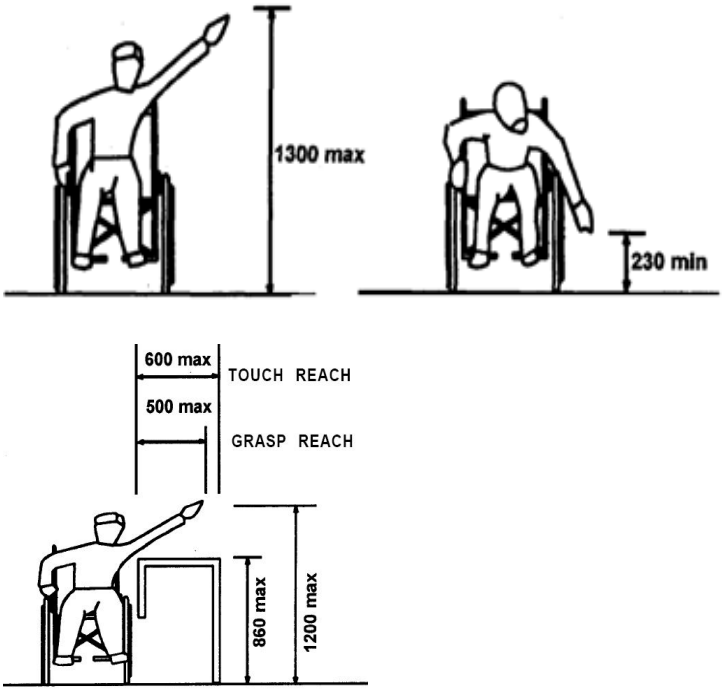


Fig. 2.11 Side reaches without obstruction and over obstruction

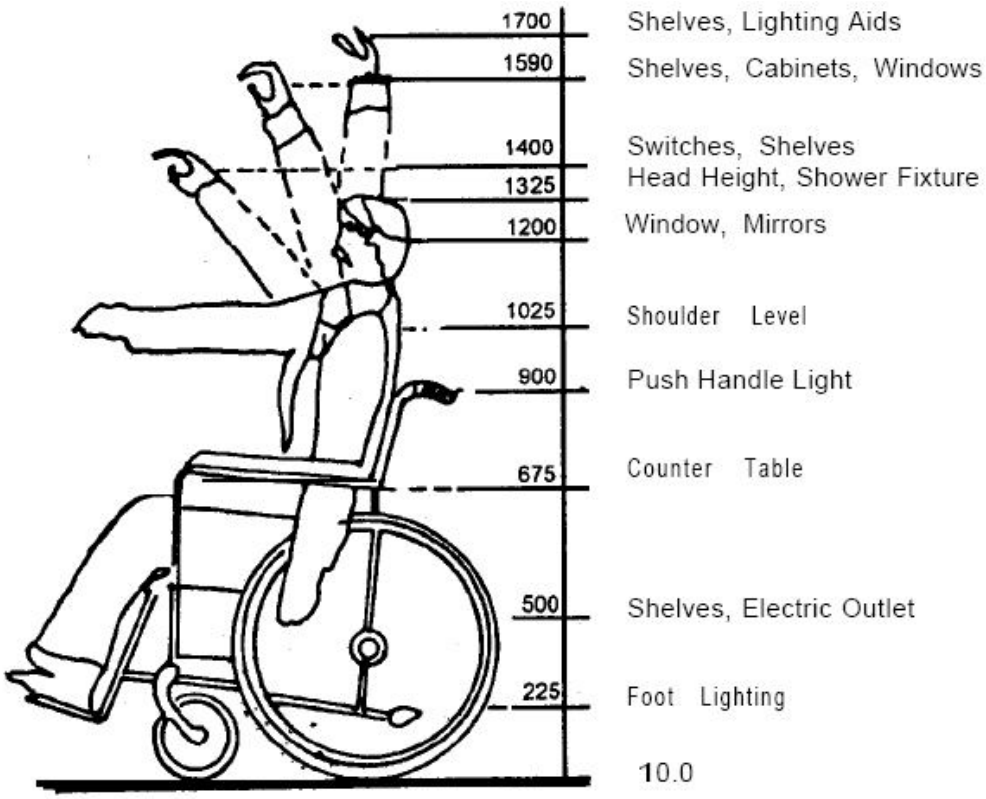


Fig.2.12 Typical Dimensions for Essential uses with in easy reach.

2.5.2 Architectural Design Considerations

The design for people with moving disabilities is related to making the environment accessible to the people confined to wheelchairs. Design and Construction Guidelines and Standards reveal that Builders, designers and architects are ultimately the users of this standard. This ensures that the specific environments created by them are suitable for all categories of people. The standards also indicated that barrier free design can be achieved without economic burden to the client, builder, designer, and the architect. It will help to provide framework for developing policies to ensure a barrier free environment and eliminate the lack of awareness in both the public and private sectors with regard to the problem of accessibility. These standards can be a valuable document to exchange comments between disabled consumers architects and others interested in an environment which does not exclude disabled people. This can also generate research activities to provide required knowledge base.

This section deals with the design requirements of vertical and horizontal access in both new and existing constructions. It is subdivided into the following subheadings:

2.5.2.1. Approach from Home (Exterior to Interior)

The design of the exterior as well as the approach to the entrance door determines those people who will and will not be able to enter the home. The wheelchair body itself is about 650 mm wide Allowing for the use of hands and arms outside the wheelchair, the passage must be as wide as 900 mm or more. Locations such as entrances and exists can be 900 mm wide. However, a continuous passage (e.g. a corridor) must at least be 900 mm wide to allow for

slight side-to-side movement of the wheelchair as it travels. At this width, however, it is difficult to turn a wheelchair.

A doorway that provides a clear opening of less than 32 inches, for example, denies entry to most people who use a wheelchair and may be difficult to maneuver for people using canes and walkers. A narrow doorway may also impede the passage of large furniture and other household items into and out of the home.

Table 2.1 Design guidelines for Approach to Home from Entrance gate

Architectural System Component	Citation	Design Guideline/Recommendation
Driveway/Parking	NBO,(1997),(2000) on Disabled: Government of India (GOI) HUD (1996)	- Shelter parking from rain, - Grades ≤ 1:20 - Avoid changes in level (steps) where possible - Provide an access aisle
Electrical Receptacles Hose Connection	NBO,(1997),(2000) on Disabled: GOI	- 18-21" above ground - 2-4' above ground
Entrance	HUD,(1996) NBO,(1997), (2000)	- Door threshold ≤ 0.5" - "good overall lighting" for security - Provide package shelf near door (latch side) Shelter entrance from the elements - Provide easy to see, lighted doorbell - Construct/raise porch to be level with interior floor surfaces - Provide focused lighting at door handle and lockset
Ramps (Exterior)	NBO,(1997) (2000) on Disabled: Government of India	- Color contrast at changes in level - Lighting ≥ 50 lux at floor level and 300 lux at top and bottom of ramp - Slope ≤ 1:20 (unless impractical, never > 1:12) - Slip-resistant surface - Rise ≤ 30" (at 1:12 slope) - Length ≤ 30' (slope > 1:20) - Width ≥ 3' (for 1 wheelchair) - Width ≥ 5'4" (for 2 wheelchairs) - Cross slope ≤ 1:50 - Handrails for ramps > 1:16 (and conform to building code) - Handrails extend 1' beyond top and bottom of ramp
Walkways	NBO,(1997) (2000) on Disabled: Government of India. CPWD,(2006)	- Surfaces firm, even and slip-resistant - Pathways 5' wide - Site grades (used by pedestrians) ≤ 1:20 - Site grades in pedestrian routes ≤ 1:12 - Lighting ≥ 50 lux - Hand rails shall be provided for ramps/slope ways - Lighting ≥ 300 lux on all changes in level

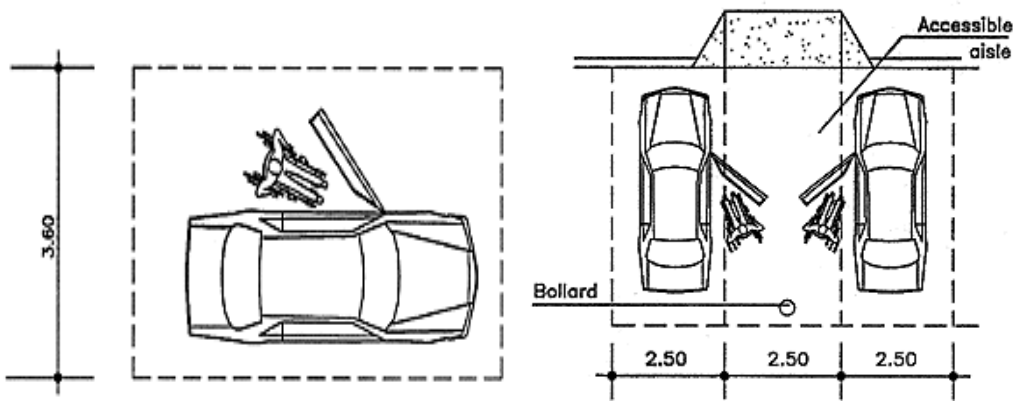


Fig 2.13 Width of accessible parking

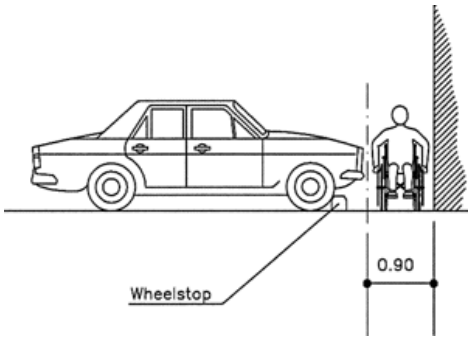


Fig 2.14 Pre-cast wheel stops used to set apart a passage pathways

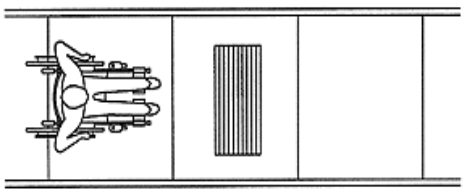


Fig 2.15 Grating on pathway

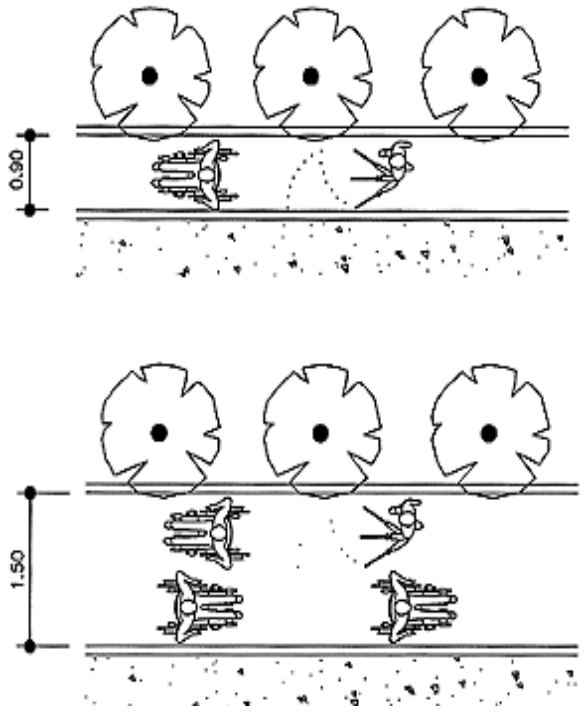


Fig2.16 Width of the pathway

Guidelines For Building Entrance

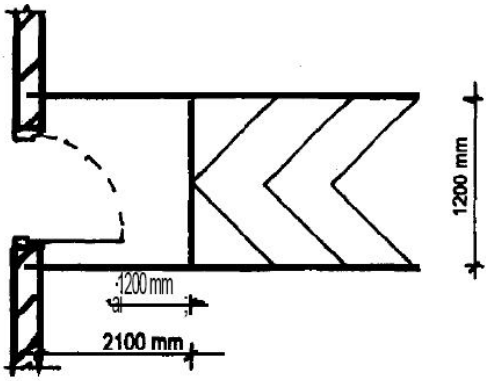


Fig 2.17 Entrance Door with walkway

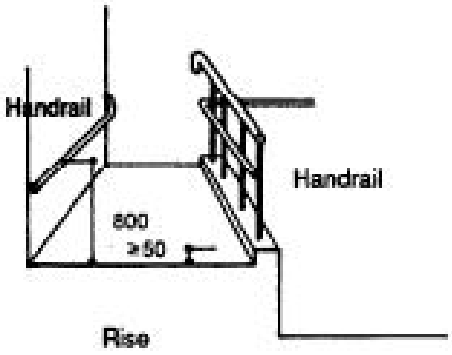


Fig2.18 Corridor connecting the Entrance/exit for the handicapped

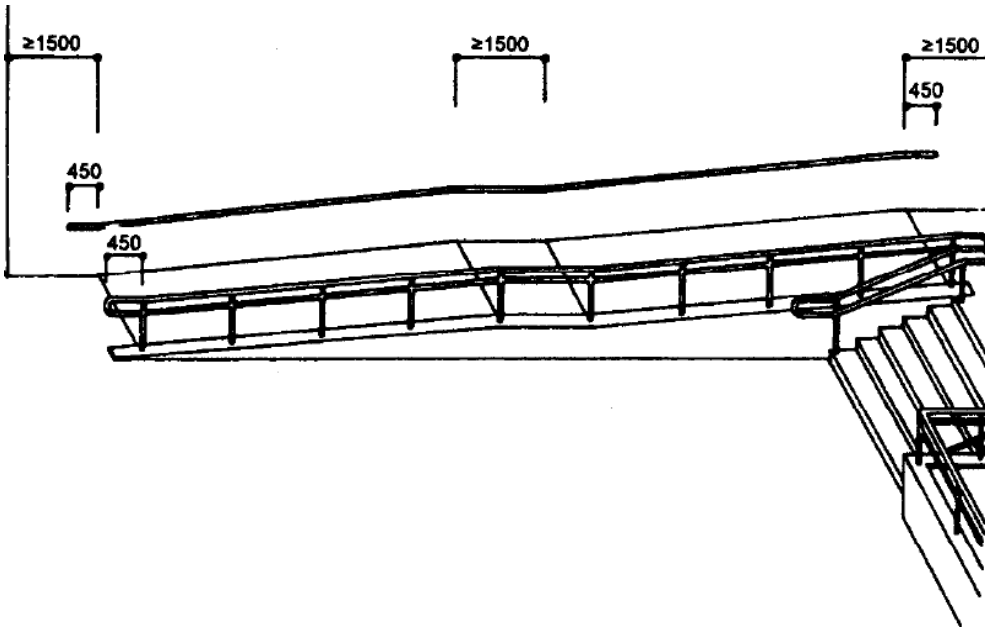
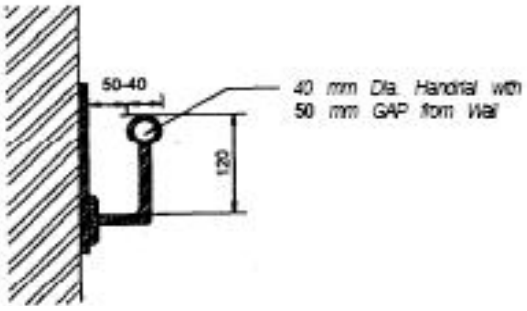


Fig. 2.19 Dimension details of ramp



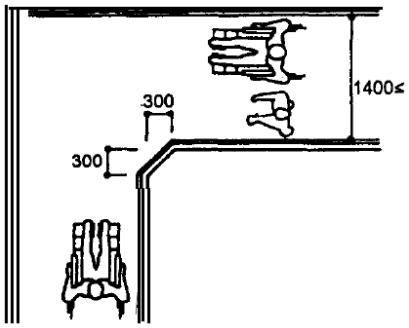


Fig 2.20 Fixing detail of handrail to the wall. Fig2.21 Passage and corner section

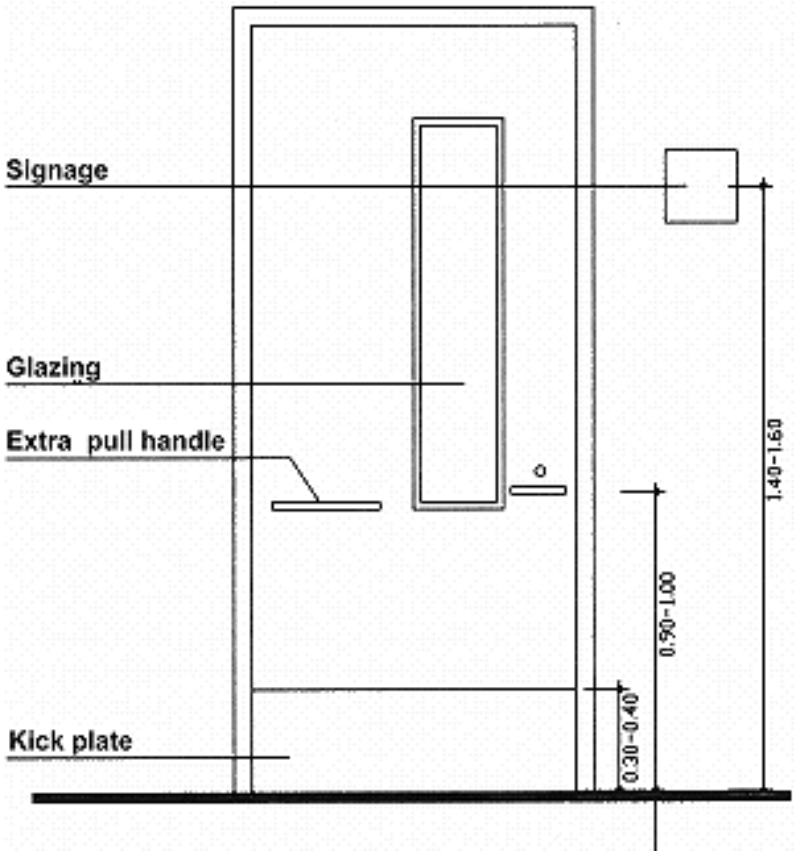
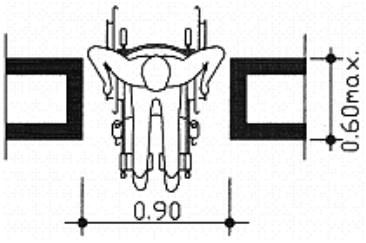
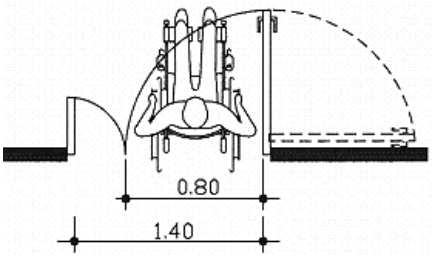


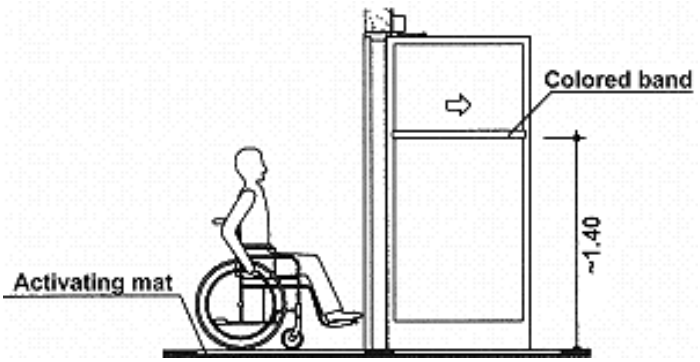
Fig2. 22 Door opening: Location of different feature in door



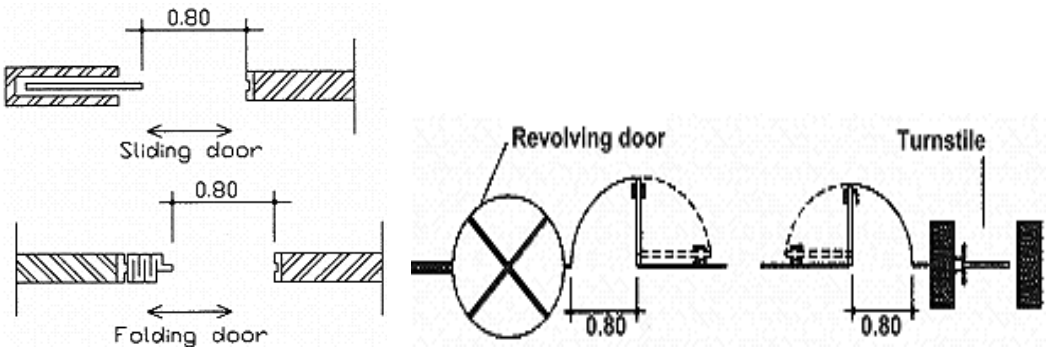
Door opening



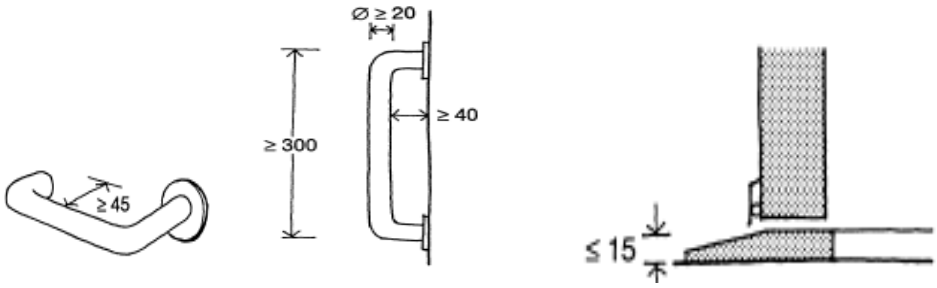
Double leaf door



Automatic door



Floor Plan of different type of doors



Door handle design Threshold design

Fig: 2. 23 Design of doors

2.5.2.2 Bedroom

The only published sets of guidelines/recommendations for the bedroom were guidelines/recommendations for closets/storage spaces and room dimensions. Guidelines for closet spaces focused on closet dimensions (Green et al., 1997; USGPO, 1977) and hanging rods or shelf height (Green et al., 1997; USGPO, 1977; NBO,(1997) on Disabled, 2000; HUD, 1996). Existing guidelines specify that hanging rods be mounted approximately 4 to 4 ½' high although HUD (1996) suggests using adjustable brackets so individuals can set desired height. Room dimensions range from 90-280+ square feet, depending on use (Beyer and Nierstrasz, 1967; Grandjean, 1973; Green et al., 1997; USGPO, 1977; Woodson, 1981). These guidelines are listed in table 7.

Table 2.2 Design Guidelines for Bedroom

Architectural System Component	Citation	Design Guideline/Recommendation
Closet/Storage	HUD(1996) NBO,(1997) (2000) on Disabled: GOI Green, I., Fedewa, B.E., (1997) Jackson, W.M., Johnston, C.A., & Deardorff, H.L.	- Use adjustable shelves and hanging rods - Loop handles on doors - Properly illuminate closet - Closets deeper than 18" should have door opening of 32" - Shelf height 39-54" - Provide at least 4' between bed and closet (5' preferred) - Hanging rods ≤ 56" high
Room Dimensions	Woodson W.E. (1981) USGPO (1977) Grandjean,E.(1973) Green, I., Fedewa, B.E., (1997) Jackson, W.M., Johnston, C.A., & Deardorff, H.L.	- Size: 90-120 sq.ft. for single adult Size: 192-288 sq.ft. for married couple - Size ≥ 180 sq.ft (for combined living room-bedroom) Ceiling height ≥ 7'6"

2.5.2.3 Kitchen

Kitchens have three special considerations in barrier-free design: wheelchair mobility, work space comfort, and accessibility to cabinets and storage spaces. When planning a kitchen for a wheelchair user, special importance is the front-to-back measurement—including footrests—because this measurement determines the turning radius your customer will need. The turning radius is normally 60" (25 square feet) for a full 360° turn.

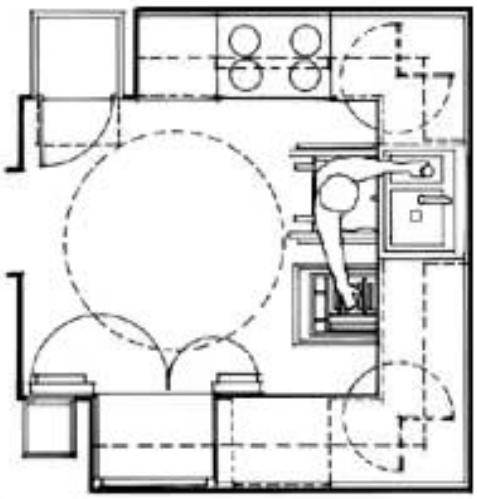
Authors like Kirvesoja et al. had analyzed kitchen cabinetry/shelving heights and countertop height used by the wheelchair users in Finland (2000), Englehardt and Goughler investigated the applicability of using robotic technologies in meal preparation (1997), and Koppa et al. performed a laboratory study to define guidelines that would aid in the design of refrigerators (1989).

To minimize bending, some recommend keeping storage shelves 12” or higher above the floor (Kirvesoja et al., 2000; Pinto et al., 2000), while the U.S. Department of Housing and Urban Development (HUD) recommends 9” (HUD, 1996). Likewise, Kirvesoja et al. (2000) and Pinto et al. (2000) recommend the top storage shelf be no higher than 63” while HUD (1996) recommends not exceeding 54”.

A common countertop height recommendation is 36” (Woodson, 1981; NBO,(1997) on Disabled, 2000); Kirvesoja et al., 2000;, HUD (1996) however suggests installing counters at various heights or using adjustable countertops to accommodate wheelchair users of different heights.

Table 2.3 Design Guidelines for Kitchen.

Architectural System Component	Citation	Design Guideline/Recommendation
Room Dimensions	International conference of (1997) Building Officials	Ceiling height ≥ 7'
Cabinet/ Storage Systems	Kirvesoja,H., Vayrynen, S., (2000) & Haikio, A. PintoM.R., De Medici, S.,(2000) HUD (1996) NBO,(1997) (2000) on Disabled,GOI Woodson,W.E (1981)	Height for storage shelves: - Shelf height 63" (1600mm) - Cupboard height between 12" (300mm) and 55" (1400mm) - Locate bottom shelf of upper cabinet at 48"; Utilize drawers that fully pull out; -Wall cupboards 14" above counters - Provide D-type handles on cupboards and drawers
Cooking Technologies	Englehardt, K.G. & (1997) Goughler, D.H.	No explicit guideline, however, authors strongly suggest that designers match the needs and abilities of older adults with the design and capabilities of technologies
Counter	Kirvesoja,H.,Vayrynen,S. (2000) & Haikio, A. HUD (1996) NBO,(1997) (2000) on Disabled,GOI	- Counter height = 33.5" (850mm) - Mount counters at more than one height - Utilize adjustable countertops - Provide visual contrast at counter edge - - Counter or table height ≤ 3'
Floor Surface	HUD (1996)	Non-skid flooring
Lighting/ Illumination	Pinto, M.R., De Medici, S.,(2000), HUD (1996)	Provide direct lighting on work surfaces
Oven/Range	Pinto, M.R., De Medici, S.,(2000) Van Sant, C.,Bianchi,A., Zlotnicki,A.,&Napoli, C HUD (1996) NBO,(1997) (2000) on Disabled,GOI	- Oven:Place on top of counter (to avoid back strain) - Range:Provide raised edge to protect against spills, Front mounted controls; Staggered burners; Consider flush (or low) burners; Consider separating oven from range and provide knee space below range (wheelchair access) ; Provide 1' wide counter surface on either side of range (at same height)
Refrigerator	HUD (1996) Koppa, R.J., Jurmain, (1989) M.M., & Congleton, J.J.	- Side-by-side model refrigerator/freezer -Allow doors to open 180° - Include pull-out shelves; Include water/ice dispenser (for those with limited hand dexterity - Pull-out shelves;Easily operable doors, with auto-close functionality; Bins should glide smoothly
Sink/Faucets	HUD (1996)	- Use lever style handles; - Select model with high temperature stop - Sink depth ≤ 6.5" - Consider adding a removable front and bottom cabinet below



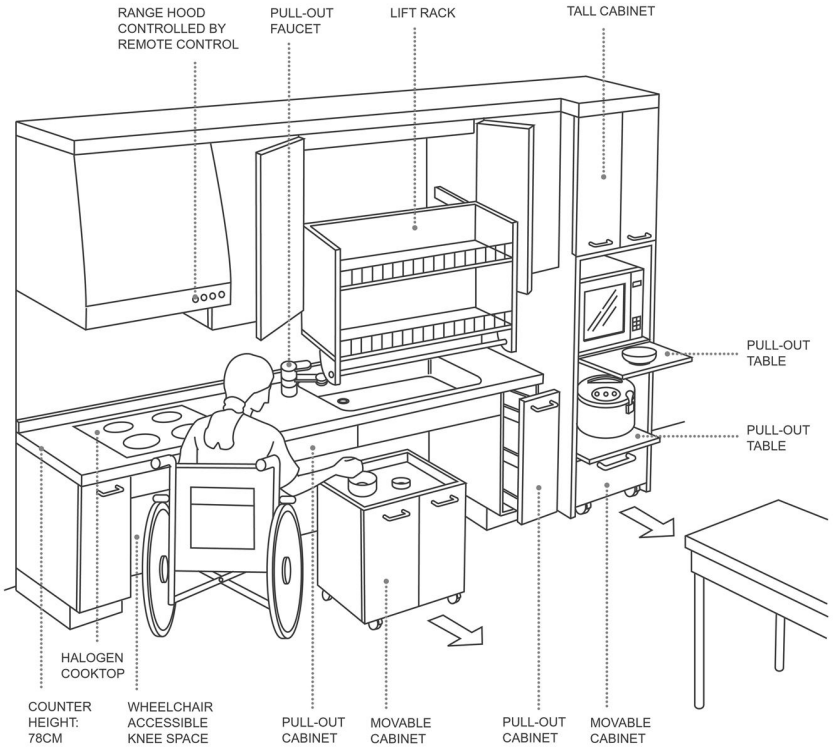


Fig 2.24 Kitchen layout and Interior Accessibility

2.5.2.4 Bathroom

A barrier-free, bathroom design should provide freedom of movement by making it easier and more convenient to bath, groom, and use the toilet in comfort. The more space for maneuvering around a bathroom in a wheelchair the easier and safer it is. A wheelchair handicapped accessible bathroom dimensions require at least 5 feet (60") in diameter to make a 180 degree turn. Bathroom doors should be wide enough to allow comfortable passage. In order to accommodate a wheelchair, (a standard wheelchair is 24-27" wide), doorways should be a minimum of 32" wide.

Meindl and Freivalds (1992) sought to determine the optimal shape and location of faucet handles (for use in bathtubs and showers) . Bordett et al. (2000) investigated the torque required to shut off water at a faucet. In the same study, Bordett et al. quantified which of seven different handle styles the physically challenged could generate enough torque to meet or surpass the shut off requirement. Using lever-style handles in bathtubs, showers, and sink faucets is a common recommendation by (Bordett et al., 2000; Meindl and Freivalds, 1992; HUD, 1996). Another consistent recommendation for bathtubs/showers is to install hand-held shower heads (NBO,(1997) on Disability, 1998; HUD, 1996).

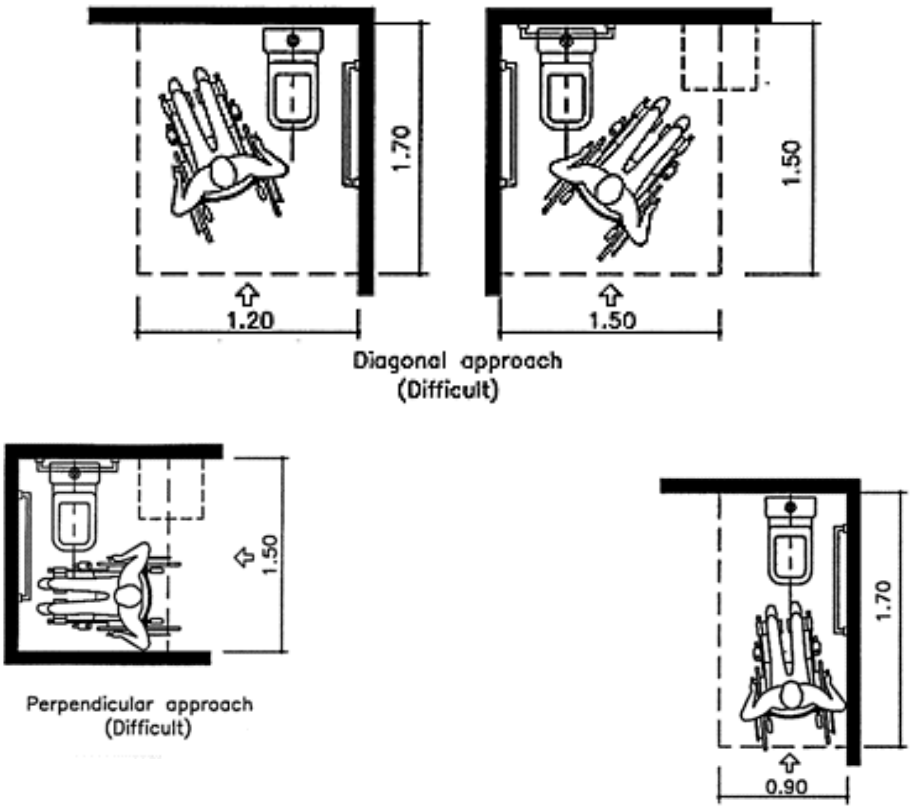
Although there is little information on flooring, HUD recommends non-skid flooring (1996); however, no further details are provided. Regarding lighting, the International Building Code (IBC) requires “appropriate artificial light” or greater than 3 square feet of window glazing (International Code Council, 2003). Both the IBC (International Code Council, 2003) and the Uniform Building Code (UBC) (International Conference of Building Officials,

1997b) specify ventilation requirements. The UBC suggests natural ventilation, although mechanical ventilation can be substituted for natural ventilation.

Regarding the toilet, the UBC (International Conference of Building Officials, 1997b) and HUD (1996) specify the amount of clear space around the toilet and HUD (1996) and the NBO,(1997) on Disabled suggest building in supports for grab bars but recommend waiting to install grab bars until necessary.

Table 2.4 Design guidelines for Bathroom

Architectural System Component	**Citation**	**Design Guideline/Recommendation**
Bath/Shower	HUD(1996), Meindl. & Freivalds. (1992) ,National Advisory Council on Disabled: GOI (2000)	- Lever style handles - Include removable seat - Include reinforcements for future grab bars -Provide hand-held shower head -Use lever handles where possible. -Use one handle for hot and one handle for cold and mark appropriately. -Install two sets of faucet handles located at 21" and 42" (above tub floor) if possible, otherwise, set height at 32". - Locate grab bar (horizontal) 30" above floor - Install vertical grab b a r - Slip-resistant bathtub floor - Hand-held shower head with adjustable positioning
Floor Surface	HUD (1996)	Non-skid flooring
Room Dimensions	International Conference of Building Officials(1997)	Ceiling height ≥ 7'
Sink/Faucets	HUD(1996), Bordett, H.M., Koppa, R.J., & Congleton, J.J. (2000)	- S ink height 3 0 - 3 4 " - Lever style handles Cover metal edges with compressible material than can also act as a nonslip surface when operated with wet hands. Lever style handles allow greater exertion o f torque. Round all edges to prevent discomfort and/or injuries.(fig-2.26)
Toilet	HUD(1996),International Conference of Building Officials(1997) National Advisory Council o n Disabled: Government of India(2000)	Clear space requirements: Width ≥ 30" Space in front ≥ 24" - Locate 18" from side wall - Provide reinforcement for future placement of grab bars -Install offset flange to allow future movement of toilet(by up to 3" -Top of toilet seat = 18" above floor(fig-2.22)



Frontal approach (Most difficult)

Fig 2.25Different approaches

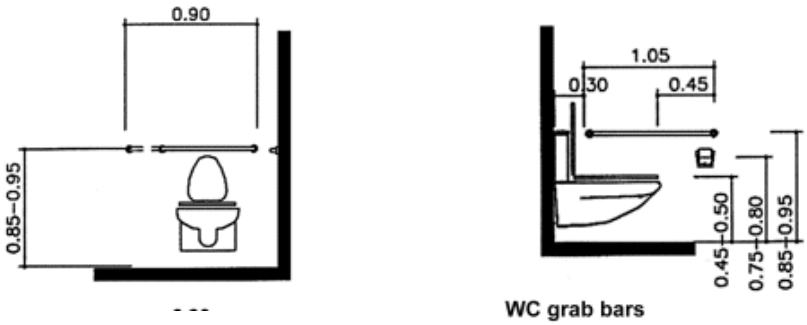


Fig 2.26 The size and layout of water-closets and toilet

Design of toilet

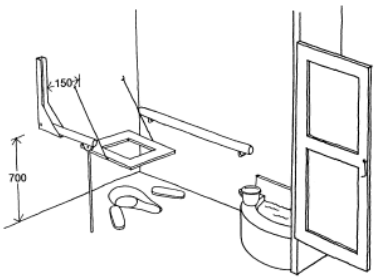


Fig 2.27 A fold down seat over a pit latrine.

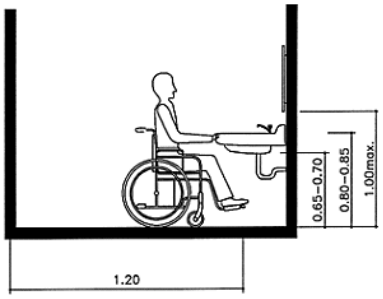


Fig-2.28 The dimensions of wash basin

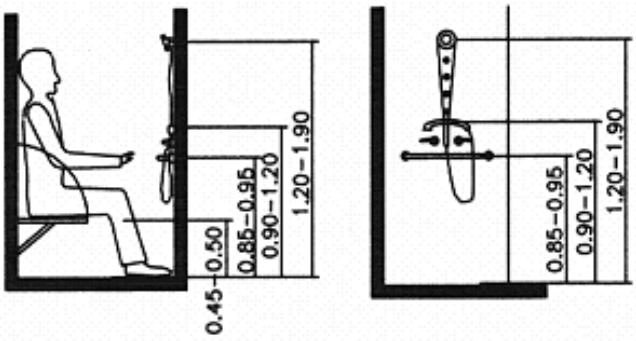
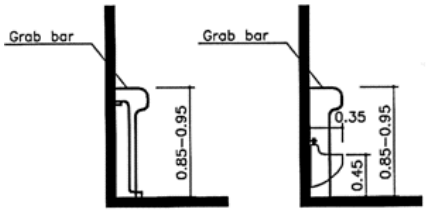


Fig 2.29 the dimensions of showers



Dimension of Urinals

Fig 2.30 Design of toilet

2.5.2.5 Living Room, Dining Room, Home Office

Except for the general requirements listed in Indian building codes (International Conference of Building Officials, 1997b; International Code Council, 2003) for lighting, ventilation, and room dimensions, no guidelines or research was ted formulated for the living room, dining room, or Home office.

Common Features

Redfern et al. (1997) conducted a study in which eight wheel chair subjects stood on seven different floor types (low to high pile, various pad types, etc.) while balance was measured using an Equitest Posturography Platform. Dickenson et al. (2001) also measured balance of wheelchair user's subjects with an Equitest Posturography Platform. In that study, subjects stood on unyielding and amenable floor surfaces and revealed that compact flooring support gives better strength and ease of wheelchair traversability .

Table 2.5 Design Guidelines for Common Areas.

Architectural System Component	Citation	Design Guideline/Recommendation
INTERIOR		
Entrance	Pinto, M.R., De Medici, S., (2000) Van Sant, C., Bianchi, A., Zlotnicki, A., & Napoli, C.	- Door threshold < 1" (25mm) - Non-skid flooring - Grab-bars near door - Reduce difference in illumination between inside and outside - Light-switches close to door - Passages free from furniture and equipment - Box to hold keys near door
Room Dimensions (General)	International Code Council (2003)	Ceiling height ≥ 7' Floor area: 1 room ≥ 120sq.ft. with other rooms ≥ 70 sq.ft. Wall dimension: ≥ 7' in all horizontal directions
Hallways	International Code Council (2003)	Ceiling Height ≥ 7' Exit Door: Minimum width = 3' ; Minimum Height = 6'8"
Doors/Doorways Ingress/Egress	Pinto,DeMedici,(1997) HUD(1996) NBO,(1997) (2000) on Disabled:GOI	-Doors:Width-36";Height-80"; -Threshold height = 0.5" - Minimum 32" clear doorway opening - Lever or loop style door handles - Door handle height 30-36" - Handles obvious and of different color - Use lighting to increase color contrast between door and surroundings
Flooring	Dickinson, J.I., Shroyer, (2001) J.I., Elias, J.W., Hutton, J.T., & Gentry, G.M. Pinto, M.R., De Medici, S., (1997) Zlotnicki, A., Bianchi, A., Van Sant, C., & Napoli, C. NBO,(1997) (2000) on Disabled:GOI	- Doorstep height < .75/1" -Height and width of floor component joints < .75” -Select firm carpet, with 0.5" maximum pile height - All hard surfaces should be non-skid -Eliminate changes in height between floor transitions - Non-glare floor surfaces - Slip-resistant floor surfaces - Inset doormat
Storage	NBO,(1997),(2000) on Disabled:GOI	Storage shelving within in range of 8-56" high
Lighting/Illumination (General)	HUD (1996) NBO,(1997) (2000) on Disabled: GOI International Conference of (1997)	Natural light ≥10% of floor area with 10sq.ft. minimum -Lighting ≥ 50 lux -Lighting even and well-diffused to eliminate spottiness or shadows -Provide supplementary task lighting where necessary Light Switches-Height 36-48" -Use rocker, toggle, or touch sensitive switches

Windows

A window should have handles/controls at a height that permits use from wheelchairs (fig2.27). A window should have an unobstructed viewing zone for wheelchair users. Curtain or Venetian blind controls/ropes should be accessible for wheelchair users.(NBO,1996 & CPWD,2006)

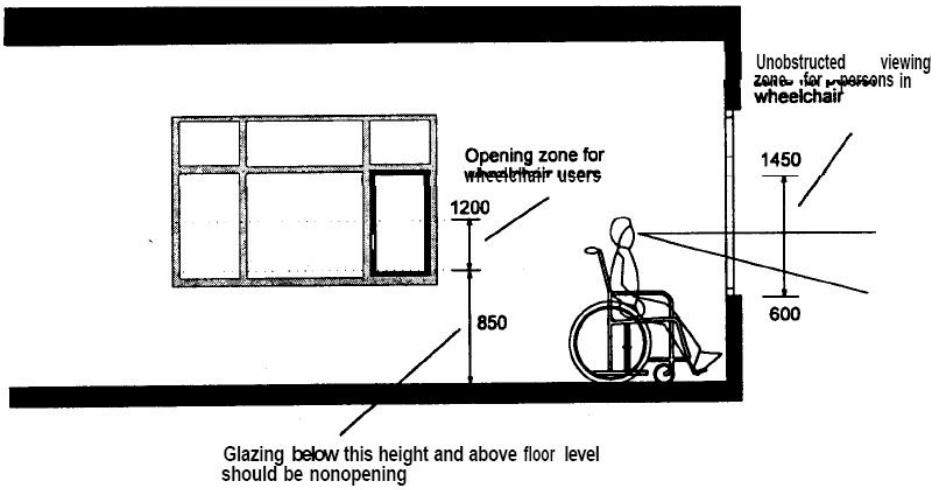


Fig 2.31 Details of window dimension

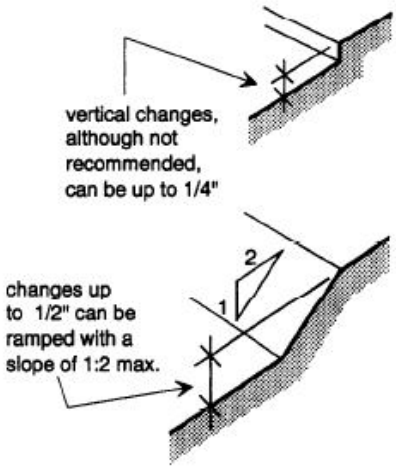
Interior floor surfaces

(NBO,1996 & CPWD,2006) has suggested that small, abrupt changes in floor levels are potentially hazardous, especially for the elderly, people with vision impairments, and those who use canes, walkers, or other mobility devices. Further, people using wheelchairs may find it difficult to reasonably negotiate vertical changes greater than 1/4-inch. Level changes up to 1/2-inch can be crossed with a surface sloped at a 1:2 rise. Changes greater than 1/2-inch will require a gently sloping surface with a maximum rise of 1:20 or a ramp.(fig2.30)

Levels: Small vertical level changes created in a floor should be corrected. Small bevels or similar sloped surfaces can be installed to create a smooth

transition between these different floor surface levels or room levels as needed(fig2.29)

Raising Floor Level: G Another method to reduce small level changes between floor surfaces is to install the new surfaces at the same level. This requires changing the type of material and its thickness to achieve a level transition.



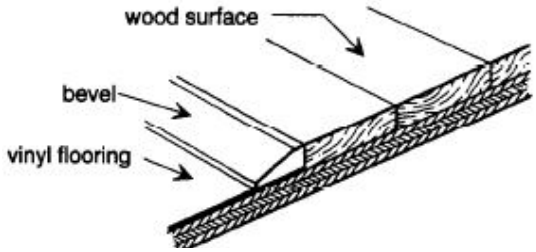


Fig 2.32 Small level changes. Fig 2.33 Bevels between floor levels.

Control and Signals

Koncelik, (1976), HUD(1996),NBO,(1997)suggested that electrical Outlet should be mounted not lower than 15 inches above the floor surface. Outlets at this height and above are easier for people who have trouble in bending and stooping to use. The location of outlets over a counter or work-top should be mounted close to the surface to help people who are seated, those who have limited reach, and those who use canes, walkers, or crutches to reach the outlet .Security System Controls should be provided with an easy to operate key pad. The buttons should be high contrast and raised, and require little force to

activate. Monochromatic control key pads with flush controls should be avoided as they are difficult for some people to operate. .(NBO,1996 & CPWD,2006)

Mounting Height: When a control unit is to be permanently installed in one location, it should be mounted not higher than 48 inches above a floor surface. Controls at or below this height can be reached by most people.(Fig.2.34)

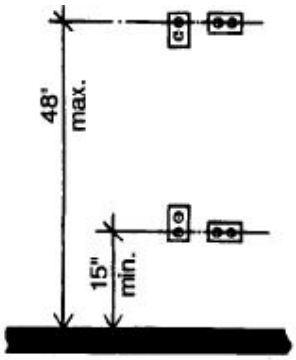


Fig. 2.34 Mounting height of switches and controls.

The Review of the Literature and design Guidelines and Standards reveals the importance of designing space for wheelchair taking their special needs into consideration. Although more attempts are being made for greater accessibility in architecture and interior design, current facilities are still not completely accessible to everyone. This is due to the lack of awareness of the needs of people with physical impairments. Architects and interior designers must come to the realization that approximately one out of every five citizens is physically disabled and lack of attentiveness and knowledge of this can lead to many injuries. It can be concluded that there is a great urgency to provide barrier-free features in residential buildings to mainstream the wheelchair user

population. Hence, it is anticipated that creating dwellings for the disabled may give an opportunity to remain close to their families in an adaptive, psychologically comforting and environmentally sound environment. They in turn will benefit from a stronger sense of place, dignity and wellbeing through out their life.

CHAPTER III

MATERIALS AND METHODS

This chapter provides the detailed description of the procedure adopted for conducting the research on “Designing Functional Residential Interiors for Wheelchair Users”, after reviewing the relevant literature and formulating the objectives of the study. Methodology adopted for this study is presented under the following headings

3.1 Research design

3.2 Selection of study area

3.3 Selection of respondents

3.4 Tools used for study

3.5 Pre-testing of tool

3.6 Collection of data

3.7 Analysis of data

3.8 Evolving design solutions

3.1 RESEARCH DESIGN

The research design is the planned structure and strategy of investigation. In other words it is the overall scheme of program of research. Research designs are planned to obtain answers to research questions and analysis of variance. It is a systematic activity directed towards discovery and the development of an organized body of knowledge and systematic application of the scientific method

to the study of problems (Creswell, 2003).The ex-post facto research design was adopted in this investigation to explore the views of wheelchair users on the design features and different areas present in their respective residential buildings and their valuable suggestions were considered to evolve suitable design features. Marion et.al (2000) have termed Ex-post facto research, as a method of testing out possible antecedents of events that have happened and cannot, therefore, be engineered or manipulated by the investigator. In effect, researchers ask themselves what factors seem to be associated with certain occurrences, or conditions, or aspects of behavior.

3.2 SELECTION OF STUDY AREA

The location for conducting the study should ensure sufficient number of sample to achieve the objective of research. Hence through purposive random sampling method, the Hyderabad city, capital of Andhra Pradesh was identified for conducting this research for the following reasons:

- As a fifth largest city in the country, it has heterogeneous population
- It has vertical and horizontal expansion to meet the housing and infrastructure requirements of the city dwellers.
- It has several highly equipped multi-specialty hospitals and hospitals for special needs like orthopedic hospitals and physiotherapy centers to meet the needs of people with loco motor disorders.

Plate .1.Encircled area showing the locations of the residences of the respondents.

3.3 SELECTION OF REPONDENTS

The objective of the research was to explore design solutions to the problems faced by the wheelchair users in residential building.The sample that fulfills the following criteria were identified for the study:

- An adult, willing to be the respondent and share personal views on their living set up.
- Should have at least 5 years of dependency on wheelchair for mobility with or without assistance of caretakers.
- Should be living either in independent building or in an apartment

Hence through the purposive random sampling procedure, a total of 10 wheelchair users living in any part of Hyderabad city were selected for conducting the descriptive research. These respondents were identified with the help of medical doctors of orthopedic hospitals and physiotherapy centers who have been extending their services to them till date.

3.4 TOOLS USED FOR THE STUDY

The study involved the collection of information from the wheelchair user's themselves and observation of their home for studying the adaptations made in their respective environment to meet the specific needs. Hence the most appropriate tools to conduct the research were identified and formulated. Since the research is an attempt to explore the views of wheelchair users on the living arrangements and to observe the adaptable features introduced in their house, an Interview cum observation schedule was selected.

Interview cum observation schedule helps to compare the direct observation and the self recorded information by the researcher (Kerlinger, 2005). This tool was developed to include information on general profile of the respondent, management of chores, access to different parts of the house, problems in accessing different parts and suggestions for improving access in their living arrangements (APPENDIX -I).

3.5 PRE-TESTING OF THE TOOL

The tool developed for collecting information was pre-tested with three wheelchair users to check the reliability of the interview cum observation schedule before undertaking the case studies. Three respondent's i.e. wheelchair users residing in Hyderabad city were approached for testing the tool. Among the three respondents, first one was suffering from cerebral palsy, second person was attacked with polio, and the third person had spinal cord injury which occurred due to road accident. This tool was slightly modified to make it comprehensive and informative.

3.6 COLLECTION OF DATA

The technical investigation was based on a user centered design approach, which recognizes the importance of human activity analysis as an effective research tool. This approach explores the interplay between the activities undertaken in various parts of at home and the impact of assistive technologies and environmental design in facilitating or acting as a barrier to activity. (Pheasant, 1999).

To take up the field investigation, respondents were contacted personally at health care center and each respondent was appraised about the aims and objectives of the study. Permission was obtained to visit them at their residence on a post date, to record information on the living arrangements.

On the day of interview, they were contacted over phone, to confirm their convenient time for conducting interview on living arrangements and to observe the adaptable features introduced in their residence for their use.

Information pertaining to general profile of the wheelchair user, their dependency on family members for management of daily chores, extent of satisfaction with the facilities incorporated for mobility and access, their problems in access to various parts of the home and their suggestions for overcoming the barriers was gathered through personal interview. Wood, and Cotugno, 2008 stated that personal interview using supervised self-administered questionnaires increases co-operation rates for sensitive questions and the accuracy of the information obtained. At the same time self-administered questionnaire provides the sense of privacy. Being in the same room with the interviewer helps to decrease the tendency to provide incorrect information.

While conducting interview, observations were made and recorded on the physical parameter of the design features of such equipment as curb ramps, doors, windows, work surface, floor level difference, height of door threshold, storage areas, switches and control, faucet position, W.C and bath fittings. Photographs were taken during data collection and observation process.

3.7 ANALYSIS OF DATA

The data obtained through the interview cum observation schedule are reported as case studies. Since case studies help to examine limited number of variables, rather than using samples and following a rigid protocol to examine. Case studies involve an in-depth, longitudinal examination of a single instance or event: a case, which provides a systematic way of looking at events, collecting data, analyzing information, and reporting the results. The researcher as such could gain a clear understanding of why the instance happened as it did, and what might become important to look at more extensively in future research.

For overall understanding of the prevailing conditions and problems faced by the respondents, collected information was consolidated, tabulated, and analyzed with appropriate statistical tools and is presented under Chapter –IV.

3.8 EVOLVING DESIGN SOLUTIONS

The results and inferences drawn from the data formed the basis for evolving the guidelines to define the accessible features required for inclusion in residential buildings. To arrive at the design solutions regarding the problems encountered by the wheelchair users, the literature study was done and guidelines suggested by different authors were used.

CHAPTER IV

RESULTS

The results emerged out of the study on “Designing Functional Residential Interior for Wheelchair Users” are presented in this chapter and the compiled data is presented under the following heads.

4.1 Case studies of the selected respondents

4.2 General profile of the respondents

4.3 Living arrangements and Views of respondents on accessibility to facilities

4.4 Suggestions given by respondents for improving accessibility

4.5 Design solutions to improve accessibility in residential interiors

4.1 CASE STUDIES OF THE SELECTED RESPONDENTS:

Information procured from ten respondents of this research are presented as case studies which are as follows:

CASE STUDY – 1 Mr. Syed Afroz, Male, 20 years

Mr. Syed, at the time of his birth, his mother had a dry delivery which resulted in his suffering from cerebral palsy and born partially crippled and unable to walk. Being a resident of remote village in Andhra Pradesh, he was given home remedies till 8 years as he was unable to walk. For the sake of providing treatment the family had migrated to city.

Since, last 12 years he is undergoing treatment at Durgabai Deshmukh Hospital and Research Center (DDHRC). Prior to treatment he was totally dependent on his family members for his mobility. But after undergoing physiotherapy he is able to sit on wheelchair and maneuver it, where there are no physical barriers. At present his upper limbs have become partially functional but lower limbs are still within limitations. His mobility condition shows that, in horizontal level he uses his wheelchair, but where there are barriers like floor level variation, door threshold, narrow doorway he has to get off from wheelchair and crawl. Till this day, he is assisted by family members to access different parts of the home.

He had taken home tuitions to read and write. Presently he can read books, newspaper etc. but cannot write as he has difficulty in having finger grip. So, he spends most of his time by reading newspaper, and books, watching T.V and playing indoor games like chess etc. He is totally dependent on his family for meeting his personal finance, though his dream is to be self reliant. He belongs to a lower income group family with earnings Rs 1, 20000 /-p.a.

Daily Time Schedule:

6:30 - 7.00 AM: Personal chores

7.00 - 8:00 AM: Practice exercises taught by physiotherapist

8:00 -10:00 AM: Grooming and relaxation.

10:00 -10.30 AM: Travel to DDH

10:30 -3:00 PM: Physiotherapy classes at DDH

3:00 - 5:00 PM: Lunch and rest

5:00 -7:00 PM: Indoor games, socialization with family members

7:00 -10:00 PM:-Watching TV, dinner, going to bed

Living Arrangements in his home (Figure4.1)

Syed's family lives in an ancestral house at Wayhed colony, old city, Hyderabad, which is more than 50 years old. Interior of the house has lots of variation in floor levels with 5" high thresholds present in each room. This house is not renovated to overcome the difficulties faced by Syed. However he is provided a room in ground floor, close to main entrance. It has windows overlooking the main road and this allows him to have exposure to outside world and see people around him.

Facilities conducive for living in his home :(Plate4.1)

- A separate room at the entrance with adequate wall lighting and two doors to access indoor and outdoor areas.
- It has a TV, storage shelves, bookracks within his comfortable reach but a coat stand is mounted high on the wall.
- Adequate space to maneuver wheelchair and easy to access bed.
- Easy accessibility to table fan and its operation
- Side table nearby to bed for keeping his personal belongings.

Constraints Present In Living Arrangement (Plate 4.1)

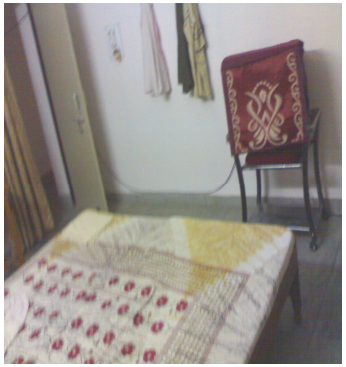
Syed confines to his room most of the time. However he is assisted by family to access to living cum dining room and bath and toilet room, but to other rooms he has no access because of following barriers.

- Width of the entrance door is 3' and all rest of the rooms is with 2'8" wide door which acts as a barrier as it is reducing the free maneuvering space.
- Presence of 5" high threshold in all the doors.

- There is a difference of floor level in all rooms of 5” from the floor level of internal corridor.
- In his room, daily used garments are stored in wall mounted hangers at a height of 5’ from floor level as it is difficult to reach; he depends on other family members to help him in accessing his clothes.
- If he is sitting at ground level, he had to struggle a lot to climb on to his wheelchair or any near by chair.
- Traditional metal latches are present in doors and windows at a height of 4’ and 5’ respectively from the floor level, which needs a lot of strength to push and open. He finds it difficult to operate as his fingers have weak muscles.
- Switch board is present at a height of 6’ from floor level which is present beyond his reach.
- Location of bathroom floor at a height of 8” from normal floor level and within that toilet floor is raised by 5”. He manages with these barriers, as he slides down from wheel chair and crawls to access to these areas with assistance from family members.
- Presence of bathroom faucet at a height of 3’ from floor level .This is of great inconvenience to him as he takes in crawling posture, and he depends on others to access bathroom faucet.
- Presence of Indian toilet pan in the bathroom at a height of 5” from bathroom floor level acts as barrier for him in accessing toilet area.

Entrance door with steps and threshold

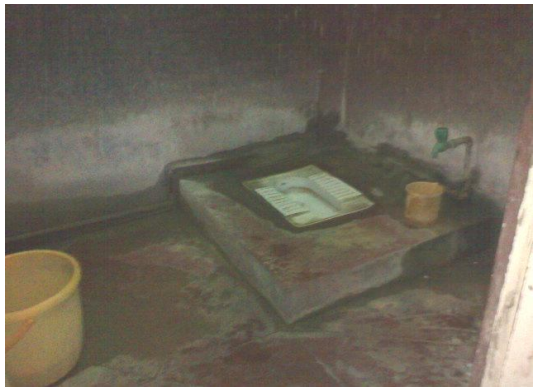
Syed accessing main entrance



Syed's personal room

Access to bathroom

Syed at the time of interview



Access to toilet.

Plate 4.1 Living arrangements in the Residence of Mr.Syed

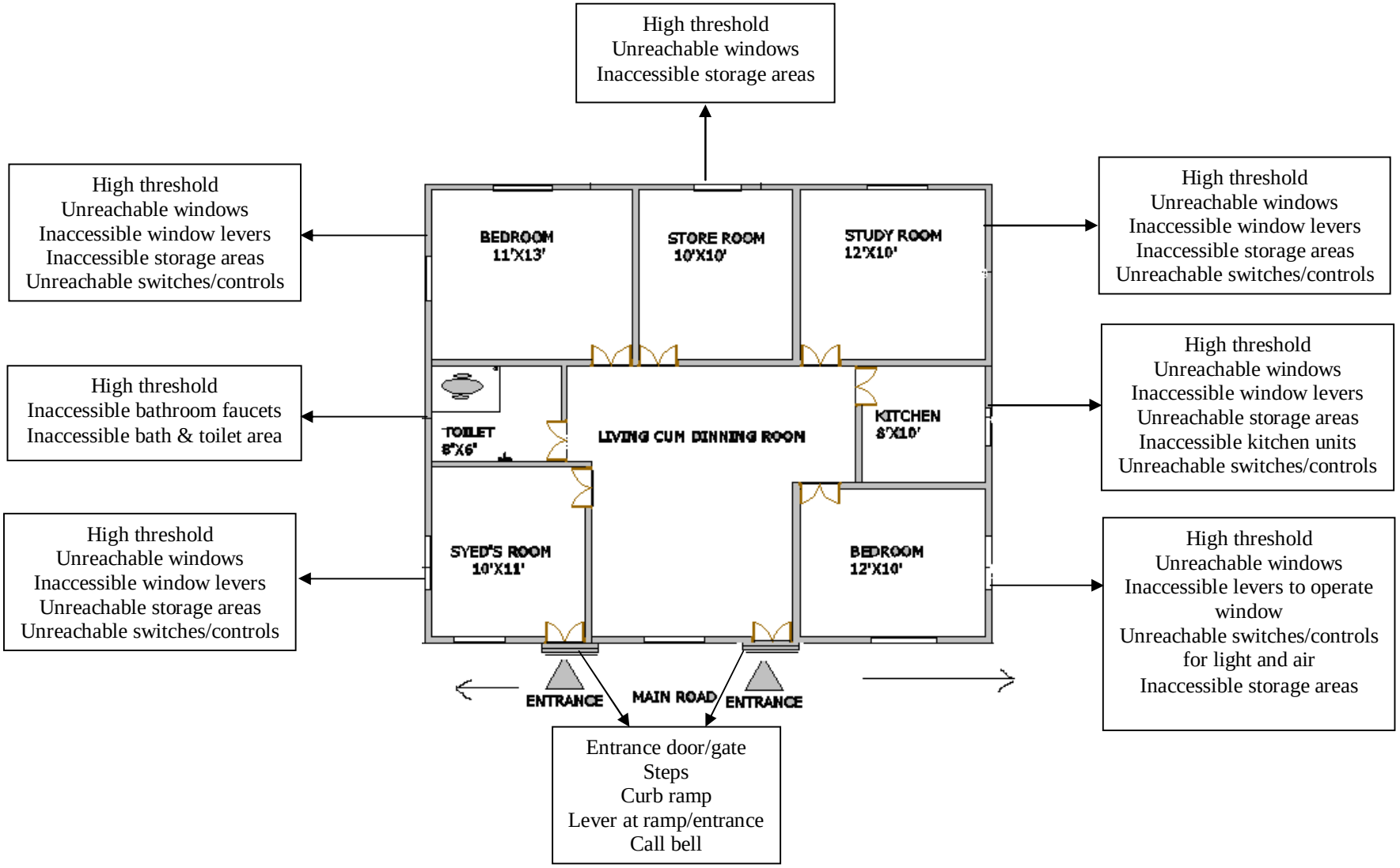


Figure 4.1 House layout of Mr. Syed showing the problem areas and features

Suggestions given by Syed for improving accessibility in his home:

- Removal of door threshold in all the rooms for having unhindered access by Syed.
- Repositioning of the switch board at a reachable height.
- Introduction of low level shelves in his room for accessing his belongings.
- Relocation of cloth hanger at his reachable height.
- Smooth ramp to connect different floor levels within the home for easy wheelchair operations.
- Repositioning bath room faucet at a reachable level.
- Replacing the faucets with easy to operate type.
- Replacing the Indian toilet pan to western commode.

CASE STUDY – 2 Ms.Anita Avula : 21 years, Female

She is the eldest daughter of her family and she is a native of Guntur district in Andhra Pradesh, but has been residing with her parents at Mehdipatnam, in Hyderabad at their own independent house. The family is living in that house since last 9 years. She was affected with Polio at the age of 6 years and her left leg has been paralyzed since then. Since the past 13 years she has been a wheelchair dependent. Though she can take care of herself, she is partially dependent on her family to access inaccessible areas due to the presence of various barriers. She doesn't want her mobility condition to be a barrier for her financial independence; hence she had showed keen interest to acquire required educational qualification. She had completed her graduation in Computer Science and presently pursuing post-graduation in MCA from Central University, Hyderabad. For her mobility outside the home, she depends on father to drop her in front of her department at Central University Campus, and she depends on tricycle and crutches to move within in university campus between classroom, laboratory and library. She belongs to an upper middle income group family with an income of Rs 5, 00000 /-p.a

Her daily life starts with physiotherapy exercises. She finishes her daily chores and goes to temple, then starts for her college and comes back by evening. Evening hours she prefers to sit in verandah and spend time with her parents, sisters and friends. After enjoying the evening with family and friends, she spends her time studying until its dinner time. During weekends she prefers to help her mother in cooking as she likes to cook. She spends her leisure time in canvas painting.

Living Arrangements (Plate 4.2)

Avula lives with her parents in an independent house, in which they have introduced few design features to meet the requirements of Anita Avula. Features like small curb ramp with grates at the entrance, wide doors, and spacious internal corridors without any obstructions and provided her with a separate room to make herself comfortable. She spends maximum time in her room for studies and sometime for prayers in the pooja room. In spite of many efforts taken by the family to meet her requirements, she still finds her home to have some inconvenient features which makes it difficult for her to access.

Features incorporated in the house to meet her special needs

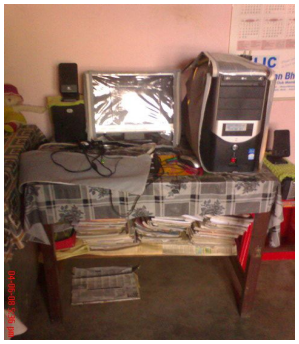
- A room of 10'X12' size with a window for light and breeze and a wide door to accommodate her movements on wheelchair. Windows are provided with low level handle and latch to ease operation.
- Room is equipped with a T.V to spend her leisure and a Computer to facilitate her studies.
- Furniture in her room includes one bed, a study cum work table which is used by her to store books underneath and a computer on the table.
- A wardrobe without shutter is provided for easy access to her clothes and other belongings.
- Features like small curb ramp at the entrance, wide doors, and spacious internal corridors for easy maneuverability of her wheelchair and to access every part of her home and the exterior.

Entrance with curb ramp

Anita at the time of interview

Kitchen counter

Anita’s personal room



Anita’s work table

Bath cum toilet

Plate 4.2 Living Arrangements in the Residence of Ms.Anita

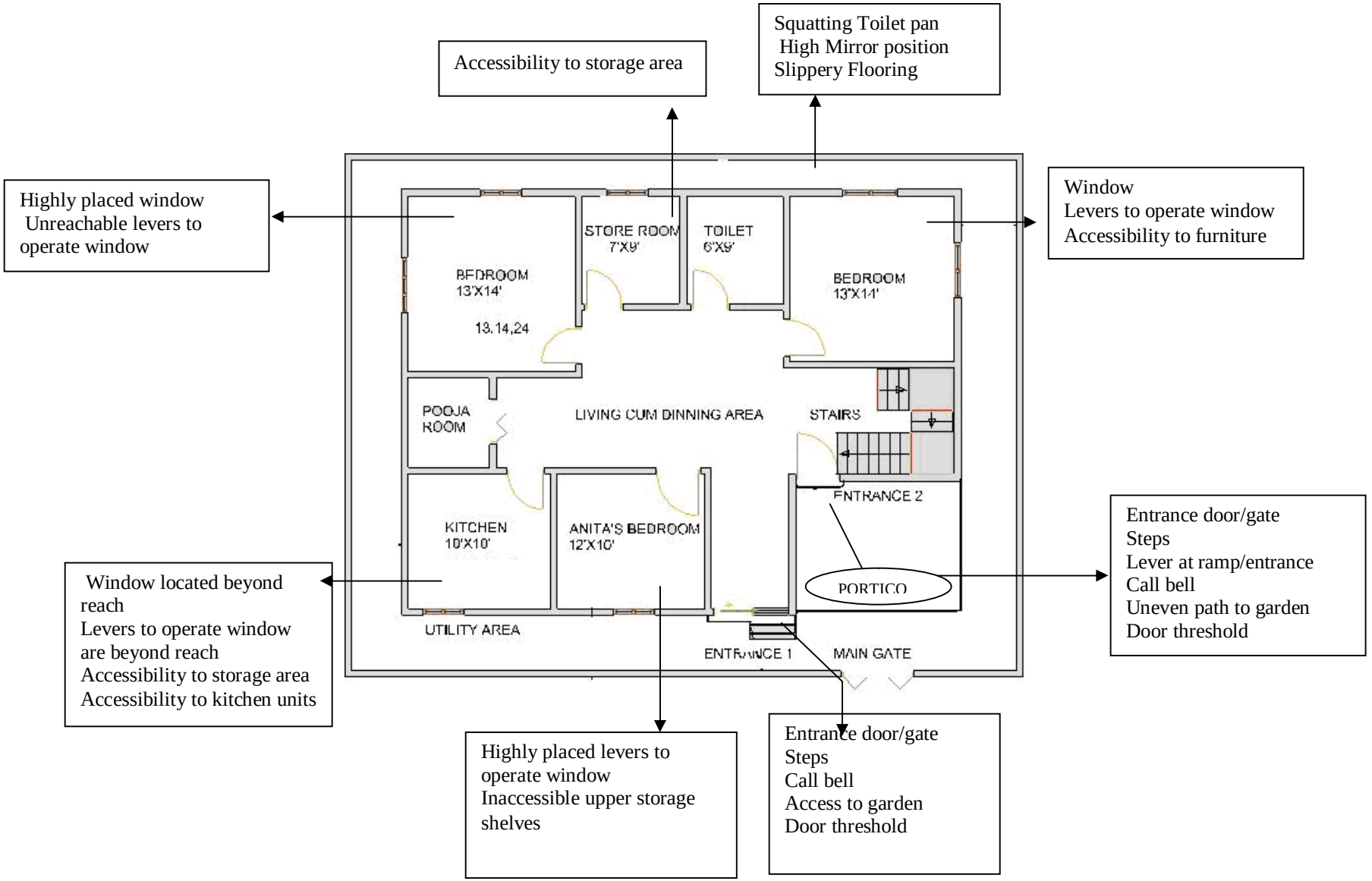


Figure4.3 House Layout of Ms. Anita with the problem areas and features

Problems faced by Anita in her home (Figure 4.3)

- ⇨ The curb ramp with groove is just 2’6” wide and she needs to be very careful while moving on it with wheelchair.
- ⇨ Out of the two entrance doors one is at 10” high from the floor level of portico and the second entrance has collapsible metal grill door. Though Anita uses the second entrance, but she finds it difficult to operate the sliding door which requires lot of strength to push it to the side.
- ⇨ Presence of threshold in pooja room makes her to depend on family members for mobility into this area.
- ⇨ She finds it difficult to access gadget on kitchen counter like electrical heater, gas stove for cooking in the kitchen as it is present beyond her reach on the kitchen platform.
- ⇨ Presence of storage facility under the computer work table comes in the way of maneuvering the wheelchair.
- ⇨ Switch board for computer is present at the back of work table which is difficult to reach.
- ⇨ She finds it difficult to access the shelves in her wardrobe which are higher to reach and depends on family members to access the things placed in the upper shelves.
- ⇨ Bed room door is wide enough but it doesn’t have any stopper at reachable height to control the opening.
- ⇨ Bathroom has a small threshold of 2” height which she manages by holding onto the door or with family member’s assistance.

- ⇨ Bathroom does not have any grab bar to take support while accessing bath and toilet area.
- ⇨ Mirror above the bathroom is out of her viewing range.
- ⇨ Bathroom has a toilet pan at floor level, and this is a strenuous for use during her toilet activities.
- ⇨ Flooring of the bathroom is with marble which demands cautiousness while moving within the bathroom especially when it is wet.

Suggestions given by Anita for improving her mobility and access in the home:

- ❖ Widen the narrow ramp present at the entrance door and replace the collapsible grill gate with normal swing-in door
- ❖ Raise the floor level of portico up to the height of internal floor level through a curb ramp, to access the interior from main entrance.
- ❖ Change the position of the switch board located behind the computer table for easy access.
- ❖ Introduce storage facilities within accessible range preferably in all the rooms.
- ❖ Change the bathroom flooring from marble with any anti-skid flooring material to reduce slipperiness.
- ❖ Lower the position of mirrors in bathroom and wash area.
- ❖ Remove the threshold present at the bathroom and pooja room.
- ❖ Replace the toilet pan located at the floor-level with western commode.
- ❖ Provide grab bar inside the pooja room, bathroom and W.C as they are in the areas where she cannot move with the wheel chair.

CASE STUDY – 3 Ms A.Nikitha, Female, 35 years

A fatal road accident that occurred 8 years back, resulted in multiple fractures of hip bones caused her to be hospitalized for 8 months. Though she has recovered, she can no longer depend on her lower limbs for movement. She was discharged from hospital as a wheelchair dependent for mobility. Initially she was using a manual wheelchair, but presently she has changed it to a power driven one. She is self dependent for most of her routine activities, except that she needs to be little alert and dependent on others to overcome small physical architectural barriers coming in her path ways.

She lives in her own independent house at Balanagar Housing Society, Hyderabad with her husband. She is a post-graduate in sociology. Before the accident she used to work as a consultant for a Consultancy firm in Hyderabad. But after the accident she discontinued the outside job and presently helping her husband in their own family business. She tries to keep herself engrossed in work in order to overcome her physical limitations. She belongs to an upper middle income group with an income of Rs 5, 00000 /-p.a.

On her wheelchair she feels very independent as she can move anywhere in her home, without much difficulty. Her daily routine life starts with morning stroll accompanied by husband within their gated community compound. On her return, she attends to physiotherapy exercises, personal chores and preparation of breakfast with the help of servant. After sending husband to office, she watches T.V. for some time while monitoring home maintenance job carried out by the maid servant and prepares lunch with the assistance of servant. She goes to office around 11.30 A.M in her car which is driven by the driver. She

assists her husband in supervisory job and returns home early to attend to her domestic work. Whenever she stays long at office, they prefer to go for a long drive, have dinner outside, comes back home, watch T.V. for some time and sleep.

Living Arrangements (Plate 4.3)

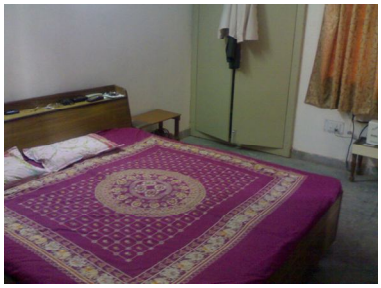
Nikitha lives in her own residence which is well designed; she has a servant to help her in performing various chores of her daily life. Basic modifications were made in her residence design after the accident, to overcome most of her disability.

Accessible features incorporated in the home:

- In their entire house, only the main entrance has 2” high threshold leading to living cum dining room and the total house is free of any floor level barriers.
- All the rooms are big and have ample wheelchair maneuverable space.
- Every room is fitted with 3’6” wide door for convenient movement of wheelchair between the room
- Her bedroom is attached with bath cum toilet fitted with western commode, bath tub and wall mounted faucets are placed within the accessible range.
- All the switch boards are present within accessible range.
- A low level kitchen counter without any base cabinets gives ample knee space to access the gas stove and sink area.

Double shuttered Entrance Doors

Mrs.Nikitha with her Husband



Bedroom with wardrobe

Living room Arrangement

Kitchen work counters

Bath cum toilet

Plate 4.3 Living arrangements in the Residence of Mrs.Nikitha

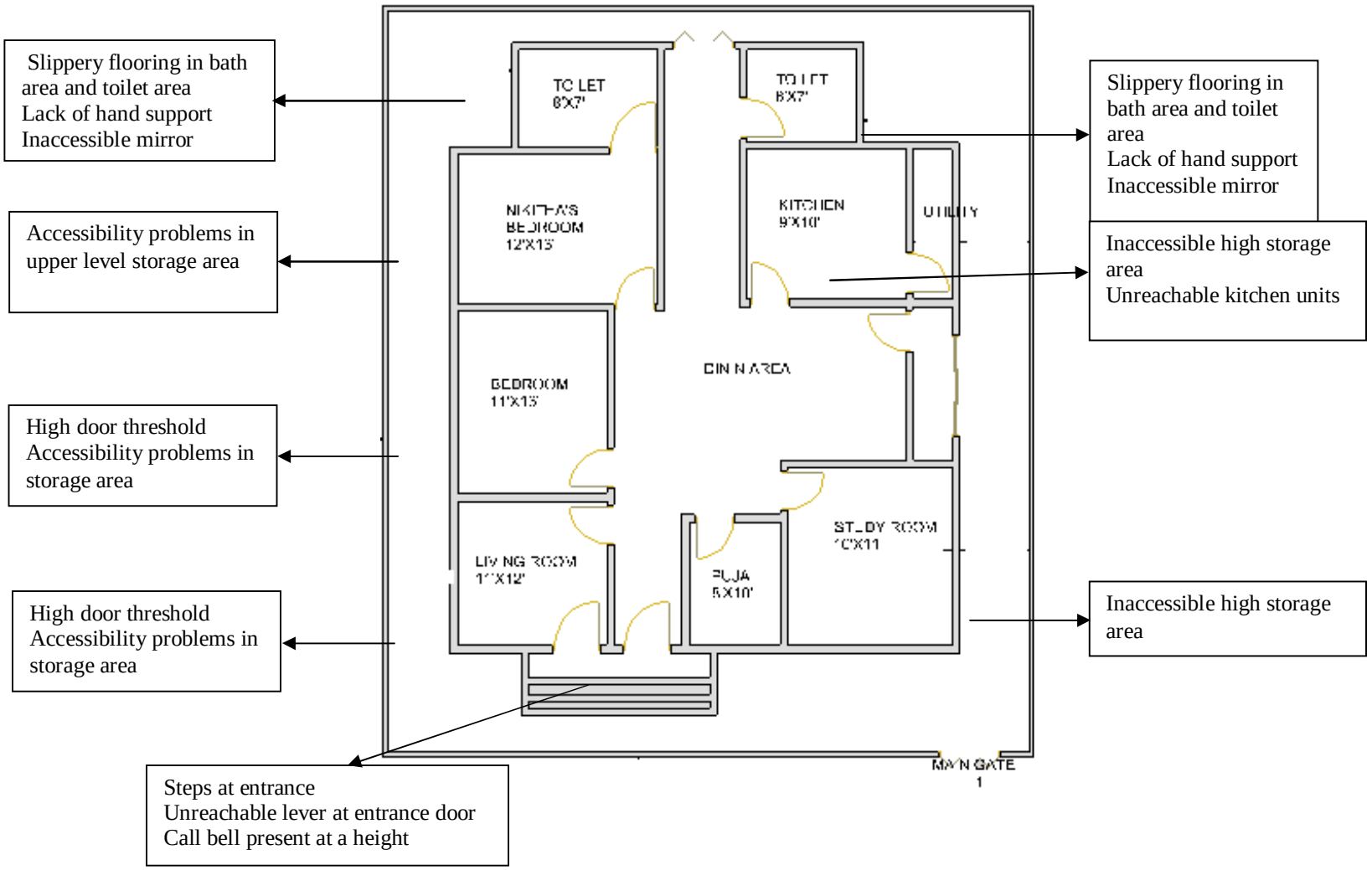


Figure4.3 House Layout of Mrs. Nikitha with the problem areas and features

Tribulations faced by Nikitha in her home (Figure4.3)

Though most of her mobility problems are minimized by incorporating special features, she still has few problems which make her to depend on other members.

- ⇨ The building entrance starts with few steps, as there is insufficient space to negotiate curb ramp. Hence her husband or servant helps her to overcome this barrier by providing her support to climb up or down.
- ⇨ The entrance foyer has two main accesses, one leading to drawing room and the other to living room. Both are fitted with two doors i.e. metal mesh door and a wooden flush door. She has to open the mesh door towards her to get access to push the flush door. She finds this operation tough to handle.
- ⇨ As the doors do not have stopper to control them, they bang back and hurt her at times.
- ⇨ Wardrobes present in the bedroom are fitted with shutters which open outside. This is difficult to operate while sitting on wheel chair in front of it. She also finds it difficult to access the top most shelves in the wardrobe as those are beyond her reach.
- ⇨ In kitchen, except the counter with cooking range rest of counters have over- head cabinets at higher levels. She depends on her family members to access the things kept in it.
- ⇨ She has sufficient knee space even under her sinks, but the placement of sink faucet creates problem to her to access it.

- ⇨ The door bolts are present at the height of 7’ in all the doors, which cannot be reached by her being on wheelchair. She depends on others to bolt the door.
- ⇨ Bathroom has a floor level difference of 1” from the other rooms. In spite of being alert, the variation in floor level causes some inconvenience.
- ⇨ Lack of support to hold on beside the bathtub and W.C creates problem while using these every day.
- ⇨ Marble flooring in bathroom is slippery when wet.
- ⇨ Before entering into the bathroom she needs assistance of others to switch on / off the lights, as the switches are present beyond her reach.
- ⇨ She cannot reach the mirror placed above the wash basin beside bathroom, so, she depends on her own dressing room mirror while grooming.

Suggestions given by Nikitha for improving her mobility and access in the home:

- ❖ Removal of steps in front of the main entrance, and replacing it with accessible curb ramp by merging the foyer space and steps. She prefers to have grates on the curb ramp to prevent slipperiness.
- ❖ Removal of metal mesh door which opens outside.
- ❖ Repositioning of the switch board near bathroom to an accessible height.
- ❖ Reduce the height of kitchen faucet to minimize the strain in accessing sink.
- ❖ Introduce accessible shelves for total access to storage.
- ❖ Change marble flooring in bathroom with any other anti- skid material.
- ❖ Reposition the mirror present at wash basin.
- ❖ Introduce grab bar near bathtub and toilet area for support.

CASE STUDY – 4:Mrs. Dennissa Daya Rose; Female; 28 years.

With confidence, coordination and concentration nothing is impossible in this world. The value of this sentence is evident from Dennissa Rose, who met with an accident 3 years before, i.e., immediately after one and half year of her marriage. In that accident she had severe spinal cord injury, from which she recovered, but the injuries in the internal spinal cord, has made her to depend on wheelchair, thereafter for her movement. But she feels that she is perfectly fine and manageable because of her family support. She has always wanted to be independent, so immediately after recovering from her accident she joined their own family finance business, where she feels that, she is as normal as others within the office environment.

Rose is staying with her husband in a flat in Malaysian Township nearby to Kukatpally Housing Board, Hyderabad. Her flat is situated on the 3rd floor of Block 'C' and she accesses her apartment by lift. In her home except some few household maintenance activities for which she depends on maid servant, she does all her work by herself without depending on anybody. She belongs to an upper middle income family with earnings of Rs.5, 00000/- p.a.

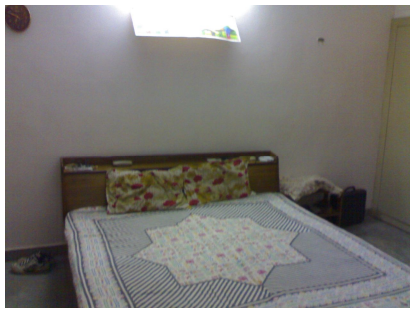
Her daily life starts with meditation, exercise and monitoring domestic chores with the assistance of maid. Her husband lends her a hand for cooking and by 10.00 A.M both of them leave for office. She comes back home from office around 3 P.M and takes rest up to 5 o'clock and then again she gets back to office and works up to 8 P.M. After coming from office, she watches TV shows and starts preparing dinner. After dinner she and her husband take a short stroll within their locality and then go to sleep.

Living Arrangements :(Plate 4.4)

Rose lives in an ownership flat with her husband. They have selected this flat as they felt, that this met her requirements of accessibility. She is very much satisfied with her house as she can access the entire house, as none of the doorways had threshold when purchased. Before occupying the ownership apartment, few suggestions were informed to the builder to get incorporated in the structure, for ex: modifications in cupboard designs, switches and controls placement to the concerned architect. So that Rose can easily access all the places without anybody's assistance.

Internal accessible provisions in her home:

- Apartment block has a driveway to go up to lift in her car. Hence it is convenient to access her apartment.
- Accessing lift with wheelchair and operating it is not a problem as all the controls are within the accessible height.
- All the rooms have threshold free doorways for easy access.
- Her bedroom is attached to the toilet with western commode, and wall mounted faucets within the accessible range.
- Bathroom attached to her room receives ample daylight and hence it is always dry.
- All the switch boards are present within accessible range.
- Kitchen counter is placed at a lower height for accessing gas stove and sink.
- Kitchen has narrow overhead cabinets within her reach



Bedroom and Dressing unit

Mrs. Rose in her residence

Storage Shelf

Kitchen work centers

Knee space under sink in kitchen

Toilet area and washing machine

Plate 4.4 Living arrangements in the residence of Mrs.Rose

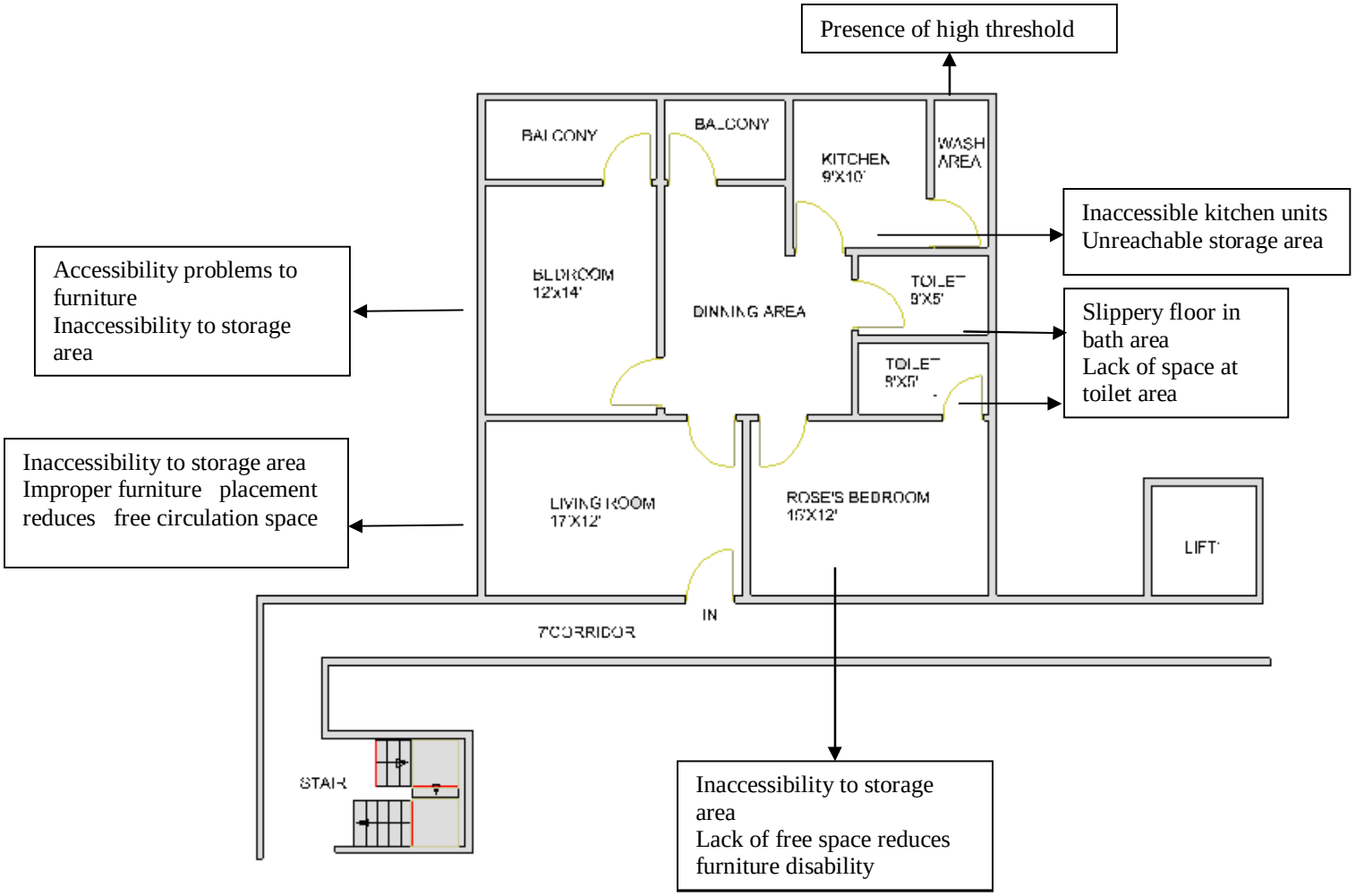


Figure4.4 House layout of Mrs. Rose with the problem areas and features

Problems Faced By Rose in Her Home :(Figure 4.4)

- ⇨ The entrance door does not have a peep hole to check the visitor.
- ⇨ Size of the doors is only 3’ wide and she needs to carefully maneuver her movement on wheelchair.
- ⇨ Window latches and handles are above her reach level hence difficult to access and operate.
- ⇨ In kitchen, lower level shelves are accessible but she can’t reach the upper levels storage cabinets.
- ⇨ The base cabinets present below the kitchen counter is an obstruction when she has to go under the counter to do work. Also she finds it difficult to access the inner areas of the base cabinet’s shelves as she cannot reach.
- ⇨ As the power connection and space for refrigerator is provided in the dining area, this increases her movement while working in the kitchen.
- ⇨ As her bed room is small to accommodate her dresser, two almirahs, and her bed, hence there is less space for wheelchair maneuverability. This causes lot of inconvenience for her to access her almirahs.
- ⇨ Storage racks present in dining area is up to the height of 6’-8” with four shelves making it difficult for her to access the upper levels.
- ⇨ The small bathroom attached to her bedroom has western commode and has only 1” floor level difference, it is convenient for her use. But she still has difficulty in this bathroom because of the presence of washing machine as the second bathroom does not have electrical provision for operating washing machine.

- ⇨ In the same bathroom she has difficulty in accessing electrical switches as it is beyond her reach
- ⇨ Lack of grab bars beside toilet and bath area causes lot of body strain, while accessing these service areas.

Suggestions given by rose for improving her mobility and access within in the home:

- ❖ Repositioning of the switch board present nearby to bathroom at an accessible height.
- ❖ Prefers to have latches and handles at lower level of the window to minimize strain on operation.
- ❖ Wishes to have accessible shelves which are easy to operate while sitting on wheelchair.
- ❖ Lower the height of mirror located near wash basin.
- ❖ Wishes to have a grab bar in bath tub and toilet area for additional support to body.

CASE STUDY- 5 :Mrs. Rukhsar Begum, 49 years, Female.

Rukhsar Begum is a housewife affected by paralysis on left part of her body, three years back and she is on treatment since then. Her treatment had reduced the intensity of problem from her face and hand, but her legs are in the same condition. Her medical history reveals that she always had high blood pressure, which is now under control because of regular intake of medicine. Since she wishes to be independent and takes care of herself, she uses a manual wheelchair to move around the house by operating it with her right hand. She stays in the ground level of their independent home located near to RTA Office, Nagole, Hyderabad.

Her family had taken some interest to introduce minor modifications in the house to overcome the barriers of Rukhsar. Since the threshold in door ways between kitchen, bed room and living room are removed .So, she is able to move between these rooms but in areas where there is variation in floor level or difficult to access or operate any object in the house, she depends on her husband, daughter, son and daughter-in-law. She belongs to a middle income family with earnings of Rs.2,75000/-p.a.

Her daily routine starts with morning prayers, followed by attending to personal chores with some assistance. She takes her breakfast by 10-10.30 AM, so that she can have her family's company while having breakfast. After breakfast, she helps her daughter-in law in cooking meals for lunch, and after lunch she takes rest. In the evening when her daughter returns back from office, both of them go for evening stroll. After that, she helps her daughter-in-law in the dinner preparation, while chatting with other family members. She takes dinner

with family and watches T.V. till bed time. She spends her leisure time near the entrance, sitting on her wheelchair, so that she can see the busy world. Otherwise she remains in the kitchen and for rest; she spends time in her bedroom.

Living Arrangements (Plate 4.5)

Rukhsar's family stays in independent house. Their residence is not remodeled, only few modifications are introduced to overcome some of the hurdles.

Problems faced by Ruksar in her home :(Figure 4.5)

- ⇨ The main gate is present at a distance of 15' from the entrance door and the drive way is not evenly leveled. This makes her to exert more pressure to move wheelchair on uneven surface.
- ⇨ Entrance of the house has a 10' wide collapsible iron gate which is difficult to push with the pressure of right hand.
- ⇨ For mobility of wheelchair to entrance gate, a narrow curb ramp is introduced As it is too steep, she needs the assistance from her family members to enter and egress.
- ⇨ Cupboard present is of 7' height with 2'-8" width with 4 shelves; she can reach the lower levels, but can't reach upper levels as the shelves are present beyond her reach.
- ⇨ Bedroom looks very clumsy and congested because of the interior arrangement which reduces space for her movement within the room.

Entrance with curb ramp

Mrs.Rukhsar Begum

Uneven walk way within compound

Well ventilated bedroom

Kitchen work center

Bath cum toilet

Plate 4.5 Living arrangements in the residence of Mrs. Rukhsar Begum

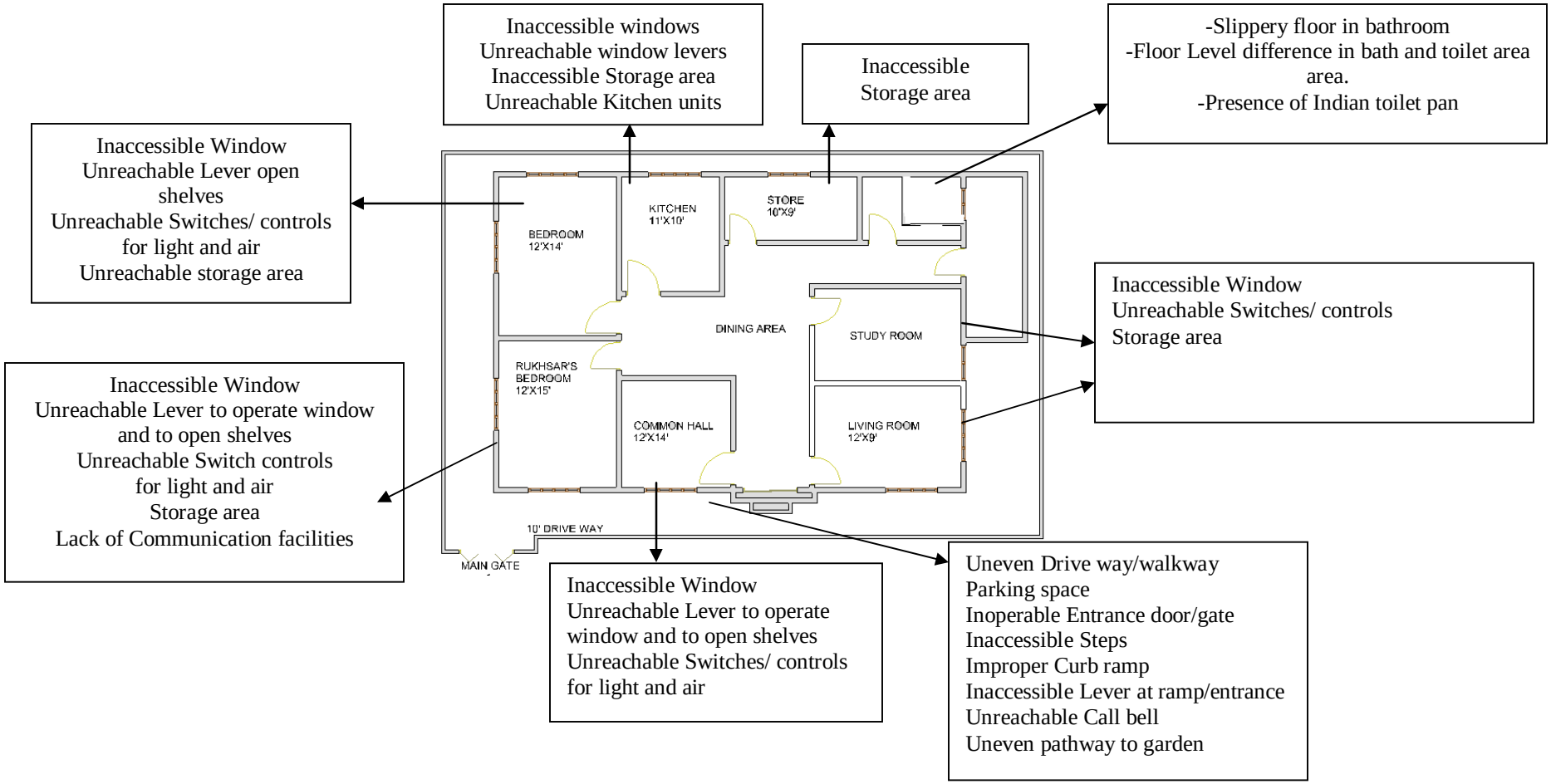


Figure 4.5House layout of Mrs. Rukhsar with the problem areas and features

- ⇨ It has a double bed with one storage rack for clothes and one almirah. The placement of storage rack and almirah occupies a lot of space in the bedroom creating lots of barriers for her movement on wheelchair within the room.
- ⇨ Storage racks are of dimension 3’ x 7’ with 4 shelves, in which she gets the most common problem of height, as she can not access the upper levels.
- ⇨ In the bedroom window operating levers are present at the top making it impossible for Rukhsar to reach upto that level.
- ⇨ Toilet is present at a distance from the bedroom.
- ⇨ It has Indian style toilet pan, which gives her a lot of problems while using it.
- ⇨ Bathroom floor is of marble which becomes slippery while taking bath. But the bathroom lacks grab bar to hold on while bathing.
- ⇨ In front of the bathroom wash basin is present on top of which mirror is placed but she cannot have a look into it.
- ⇨ Besides wash basin, washing machine is kept which even further reduces free space for her movement.
- ⇨ Kitchen has both overhead and base cabinets. She cannot reach upto the height of overhead cabinet and even she cannot reach into the depth of base cabinets.
- ⇨ Even the presence of cabinets reduces knee space below counter and the sink is such placed leaving a knee space of only 2’ under it.

Suggestions given by Rukhsar for improving her mobility and access in the home:

- Reducing the angle of inclination of curb ramp
- Repositioning of the switch board present nearby the bathroom at an accessible height.
- Reduction of height of the kitchen counters to reachable level.
- Introduction of low level accessible shelves.
- Change of marble flooring material in bathroom and kitchen to that of anti skid variety.
- Repositioning of mirror present along with wash basin to her access range.
- Introduction of grab bar near bath and toilet area.

CASE STUDY – 6 :Mr.Imtiaz Ahmed, Male, 50 years.

Life of Imtiaz Ahmed was very miserable when he met with a road accident 7 years ago. In that accident he got severe spinal cord injuries and multiple fractures of thigh bone. That accident has shattered his life, by making him to be confined to bed, left on somebody's assistance for every purpose. He discontinued his business as he was immobile. But later as he started taking physiotherapy, he was able to regain the ability to use right hand first and later even left hand, but with limitations. When he regained the function of upper limbs, he started using a manual portable wheelchair, which he can manage to maneuver. He belongs to an upper middle income family with earnings of Rs.4, 75000/- p.a.

He lives in independent home present in Hayathnagar Colony, Old City, and Hyderabad. Along with a small family consisting of his wife, his son and daughter. His room is located on the ground floor of the house. He moves in his own room without any assistance, but he needs assistance to go to toilet. He tries to do most of the works by himself, but due to physical limitation he seeks assistance while performing certain activities.

His daily time agenda:

5:30 - 7:30am - Morning Prayer followed by simple exercises on his own, then used to have breakfast.

7:30 -10:00am - Watches T.V. and reads morning newspaper

10:00 -1:00pm - Physiotherapist used to come to the house to help him to do the exercises

1:00 - 5:00pm - After lunch, take rest till late afternoon, plays chess with the family members or with friends sometimes.

5:00 - 8:00pm - Time with family members, watching T.V.

8:00 - 10:30pm - Dinner, followed by night scroll and goes to sleep.

Living Arrangements :(Plate 4.6)

It is a two storey building with internal staircases as a connection between the floors. They have modified their residence to cater to the needs of Imtiaz Ahmed.

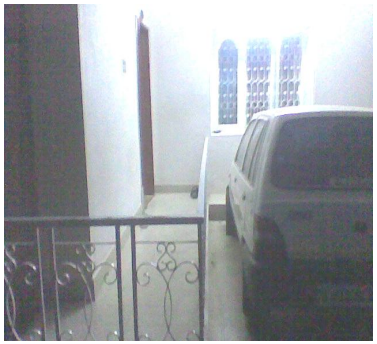
Conducive features present in his home:

- Main gate is present at a distance from 10' from entrance door.
- It has a driveway of 12' x 10' which is attached to a small ramp leading to the main entrance.
- Within the drive way the parking space is allotted for vehicle.
- It's a total four bed room house with one attached toilet with two bedrooms located on the ground floor beside living room and another two bedrooms present at the first floor and it has one dining room and kitchen present at the ground floor.
- In the entire house thresholds are removed.
- Doors are wide enough for easy wheelchair maneuverability. He moves freely in his house with absence of any floor level barriers except in bathroom.
- Window's levers are present at the bottom levels of windows.

Constraints in the home (Figure 4.6)

⇨ Entrance to the building has an accessible ramp, but its location is in opposite direction from car park. He has to take a long route to access ramp.

Imtiaz Ahmed



Entrance with ramp and parking

Entrance with threshold

Imtiaz's Bedroom

Dining Area

Kitchen units

Plate 4.6 Living arrangements in the residence of Mr. Imtiaz Ahmed

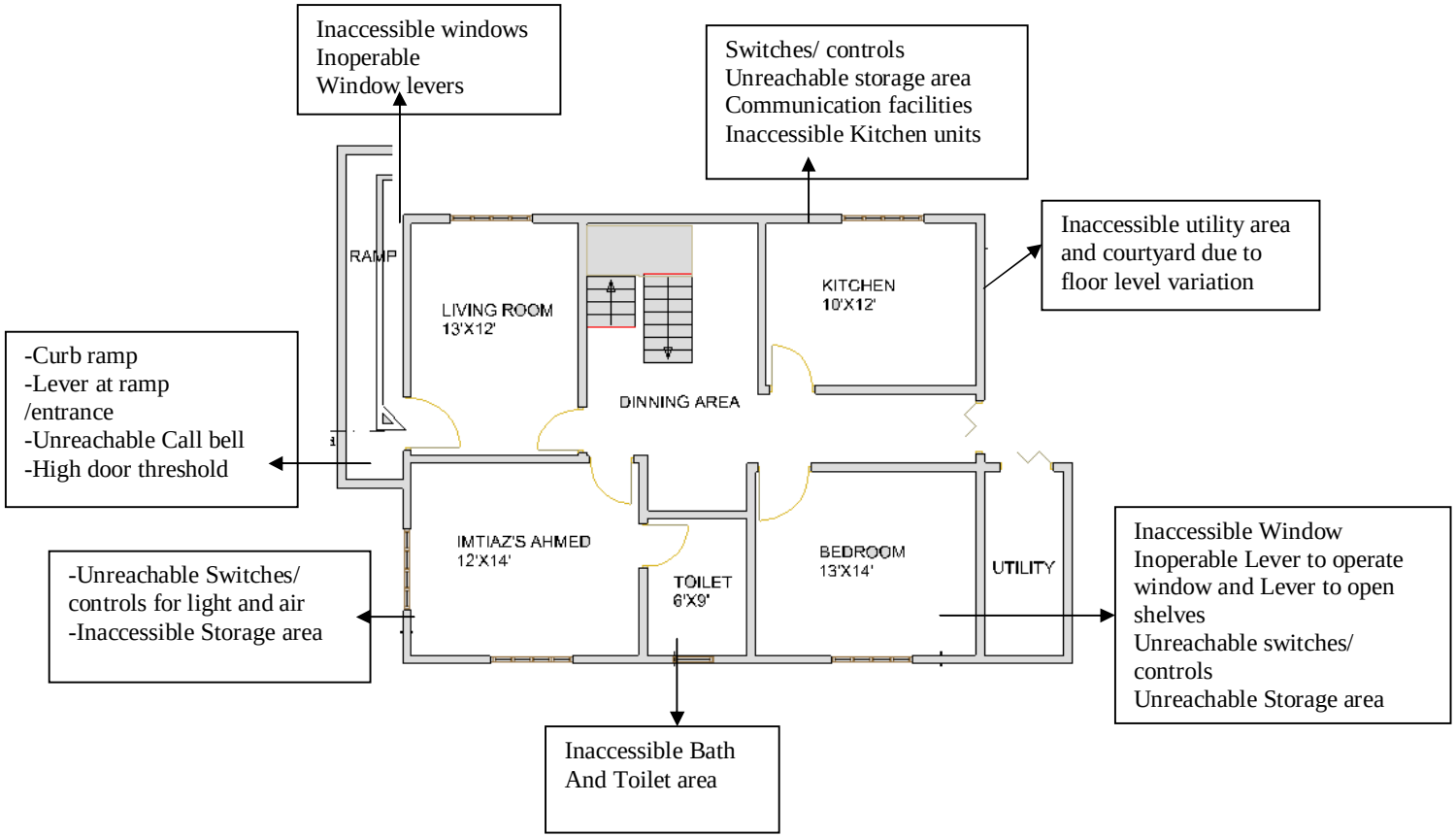


Figure 4.6 House layout of Mr. Imtiaz Ahmed with the problem areas and features

- ⇨ Call bell is present at a height of 5’-8” which is beyond the reach of Imtiaz when he is on wheelchair.
- ⇨ The switch board for T.V., lights and fan are behind T.V. This is difficult to reach and operate being on wheelchair.
- ⇨ Storage shelves above the height of 5’ are difficult to reach in all rooms. He depends on others to access the things placed in those upper levels which are not accessible.
- ⇨ Kitchen has high over head cabinets which are present beyond his range. And also, kitchen counter has no knee space for wheelchair to go under it.
- ⇨ Placement of sink faucet at a height beyond reach and improper sink dimension, like no knee space, depth of sink creates a lot of problems as he can not reach up to that level.
- ⇨ Absence of wall support is felt as major a problem in toilet. He struggles to overcome problems when he is using the toilet.
- ⇨ He finds that the flooring is slippery especially when it is wet. So he needs to be careful while moving inside bathroom.
- ⇨ Inaccessible utility area and courtyard due to floor level variation of 8”, between the level of house and the courtyard level.

Suggestions given by Imtiaz for improving his mobility and access in the home:

- ❖ Remodification of ramp to connecting portico to main door.
- ❖ Repositioning of the switch board in all rooms and especially the one near bathroom to an accessible height.
- ❖ Rearrange furniture to access window and switch board.
- ❖ Reduction of the height of the kitchen counters to a reachable height.

- Provide accessible storage facilities in all the rooms.
- Change of flooring in bathroom from marble to anti skid variety.
- Introduction of grab bar near bath and toilet area.
- Leveling of the floor level difference present between internal floor area and backyard.

CASE STUDY – 7 : Ms. L. Sudhamani, 28years, Female

Life for Sudhamani was full of hurdles since 5 years of her age when she got affected by polio which had made her both the legs paralyzed with right leg most affected. She has studied up to Bachelor of Science and presently she is working as a soft skills trainer in a private firm. To be independent she started using wheelchair since last 18 years, but she always preferred to be on a manual wheelchair because she feels that she can control her speed and can avoid any unavoidable circumstances.

She stays in a flat with her family on 4th floor of the apartment and access it through lift as it is easily accessible. She tries to get through all the activities by herself, but physical limitation comes as a hurdle in some places, making her dependent on family members. She belongs to middle income family with income of Rs.2, 85000/- p.a.

Her time schedule is as follows:

6:30 - 7:30am- Meditation, gardening, net browsing for latest updates

7:30 - 9:30am- Personal daily chores and starts for office by 9.30AM and reaches office by 10:00AM

10:00-7:00pm- Attends Office and reaches home by7:30PM

7:30-9:00pm- While watching T.V. helps her mother in cooking.

10-11:00pm-Dinner and bed time

Since her hobby is painting and gardening, in her free times she loves to paint and maintain a small terrace garden in the utility area of her flat. She allocates at least some time of the day for taking care of her plants.

Living Arrangements (Plate 4.7)

Sudhamani stays with her family in a 2 bedroom flat at Chaitanya Residency, East Marredpally, and Hyderabad. As they have purchased the flat, it was quite impossible for the family to remodel it, but they have brought in slight modifications like removal of all the door thresholds, placement of the bathroom faucets at lower levels. The flat is very spacious with the furniture arranged along the wall leaving a lot of unobstructed space. She spends her maximum time at her computer table.

Tribulations in Living Arrangement (Figure 4.7)

- ⇨ Entrance of the apartment has two doorways: iron grill that opens into a balcony and a wooden door at main entrance. Both of these have threshold of 2” and these act as a barrier and require additional effort to cross.
- ⇨ Call bell is present inside the iron grill gate, where she cannot reach by herself as it is located beyond her reach.
- ⇨ Living room has the shelves which are beyond her reach.
- ⇨ In front of the windows furniture pieces are placed, so to operate them she has to climb onto those furniture pieces.
- ⇨ The light switches and T.V. switches are present behind the T.V. unit and refrigerator in living room and dining room respectively, which cannot be reached by her.
- ⇨ The presence of base cabinets reduces the knee space under kitchen counter, and this makes it difficult for her to work there.

Sudhamani in Front of her Apartment

Entrance door with threshold

Entrance Metal Door

Sudhamani's Bedroom

Study area

Kitchen units

Bath cum toilet

Plate 4.7 Living arrangements in the residence of Ms. L.Sudhamani

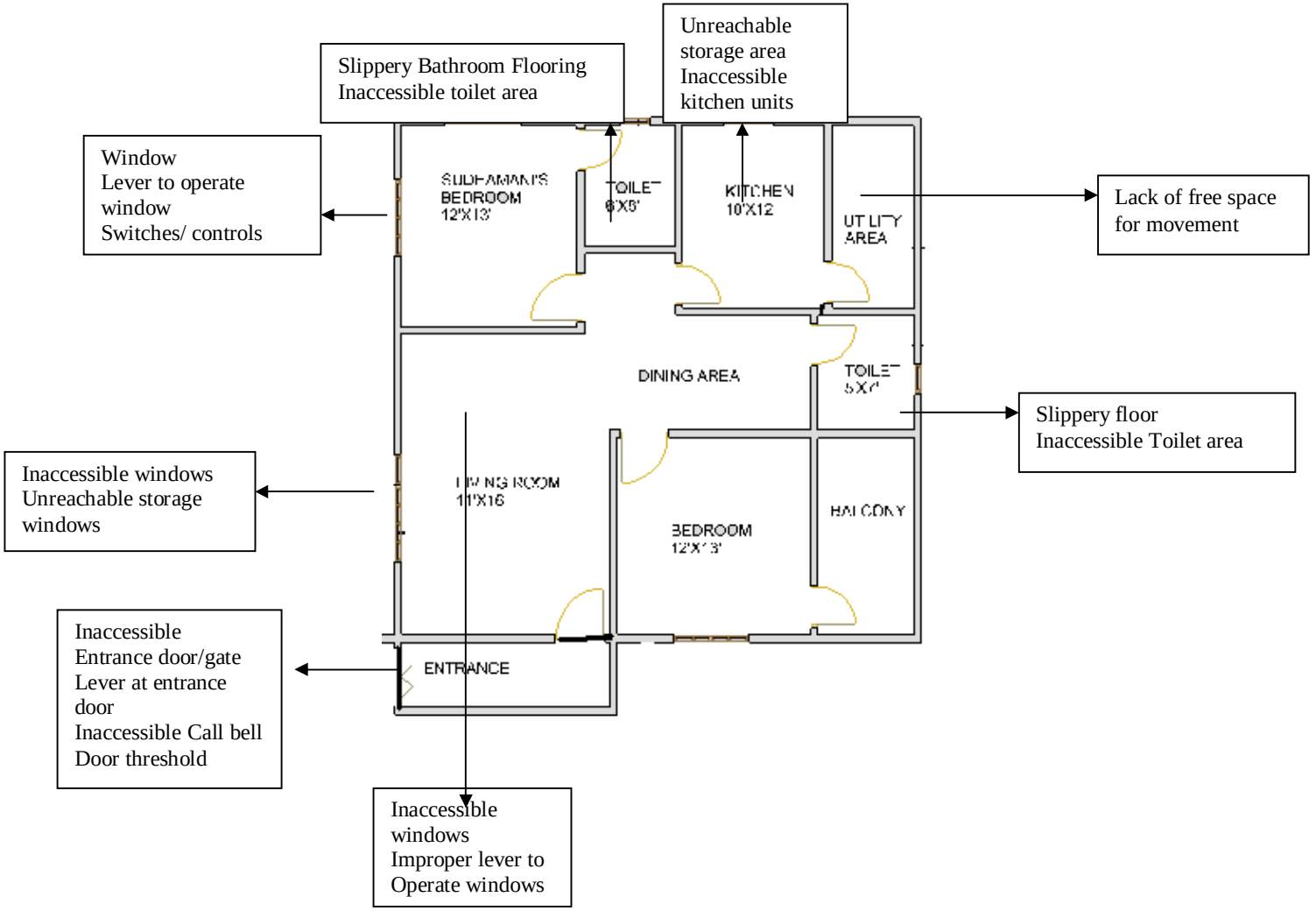


Figure 4.7House layout of Ms L. Sudhamani with the problem areas and features

- ⇨ Under the sink inadequate knee space is present which acts as a barrier when she tries to reach to the sink.
- ⇨ The light switches are present at a height of 5'-4" from floor level, which is slightly above her reach and to reach up to that level she has to strain herself.
- ⇨ Her wardrobe is just beside the bed. Between these there is a gap of only 2' which is of great inconvenience to maneuver her wheelchair. Due to this she can access her wardrobe only from a distance and can access only middle level shelves.
- ⇨ Presence of Indian toilet pan in the bathroom creates a lot of problems.
- ⇨ Bathroom has no provision to take support inside the bathroom.

Suggestions given by Sudhamani for improving his mobility and access in the home:

- ❖ Removal of threshold at the entrance iron grill to have an unhindered access to interior.
- ❖ Repositioning of call bell at a reachable level.
- ❖ Reduction of height of the kitchen counters to a level within her access.
- ❖ Introduction of low level accessible shelves.
- ❖ Introduction of grab bar near bath and toilet area to hold on while using those areas.
- ❖ Repositioning of the switch board at an accessible height especially near the bathroom

CASE STUDY – 8 :Mr.Parmeshwar Adipu: 40 years, Male.

Polio has made his both legs paralyzed; while his upper limbs are functional. He was affected by polio since, 5 years of his age, but he is using wheelchair since last 32 years. He stays alone with his flat in Kukatpally housing board locality, Hyderabad. He attends to most of the chores by himself, but some of the physical barriers in his house create accessibility problems. To overcome these and to attend to home maintenance, he depends on a paid help. He cooks by himself with the help of maid. However his sister who lives in Hyderabad visits him at least once in a week to sort his requirements.

He is a post-graduate and runs a tutorial institute to be financially independent from which he is able to earn Rs.3 lakhs per annum. He drives a car that has been adapted for his needs.

Day schedule of him is as follows:

6:30-7:30 - Morning stroll, exercises

7:30-9:30 - Personal chores, breakfast

9:30-10.00 - Travel to Office by self-driven car

10:00-1:00 - Tutorial Management

1:30-3:30 - Lunch and rest

3:30-4:00-Travels back to office

4:00-7:00 - Tutorial Management

7:30-10:00 -watches TV, dinner, goes to sleep

During week days his schedule is fixed but on weekends he spends his time with friends and keeps himself completely occupied.

Living Arrangements (Plate 4.8)

He needed very few adaptations to meet his requirements, as he feels the basic design of the house fulfills his maximum requirements.

Internal Conducive Provisions in His Flat

It is a two bedroom flat, with bedrooms present on either side of living cum dining room. Two toilets are there one is attached to the master bedroom and one common toilet is attached to living room.

- Kitchen is present besides dining area reduces his frequency of movement in those areas.
- Furniture in his room includes one bed, a study cum computer table.
- Dimension of the bed helps him to get in to and out of wheelchair.
- An open cupboard is present for his personal belongings.
- Windows are with low level levers to operate them.
- Bathroom floor is 1” lower than other floor level, which is of no inconvenience to maneuver with his wheelchair.

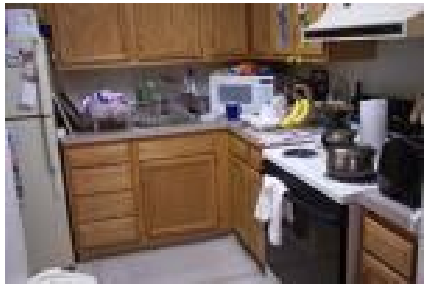
Tribulations in Living Arrangements (Figure 4.8)

He spends his maximum time in his living room and bedroom. Overall he feels very independent in his house but in some places he does face problems. Problems which acts as barrier in his home are:

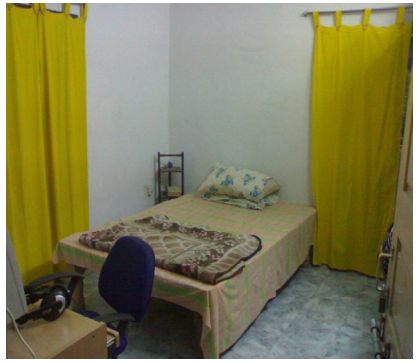
- ⇨ There is a floor level difference between the corridors of the apartment to the lift of 1” which makes him to struggle to overcome the barrier.
- ⇨ Entrance door is present at a level of 1” high from the external corridor of the entire apartments, which makes him to exert some strain to overcome the height by sitting on his wheelchair

Living room

Parmeswar Adipu



Kitchen layout



Bedroom

Bath cum toilet

Adaptation in Car interior

Plate 4.8 Living arrangements in the residence of Mr. Parmeswar Adipu

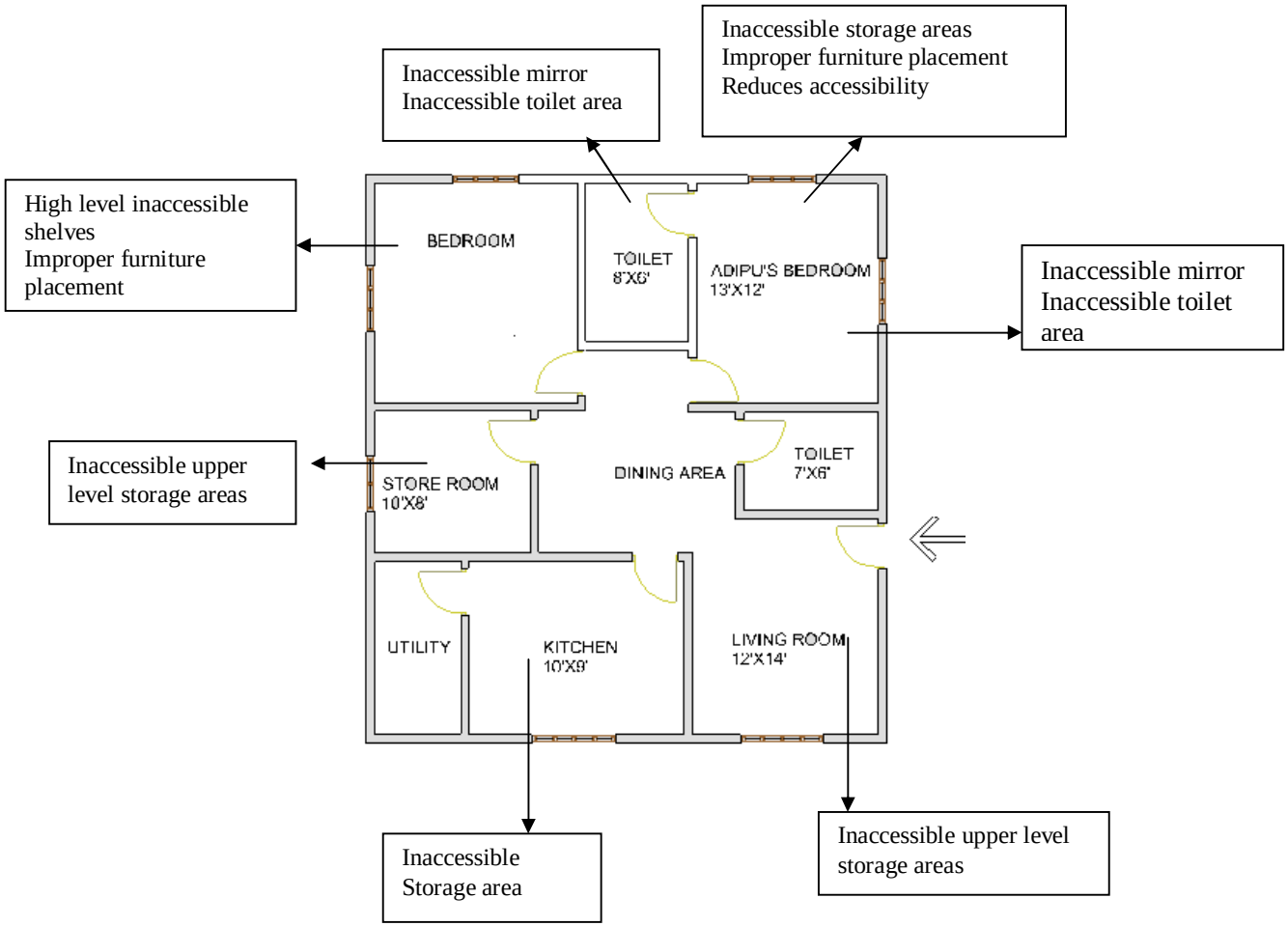


Figure 4.8House layout of Mr. Parmeswar Adipu with the problem areas and features causing hitches for access

- ⇨ The kitchen counter is present at a height of 2’8” from floor level; on the top of it cooking range is present.
- ⇨ An overhead cabinet is present in kitchen , where he used to store rarely used items as he can not reach up to that level ,and depends on his maid or sister to access the belongings present in that area.
- ⇨ He keeps his daily wear clothes in lower levels and rarely used dresses and books in upper levels as he cannot reach the upper levels of shelves.
- ⇨ Switch board near by to bathroom is present at a level of 5’4” from floor, which is slightly beyond his reach.
- ⇨ The bath and toilet areas are slippery and do not have any grab bar to hold on while accessing these areas.
- ⇨ He can not reach up to the level of mirror present inside the bathroom and above wash basin.

Suggestions given by Parmeshwar for improving his mobility and access in the home:

- ❖ Leveling the lift access path with the normal floor level.
- ❖ Repositioning of the switch board at an reachable height present near by to bathroom
- ❖ Introduction of low level accessible shelves in his room
- ❖ Change of flooring in bathroom from marble to anti skid variety along with the provision of grab bar all along.
- ❖ Reducing the height of mirrors present both inside the bathroom and along the wash basin to suit his visible range.

CASE STUDY – 9:Mr. Ravi Krishnan, 26 years, Male.

His case history reveals that, he had an accident 7 years back which had caused him several spinal cord injuries, as a result of which he is not able to use his lower limbs; even he is not able to speak. Since, last 5 years he is dependent on wheelchair. Earlier he was much dependent on his family members for his mobility, as he was not able to use his hands but presently after undergoing physiotherapy he is able to use his hands within a short range but he needs assistance from somebody for his wheelchair maneuverability to all the places. He tries to be independent but his physical condition does not permit him to be independent. He is staying along with his family comprising of his parents and a younger sister.

He had studied up to B.Tech 1st year, after that he had to discontinue his studies because of the accident. Now he spends time in reading books, newspaper, but cannot write properly. So, most of his time is spent in reading, watching T.V. He is dependent on family members for wheelchair mobility; due to lack of grip to hold he is fully dependent on his family financially. He belongs to a middle income group family with earnings of Rs. 2, 75000 p.a.

Daily Time Schedule:

6:30- 7:30:- Exercises

7:30-10:30:- Relaxation, finishes his personal chores.

10:30 – 3:00:- Goes for physiotherapy classes.

3:00- 5:00:- Lunch and rest

5:00-7:00:- Reading books enjoys evening with family.

7:00-10:00:-Watching TV, dinner, goes to bed

Living Arrangements (Plate 4.9)

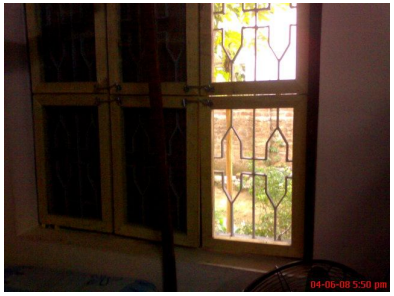
Ravi's family lives in their flat at Sonata Apartments, Vidyanagar, Hyderabad. House has lots of variation in floor levels with thresholds present in each room. As they have not renovated their house to meet the needs of Ravi as it was a ready-made flat, purchased for occupancy. However they have provided some conducive place for his living like - the location of his room attached to bathroom, close to main entrance and balcony. His room has a convenient bed a side table, and a wardrobe.

Accessible Provisions Incorporated In His Home

- He is having a personal bedroom present near by to toilet.
- He has space in his room to carry out all his activities
- The toilet is with western commode, and bathroom faucets are placed at appropriate height where he can easily access to them by being on wheelchair.
- All the rooms are in the same level with no floor level variation.
- Bed dimension helps him for easy movement between bed and wheelchair.
- Switch board is placed at an accessible height.
- Side table is present nearby to bed for keeping his personal belongings.

Ravi's Bedroom

Ravi Krishna in front of his house



Window and window levers

Bathroom faucets

Toilet

Plate 4.9 Living arrangements in the residence of Mr.Ravi Krishnan

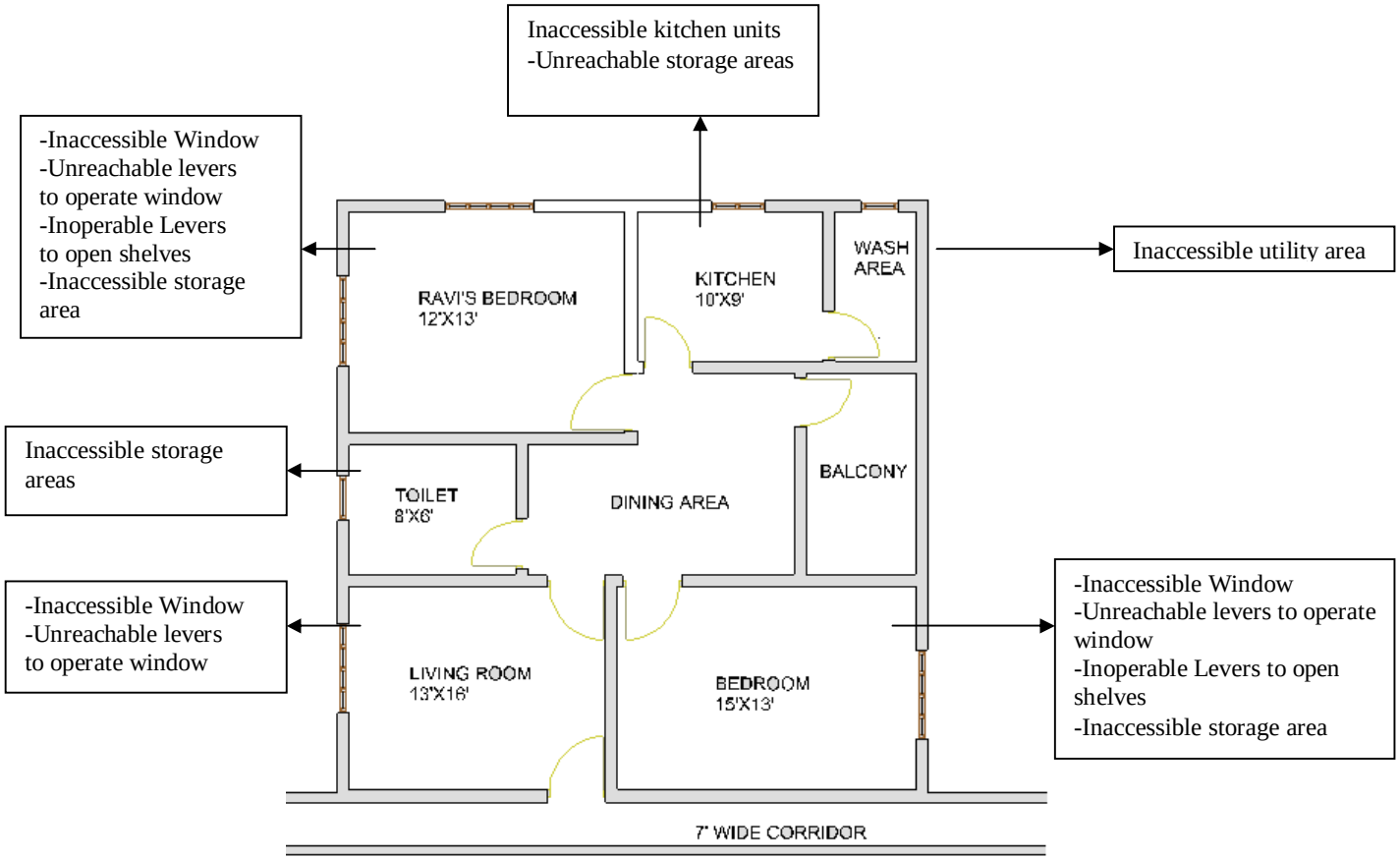


Figure 4.9 House layout of Ravi Krishnan with the problem areas and features

Tribulations in Living Arrangement: (Figure.4.9)

All of his activities are carried out in his room, toilet and living cum dining room. Rests of the rooms are not accessed to be used because of presence of threshold that causes a lot of difficulty for his mobility within the rooms

Accessibility problems faced by him are

- ⇨ Width of all the doors is 3’ which makes him to be cautious while going from one room to another. Window is present at an unreachable height of 3’ from floor level with lever present at top level which is beyond his reach.
- ⇨ Brass levers are present at doors but he cannot use them because of lack of grip to hold on.
- ⇨ The floor level of toilet and bath area is 6” above the floor level of other rooms.
- ⇨ Switch board is present at a height of 6’ from floor level which is beyond his reach.
- ⇨ Location of bathroom floor is at a height of 8” from normal floor level and present beside his room, so he needs to be lifted there.
- ⇨ Location of bathroom faucet is at a height of 3’ from floor level, where he can reach, but cannot operate that so, he depends on others to fetch water or to access shower tap.

Suggestions given by the Ravi for improving his mobility and access in the home:

- Repositioning of the switch board at an accessible height.
- Introduction of low level accessible shelves in his room.
- Leveling of the Bathroom floor variation.
- Replacing of bath room faucet from turn around type to slide lever type.

CASE STUDY - 10: Mr. J.Ramesh, 22 years, Male.

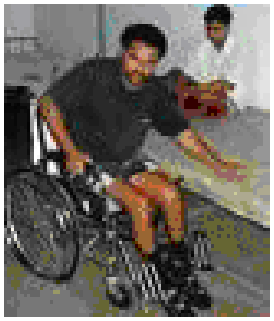
He is a polio affected young college going boy. At the age of seven he was affected by polio and this has made his right leg paralyzed, while his upper limbs are perfectly fine. He has been using wheelchair since last 12 years. He is the second son of his family. He is staying with his parents, and brother in a Flat, near Moosapet, Sanathnagar, Hyderabad. He belongs to a family of middle income group with earnings of Rs.2, 85000 /- p.a.

He does most of the works by himself, wherever it is barrier free. However in the areas where there are physical architectural barriers, he is partially dependent on his family members. Ramesh does not want his mobility condition to be a barrier for his financial independence, for which he is pursuing MA in Economics from Central University, Hyderabad. His family takes the responsibility of his transportation to his college. At University, he uses his tricycle, to move around to various departments. During weekends he prefers to play cricket with his friends in his apartment complex as he is fascinated by the cricket game. In his leisure time he used to write stories as he has a dream to join film industry.

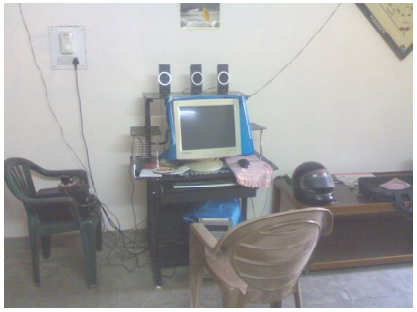
Living Arrangements:

Ramesh is staying with his family in a two bedroom flat which is incorporated with few modifications to meet his requirements. He feels very independent within his home because of spacious internal arrangements.

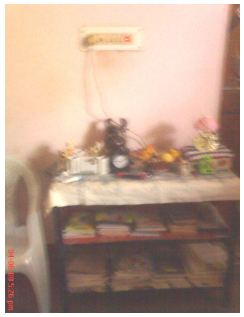
Ramesh's Bedroom



Ramesh in his living room



Study table arrangement



Storage area for books

Toilet Provision in Bathroom

Plate 4.10 Living arrangements in the residence of Mr. J.Ramesh

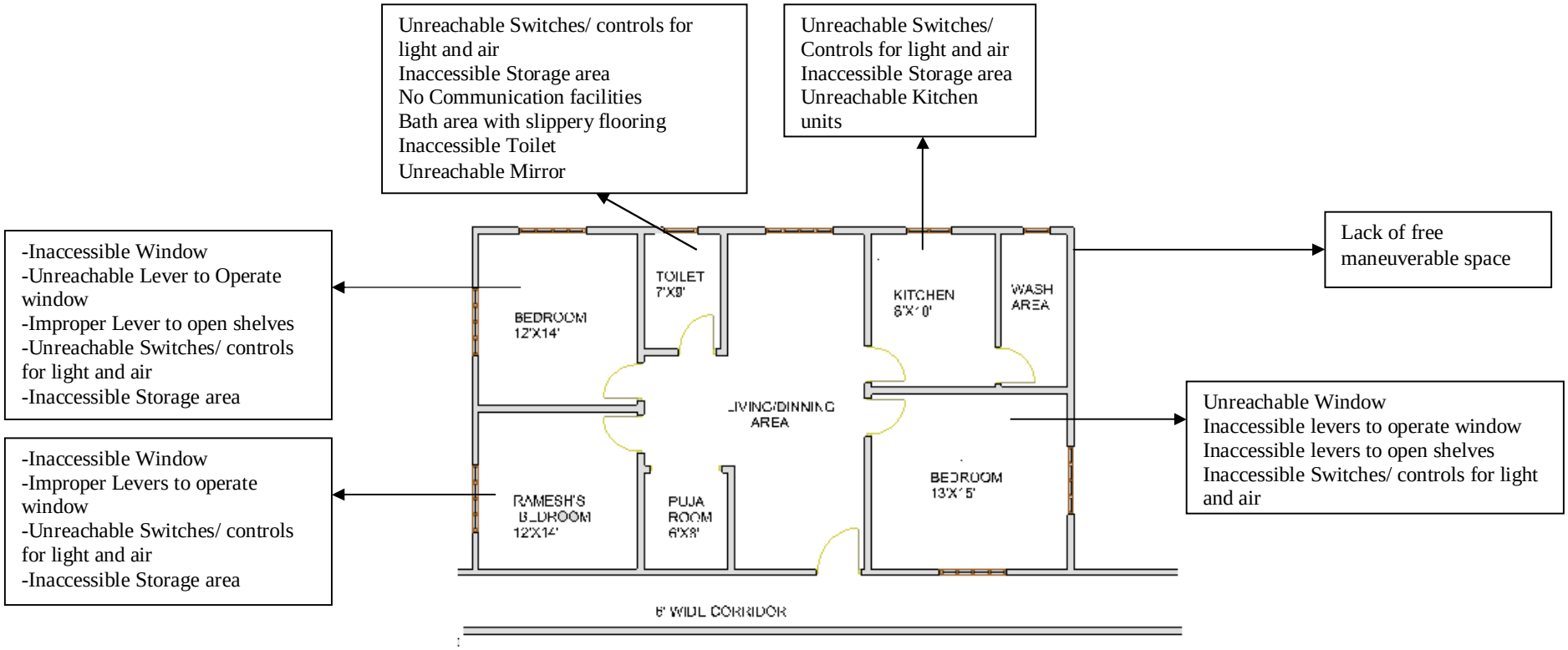


Figure4.10 House layout of Mr. J.Ramesh with the problem areas and features

Internal Conducive Provisions in His Room (Plate 4.10)

Furniture in his room includes one bed, a study cum computer table and a cupboard with out shutters for his personal belongings. Windows are with low level levers to operate them.

Problems in Living Arrangements: (Figure 4.10)

He spends his maximum time in his room for studies and in living room. Overall he feels independent in his house but in some places he does face problems, so he tries to avoid such places with barriers, otherwise seeks assistance from his family members. Problems which act as barrier in his home are:

- Threshold is present at door make him to struggle to enter into home.
- He avoids going to kitchen because of presence of thresholds, and high work counter. Even the storage shelves are present beyond the accessible range.
- The placement of utensils stand in kitchen is mounted on wall at a height from floor level; he can access the lower levels but cannot reach the upper slots.
- Improper placement of sink faucet causes problem for him.
- His computer tables dimension is overloaded with his belongings.
- Switch board for computer is present at the back of computer table.
- He used to keep his regular dresses and books in lower levels and rarely used dresses and books in upper levels.
- Bed room door is wide enough but it doesn't have any stopper to control it , which may lead to accidents some times.
- Bathroom has a small threshold of 2" height which he manages by holding onto the door or with anybody's assistance.

- Bathroom is having Indian toilet pan that was located 1’ above the bathroom floor level, creating difficulties for his toilet activities.
- Bath and toilet areas do not have any grab bar to hold on.
- He can not even reach mirror above wash basin present adjacent to bathroom.
- Flooring of bathroom is of marble, making him to be too cautious to move within the bathroom.

Suggestions given by Ramesh for improving his mobility and accessibility in the home:

- ❖ Repositioning of the switch board at an accessible height.
- ❖ Introduction of low level accessible shelves in his room.
- ❖ Change of flooring material in bathroom from marble to anti skid variety.
- ❖ Repositioning of mirror present with wash basin to a reachable range.
- ❖ Removal of threshold present in bathroom doorway.
- ❖ Replacing the Indian toilet pan with western commode.
- ❖ Leveling of bathroom and toilet floor to improve his accessibility within the bathroom.
- ❖ Introduction of grab bar in both bath and toilet areas.

4.2 GENERAL PROFILE OF THE RESPONDENTS

The general profile of respondents includes information pertaining to disability and wheelchair dependency, personal profile of the respondents and management of daily routine activities by the respondents.

4.2.1 Disability and Wheelchair Dependency

Information pertaining to reasons for disability, body parts affected, period of dependency, present state of health and the type of wheelchair used by the respondents is given in Table 4.1

Table 4.1 Disability and Wheelchair Dependency

Disability and wheelchair dependency	Reason for wheelchair bound				Total (N=10)
	Polio n=4)	Accid-ent (n=4)	Paral-ysis (n=1)	Cerebr-al Palsy (n=1)	
Age of onset of disability					
Birth	-	-	-	1	1
0-10Yrs	4	-	-	-	4
10-25 Yrs	-	3	-	-	3
>25 Yrs	-	1	1	-	2
Body parts affected					
Only lowers limbs	4	2	-	-	6
Lower and Upper limbs	-	1	-	--	1
Limbs and face	-	1	1	1	3
Wheelchair dependency in yrs.					
0-10 yrs	-	4	1	-	5
10-20 yrs	3	-	-	1	4
20-40 yrs	1	-	-	-	1

Information pertaining to the disability reveals that four of the respondents were affected by polio and while another four were victims of accident. Two other members were sufferers of cerebral palsy and paralysis. The body parts that

restricted their mobility were lower limbs in all the cases. Six respondents also had problems with upper limbs and deformed facial bones. Number of respondents suffering with prolonged disability was affected by polio. Four young adults who were the victims of accident had been on wheel chair for a period of less than 10 years.

4.2.2 Personal Profile of the respondents

The particulars related to the marital status, type of family support, educational qualification and employment by age group and gender is presented in Table 4.2.

Table 4.2 gives particulars of the sample by age and gender. Out of 10 respondents 7 were within the age group of 20-30 yrs and three were between the age group of 30-50 years. Among the young adults, 3 were males and four were female members. Among middle aged adults two were males. This means that equal number of males and females participated in the study. Except one person, everyone had the support of parental or conjugal family. Education level of the sample shows that only one sample had an informal education, and another was a dropout after intermediate studies. While five respondents have completed their graduation or post-graduation, two more are pursuing their post-graduate studies.

With regard to employment it is evident from table that three respondents were engaged managing their own enterprise, one of the respondent was employed outside home. But it is worthy to note that four of the respondents were dependent on family members for financial support.

Table 4.2 Personal profile of the respondents

Personal profile	No. of Respondents				Total (N=10)
	Young adults (n=7) (20-30yrs)		Middle aged adults (n=3) (30-50yrs)		
	M =3	F=4	M=2	F=1	
Marital status					
Married	-	2	1	1	4
Unmarried	3	2	1	-	6
Family support					
Self managed	1	-	-	-	1
Parental support	3	2	-	-	5
Conjugal support	-	2	1	1	4
Education					
Literate – (Informal)	1	-	-	-	1
Pre-university	-	-	-	1	1
Graduate					
Completed	-	1	1	-	2
Drop-out	1	-	-	-	1
Post Graduate					
Studying	1	1	-	-	2
Completed studies	-	2	1	-	3
Employment					
Nil (Financially dependent)	2	-	1	1	4
Employed outside the home	-	1	-	-	1
Self/ family enterprise	-	2	1	-	3
Pursuing studies	1	1	-	-	2
Economic Condition					
Low income (Rs 150000/-p.a.)	1				1
Middle income (UptoRs.300000/- p.a.)	2	2	1	1	6
Upper-middle income (Rs.300000/- & above)	-	2	1		3

The economic profile of the respondents shows that one of the respondents belonged to low income family, while a majority of six respondents belonged to middle income, and the remaining three belonged to upper-middle income group.

4.2.3 Management of routine chores by the respondents

The habits of managing of everyday jobs by the respondents with the assistance from family members or independently is shown in Table 4.3

Table 4.3 reveals the fact that with regard to oral hygiene (brushing) and eating all the 10 respondents were able to take it up independently, while two persons needed assistance for activities like bathing and grooming. Seven respondents needed assistance in toilet activities and clothing management. Cooking and home management was taken up independently by 3 and 4 members respectively. Also an equal number of respondents performed these two activities with the assistance of family members.

Table 4.3 Management of Daily Routine Activities

Routine chores	Numbers of respondents (N=10)	
	Independently	Assisted
Movement within the house	7	3
Oral hygiene	10	-
Toilet Activities	3	7
Bathing	8	2
Grooming / Dressing	8	2
Eating	10	-
Cooking	3	3
Home management	4	4
Clothing Management	1	9

4.3 Living arrangements and Views of respondents on accessibility to facilities

Information gathered with regard to the housing arrangement and adaptations made in the home, accessibility features in different functional areas and problems in these facilities are presented below.

Housing Arrangement and Adaptation in the homes

Table 4.4 shows the housing arrangement and adaptation introduced in the homes. This includes particulars on home ownership, type of building, adaptation made in the home before or after occupancy.

Table 4.4 Housing Arrangement and Adaptation Introduced in the Homes

Living Arrangement	Independent House (n=5)	Apartments (n=5)	Total (N=10)
Home ownership			
Own	5	5	10
Rented	-	-	-
Mode of Home Ownership			
Purchased Homes	1	5	6
Own Construction	4	-	4
Years of construction			
<10Years	2	3	5
10-20 Years	1	1	2
20-50 Years	1	1	2
>50 years	1	-	1
Modification in the design			
No modification	1	2	3
Renovated existing building	3	-	3
Introduced before purchasing home	-	3	3
Introduced at the time of construction	1	-	1
Features ascertained before occupancy			
Presence of lift	-	5	5
Close access to lift	-	3	4
Wide entrance doorways	1	3	6
Adequacy of space for wheelchair mobility	1	3	6
Adaptations made after occupancy			
Inclusion of curb ramp at entrance	2	-	2
Inclusion of ramp at entrance	1	-	1
Provision of second entrance door	2	-	2
Widening of main entrance	1	-	1
Reduction of kitchen counter height	1	-	1
Inclusion of W.C	-	2	2

Table 4.4 reveals that an equal number of respondents lived in Independent houses and apartments. Six out of ten houses were purchased, which were ready to occupy. Most of the independent houses were old and were constructed by family. Out of the 10 homes occupied by wheelchair users, 5 were constructed in the last 10 years and among them three were readymade apartments.

Data reveals that out of 10 respondents, 3 each were residing in the homes which were not modified, renovated after construction, ensured few features before purchasing. All the apartment dwellers took care of the access to lift provision before occupancy. In addition, three others who acquired apartments recently ensured features like close access to lift, adequacy of space for wheelchair maneuverability within the home and wide doors for entry and egress.

The independent houses were introduced with few adaptations like inclusion of curb ramp or ramp at entrance, provision of additional entrance for wheelchair access i.e. wide door, reduction of height of kitchen platform and introduction of western commode in the toilet.

4.3.2 Accessibility to facilities and views of respondents

Living arrangement accessible to the respondents, their satisfaction and reasons for dissatisfaction was explored and reported.

4.3.2.1 Approach to Home from Outside

The arrangements provided to approach the main building from building exterior by the wheelchair user is presented in Table 4.5. Entrance to main building was through a gate for 9 respondents but this provision was not satisfactory for two respondents as the gate was difficult to access and operate. All these nine respondents had parking space within the compound. But two were again dissatisfied as there was variation in floor level and less space for wheelchair mobility.

Three respondents entered into the house through portico or parking space and this arrangement was satisfactory to only one and the other two faced difficulty because of the difference in floor level and less of space for wheelchair movement. Three among the seven who had an access directly from gate to reach main door were unsatisfied either due to uneven walkway or presence of steps.

Table 4.5 Accessibility to facilities and areas at Approach area to house

Design Feature	No. of users	Satisfaction		Reasons for dissatisfaction						
		Yes	No	Une-ven floor level	Presence of steps	Impr-oper design	Diffi-cult to oper-ate	Prese-nce of thres-hod	Lack of supp-ort or hand grip	Less space for move-ment
Main gate	9	7	2	-	-	2	2	-	-	-
Parking space	9	7	2	2	-	-	-	-	-	1
Direct access from parking	3	1	2	2	-	-	-	-	-	1
Direct access from gate	7	3	4	3	1	-	-	-	-	-
Lift and lift control	5	3	2	1	1	-	1	-	-	-
Curb Ramp / Ramp	3	0	3	-	-	3	-	-	3	-
Call bell	10	3	7	-	-	-	7	-	-	-
Entrance door	10	4	6	-	-	-	4	6	-	-
Garden area	5	0	5	5	-	-	5	-	-	1
Utility area	8	1	7	5	-	-	5	5	6	2

Three respondents had the provision of ramp and curb ramp but none were satisfied as the design was not satisfactory for wheelchair movement and also it did not have any support or hand grip facility.

Four out of five apartment dwellers were satisfied with access to lift and lift control. One was dissatisfied due to the difference in two floor levels.

All the respondents had call bell provision near main entrance but the switch control was not reachable by seven respondents.

The main door which gave way to enter into the house was posing problem to six of them due to the presence of threshold and the door design was difficult to operate.

The other space that was connecting to outdoor area was garden area and utility area. Nearly all were dissatisfied with the access to this because of variations in floor level, presence of threshold and uneven walkway.

The above facts reveal that every respondent had some difficulty or the other in finding access to home from exterior of the building.

4.3.2.2 Personal (Bed) Room

The information obtained with regard to the living arrangements at personal (Bed) room are reflected in Table 4.6

Table 4.6 shows that all ten samples had a personal room with adequate space for various activities. Two respondents stated that there was inadequate space for circulation. Except for one respondent, all the others were satisfied with the accessible door. All of them had windows with latch for control, but only four were satisfied with the design and the rest were dissatisfied as it was unreachable and difficult to operate.

A salient feature from this table is that, though all the respondents had storage facility almost nine of them were discontented with this provision as the design was inconvenient to access totally and were difficult to operate its shutters.

Table 4.6 Accessibility to facilities and areas at Personal (Bed) Room

Design Feature	No. of use-rs	Satisfaction		Reasons for dissatisfaction						
		Yes	No	Unev-en floor level	Unrea chable height	Impro per design	Diffic-ult to access & ope-rate	Prese-nce of thres-hod	Lack of supp ort or grip	Less space for move-ment
Adequate space for activities	10	10	0	-	-	-	-	-	-	-
Space for circulation	10	8	2	-	-	-	-	-	-	2
Door / doors to enter & egress	10	9	1	1	-	1	1	1	-	-
Windows with latch for control	10	4	6	-	1	-	6	-	-	-
Storage for clothes	10	1	9	-	9	9	9	-	-	-
Switches and socket controls	10	6	4	-	3	4	4	-	-	-
Attached bath cum toilet	6	4	2	1	-	-	-	2	2	-
Access for emergency contact	10	4	6	-	6	-	6	-	-	-

Six respondents had access to attach bath. However two among them were dissatisfied as its door had threshold and the room was at a different floor level.

Access for emergency communication like telephone and intercom was provided in all the houses but for six respondents it was located at an unreachable height and was hence difficult to operate.

4.3.2. 3 Family room

The information obtained regarding the family rooms and the views of respondents are shown in Table 4.7

All the respondents had access to family areas like living and dining areas except one. Within the home all the nine respondents had sufficient space for various activities and wheelchair maneuverability except one. Eight were satisfied

with the free circulation space present within the rooms and two were dissatisfied due to lack of free circulation space.

The storage areas were posing problems to nine families except one respondent, and with the presence of window for light and breeze only four were satisfied and six were not satisfied.

Table 4.7 Accessibility to facilities and areas at Family Room

Design features	No. of users	Satisfaction		Reason for dissatisfaction						
		Yes	No	Vari-ation in floor level	Unr-eacha ble	Impr oper Des-ign	Diffi-cult to access & ope-rate	Pres ence of thres hold	Lack of hand sup-port	Inade quate circul ation
Door to access and operate	10	9	1	1	-	1	4	1	1	-
Window to control light & breeze	10	4	6	-	1	6	6	-	-	-
Space for all activities	10	10	0	-	-	-	-	-	-	-
Circulation space within room	10	8	2	-	-	-	-	-	-	2
Storage Area	10	1	9	1	9	9	9	-	-	-
Switch Controls	10	6	4	-	3	4	4	-	-	-
Emergency communication facility	10	4	6	-	6	-	6	-	-	-

4.3.2.3 Kitchen

Table 4.8 shows that the kitchen was accessed by only six respondents. Among them all were satisfied with the door position in kitchen and with the space for various activities. Among the respondents only two were satisfied and four were not satisfied with the kitchen counter as they were not able to reach up to that level with ease.

Four respondents however were satisfied with the circulation space for access to all areas and two were dissatisfied. Regarding the position of switch controls only of two were satisfied and four are not satisfied due to unreachable placement which was creating problems in accessing and operation.

Table 4.8 Accessibility to facilities and areas at Kitchen

Design Feature	No. of users	Satisfaction		Reasons for dissatisfaction						
		Yes	No	Vari-ation in floor level	Unr-eacha ble	Impro per Des-ign	Diffi-cult to access & ope-rate	Presen ce of thresh old	Lack of hand sup-port	Inade quate circul ation
Space for various kitchen activities	6	1	5	-	3	-	5	-	-	-
Circulation space to access all areas	6	4	2	-	-	-	2	-	-	-
Door to access and operate	6	6	-	-	-	-	-	-	-	-
Kitchen Counter	6	2	4	4	2	4	4	-	-	2
Knee space below kitchen Counter	6	2	4	-	-	4	-	-	-	4
Access to sink and faucet	6	3	3	3	2	3	2	-	-	-
Knee space below the sink	6	3	3	-	-	3	1	-	-	-
Window to control light and breeze	6	1	5	-	3	-	5	-	-	-
Storage shelves/cabinet	6	2	4	4	2	4	4	-	-	-
Switch Controls for lights & equipment	6	2	4	1	3	-	4	-	-	-

It was observed that with the presence of window to control light and breeze only one respondent was satisfied among six, the remaining five were not satisfied as it was present beyond their reach. Only two of the respondents were found to be satisfied with the kitchen counter, storage shelves, access to sink and the lack of knee space below but four were not satisfied.

4.3.2.5 Bath cum Toilet

Table 4.9 on the bath cum toilet arrangements of the respondents shows that, out of ten respondents six were satisfied with the door at bathroom but four expressed their dissatisfaction.

Table 4.9 Accessibility to facilities and areas at Bath cum Toilet

Design features	No. of users	Satisfaction		Reason for dissatisfaction						
		Yes	No	Vari-ation in floor level	Unr-eacha ble	Impr oper Des-ign	Diffi-cult to access & ope-rate	Prese nce of thresh old	Lack of hand sup-port	Inade quate circul ation
Door to access and operate	10	6	4	-	-	1	4	4	-	-
Circulation space for different activities	10	3	7	3	-	7	7	-	-	-
Faucets to access and operate	10	8	2	-	2	2	2	-	1	2
Water closet - Indian	5	-	5	5	-	4	5	-	5	2
Water closet - western	5	-	5		-	-	-	-	5	2
Wash basin	8	6	2	2	1	-	2	-	-	2
Mirror	8	0	8	-	8	-	8	-	-	2
Towel /cloth hanger	10	3	7	-	7	-	7	-	-	-
Storage space for soap / shampoo	10	6	4	-	4	-	-	-	-	-
Flooring	10	4	6	3	-	-	-	-	3	-
Switch Controls	10	6	4	1	3	-	3	-	-	-

Accessing Indian water closet was found to be most difficult area by all the 5 respondents. Though the rest had access to western toilet, all the ten respondents felt problem in accessing toilet without hand support. With regard to circulation space and flooring seven were not satisfied. Flooring was found to be a problem for 6 respondents because of difference in floor level and lack of hand support. Presence of door threshold, unreachable switch boards, access to towel hanger and

mirror were some of the problems expressed by 3 to 8 respondents. Eight respondents were satisfied with the type and placement of bathroom faucets. Two were dissatisfied with location of faucet and difficulty in operation.

4.4 Suggestions given by respondents for improving accessibility features

To arrive at the design solutions for the problems encountered by the wheelchair users suggestions suggested by each respondents were taken into consideration while developing the design solutions to improve their accessibility within their home were. These suggestions are tabulated under two sections.

4.4.1 Suggestions for improving access at outside the Home

Table 4.10 Suggestions for improving accessibility outside the home

Suggestions	No. of Respondents (N=10)
Renovate the curb ramp angle of inclination and provide hand rail	3
Introduce curb ramp in place of steps at the entrance	2
Relocate switch controls for light and call bell to a reachable height	8
Removal of collapsible iron door to sliding door	2
Removal threshold from main entrance door	4
Leveling the lift floor level with corridor floor level	2
Incorporate access to garden with wide and even pathway	4

Table 4.10 reveals that three respondents had given suggestions for renovating the curb ramp, while two had suggested for the introduction of ramp, removal of collapsible iron door with sliding door and leveling of the lift floor level with corridor floor level. Eight respondents had stressed on the need of relocation of switch control at a reachable height at entrance.

Suggestions by four respondents were for removal of threshold from entrance and incorporation of wide and even pathway to the garden among the ten respondents.

4.4.1 Suggestions for improving access at inside the Home

The suggestions given by the respondents for improving access in interior parts of their home is presented in Table 4.11

Table 4.11 Suggestions for improving access within the home

Suggestions	Numbers of respondents (N=10)				
	Personal room	Family Rooms	Kitchen	Bath & W.C	Utility Area
Wide single shutter door for free mobility	1	1	1	1	1
Removal of thresholds in all doors	1	1	1	4	4
Removal of second door shutter from the door frame	-	1	-	-	1
Change the position of door handle and latches to reachable height	6	6	-	7	3
Inclusion of door stopper in all the doors	4	4	2	4	2
Leveling the floors to match with other rooms	1	1	1	4	4
Provide shelves that can be reached and used	9	9	8	-	-
Storage shelf handles should be reachable and convenient to hold	3	-	1	-	-
Rearrange furniture for unimpeded circulation	3	-	-	-	-
Relocate the switch controls to reachable height	4	4	4	4	4
Alter the location of window latches from top to bottom	6	4	9	-	-
Replacement of bathroom faucets with long handle type	-	-	-	2	-
Lowering the placement of bathroom faucet	-	-	-	2	-
Change of different floor level in bath and toilet area to one level	-	-	-	5	-
Replace floor level squatting pan with western commode	-	-	-	5	-
Provide hand support for grip near shower and commode	-	-	-	10	-
Reduce the height of wash basin for easy access	-	-	-	3	-
Reduce the height of mirror for self grooming	-	-	-	3	-
Change flooring material to anti skid variety to prevent accident	-	-	4	6	4

Facts stated in Table 4.11 reveal that maximum suggestions were given by the respondents for the improvement of access in bath and toilet area. All the ten respondents had stressed on the provision for hand support nearby to bath and toilet area. Seven had suggested for relocation of door handles and latches at a reachable height in window, while six had suggested the need for change in flooring material to anti skid variety. Five respondents had asked for leveling of the floor level variation and change of squatting toilet pan to western commode.

Four respondents suggested the removal of threshold from doorways, leveling of the floors to match with other rooms and relocation of switch controls.

For personal room, family room and kitchen, nine respondents had suggested for the provision of low level accessible shelves, handles and latches at reachable heights, and alteration of the location of window latch from top to bottom.

4.5 Design solutions to improve accessibility in residential interiors

The information pooled out of the case study revealed that every respondent of the study had problems in accessing different parts of the interior and exterior. To overcome the inconveniences faced by them on day to day basis, they had proposed suggestions.

Taking their problems and suggestions into consideration, design solutions were evolved to improve the accessibility in residential interiors. The guidelines and standards suggested by various authors and authorities were used as theoretical support to develop feasible solutions. The design solutions are proposed as graphic models generated in AutoCAD 2007 in the form of plans and perspectives and are presented in Chapter V.

CHAPTER V

DISCUSSION

The results emerged out of the study on “Designing Functional Residential Interior for Wheelchair Users” are presented in this chapter and the compiled data is discussed under the following heads.

5.1 Case studies of the selected respondents

5.2 General profile of the respondents

5.3 Living arrangements and Views of respondents on accessibility to facilities

5.4 Suggestions given by respondents for improving accessibility features

5.5 Design solutions to improve accessibility in residential interiors

5.1 CASE STUDIES OF THE SELECTED RESPONDENTS

To explore the prevailing living arrangements of the wheelchair users and the problems faced by them in their homes on day to day basis, 10 adult wheelchair dependents who were in the age group of 20-50 years and were the victims of accident, paralysis, cerebral palsy or birth defects were contacted personally. List of respondents include

Case study 1 – Syed Afroz, Wahed Colony, Charminar, Hyderabad

Case study 2 – Anita Avula, Mehdipatnam, Hyderabad

Case study 3 – A.Nikhitha, Balanagar Housing Society, Hyderabad

Case study 4 – Dennissa Daya Rose, Malaysian Township, Hyderabad

Case study 5 – Rukhsar Begum, Nagole, Hyderabad

Case study 6 – Imtiyaz Ahmed, Hayath Nagar Colony, Hyderabad

Case study 7 – L. Sudhamani, East Marredpally, Hyderabad

Case study 8 – Parameswar Adipu, KPHB, Hyderabad

Case study 9 – Ravi Krishnan, Vidya Nagar, Hyderabad

Case study 10 – J. Ramesh, Moosapet, Sanathnagar, Hyderabad

The sample identified for conducting research was represented by an equal number of male and female members, who were residing in either independent houses or multi-storied apartments in different locations of Hyderabad city, Andhra Pradesh. Some of them were wheelchair dependent for more than 20 years and had been dependent on family members for managing their daily activities. All of them lived in their own house and had a separate room easily accessible from entrance. For a few of the respondents moved out of the home either for higher education or for employment. Two of them opted to secure higher education for financial independence, while three were involved in managing their own family enterprise and one other individual was employed outside the house. Almost all the houses except one had introduced few features to meet the needs of the wheelchair dependents. Though these met the needs to some extent, almost all were dissatisfied with the living arrangements. In order to overcome those barriers, they suggested a number of solutions.

Independent analysis of case studies revealed that each one desires to be self-dependent in spite of physical limitations and aspire to be financially secured. analysis of the information collected from these respondents reveals the importance of taking up research to improve the residential building design features.

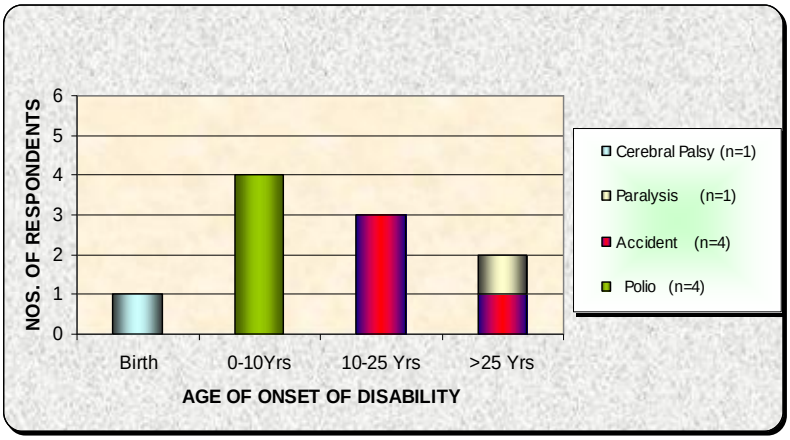
5.2 GENERAL PROFILE OF THE RESPONDENTS

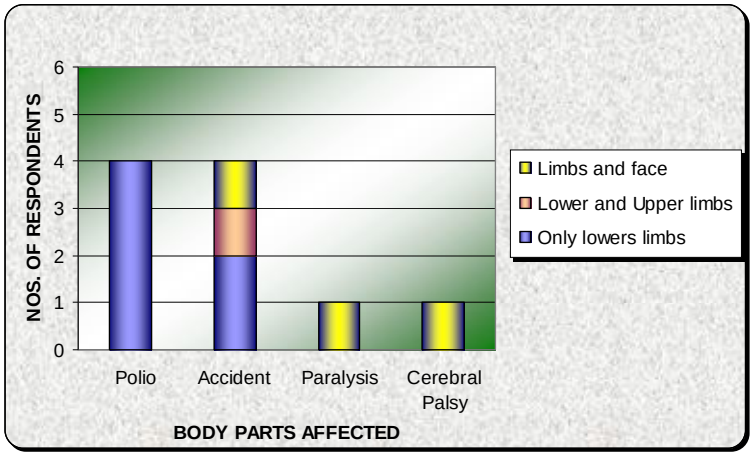
5.2.1 Disability and Wheelchair Dependency

An analysis of Table 4.2 and Figure 5.1 reveals that four out of ten samples were on wheelchair due to road accidents and this coincides with the views of Mahesh (2006) who stated that the increasing rate of urbanization and vehicular population in the country is leading to some unavoidable accidents daily, which may result into some permanent physical limitations. One respondent, who was affected by cerebral palsy, migrated from remote rural area of Andhra Pradesh for treatment. Poverty and illiteracy may be the reasons for these birth or genetically disorders as cited by Zutshi, (2007).

The facts emerged out of the study divulge that everyone had the problem with lower limbs, while those who were the victims of accidents, paralysis or cerebral palsy also had problem with upper limbs. According to Adak, (2004) these problems changed the anthropometry of body and in turn their normal mobility, access and reach.

Five respondents were dependent on wheelchair from a very small age while rest became dependent on it after the mishaps that occurred in their adulthood. This situation proves that disability is not restricted to any age or gender and can occur to any one at any stage of life. Foreseeing the situation has become inevitable in the present days with rise in man-made crisis. Hence, every home that is designed to meet the needs of its users should ensure an environment that is universal or barrier-free.





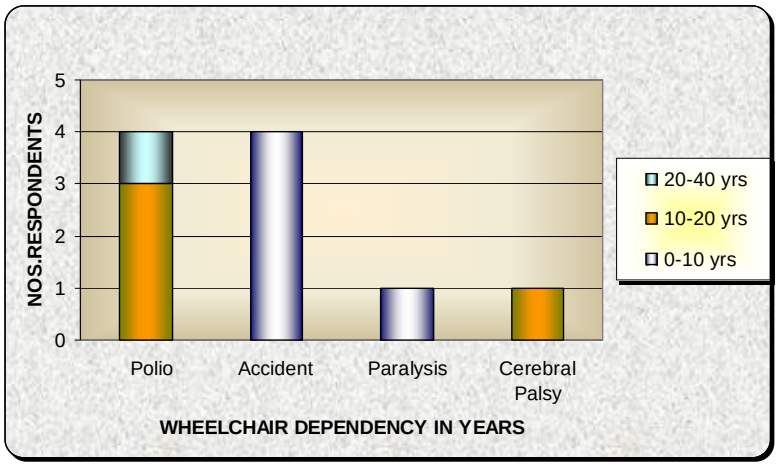


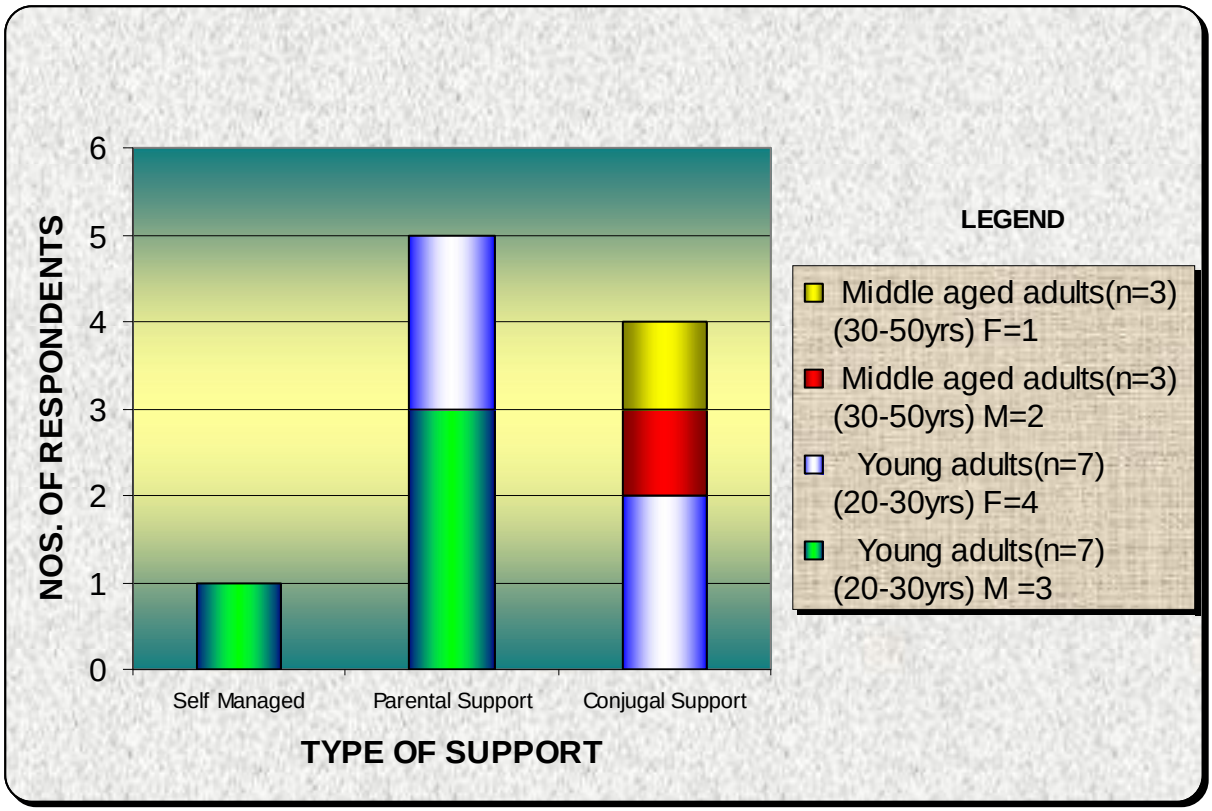
Figure 5.1 Disability and wheelchair dependency

5.2.2 Personal Profile of the respondents

The particulars related to marital status, type of family support, educational qualification and financial dependency can be recalled from in Table 4.1. It can be noticed that maximum (7), out of the 10 respondents were young adults within the age group of 20-30 years (Figure 5.2a). This may be due to some inevitable biological disorder like attack of polio, cerebral palsy occurs at an early age apart from some unnatural accidents, (Indian census (2001), NSSO, (2002) and Mohapatra (2007). It can be observed from Figure 5.2b that respondents depended on parental and conjugal homes for managing their day to day chores. Zutshi,(2004) and Parry & Thompson(2005), stated that respondents preferred to be at home instead of going for any rehabilitation center as home gives better care and attention.

Another interesting observation in this research is that, six members even moved out of the home either for education or financial independence. This proves that physical limitation did not come in the way of either higher education or financial security. As cited in NDA (Kumkumian, 2004), if barriers can be minimized inside and outside the home, disabled population can equally participate in productive activities and join the mainstream.

The observation made through case studies on economic status of the respondents showed 9 respondents who belonged to middle and upper-middle income families received more care from family members and also facilities for living made conducive. The only respondent who belonged to lower income group was made to adjust to the old ancestral home without any modification. This observation coincides with (Zutshi,2007)



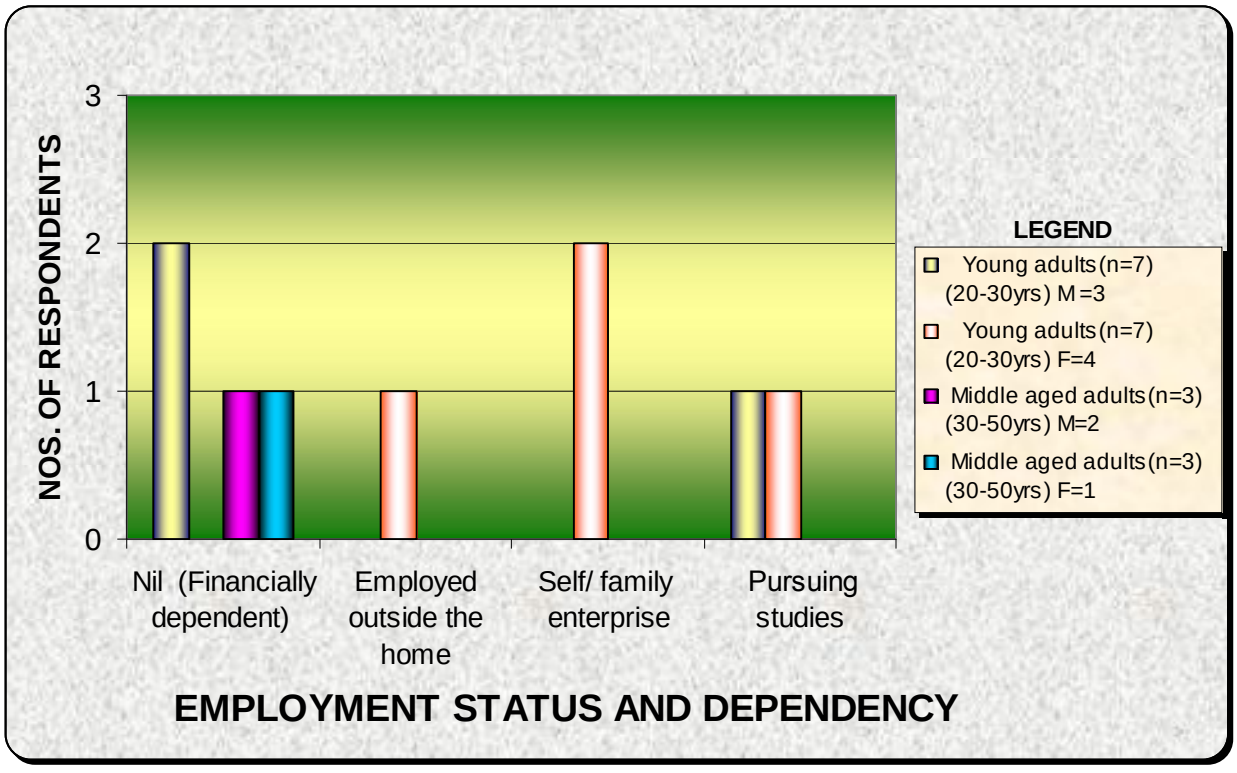


Figure 5.2 Type of family support and financial dependency on the family

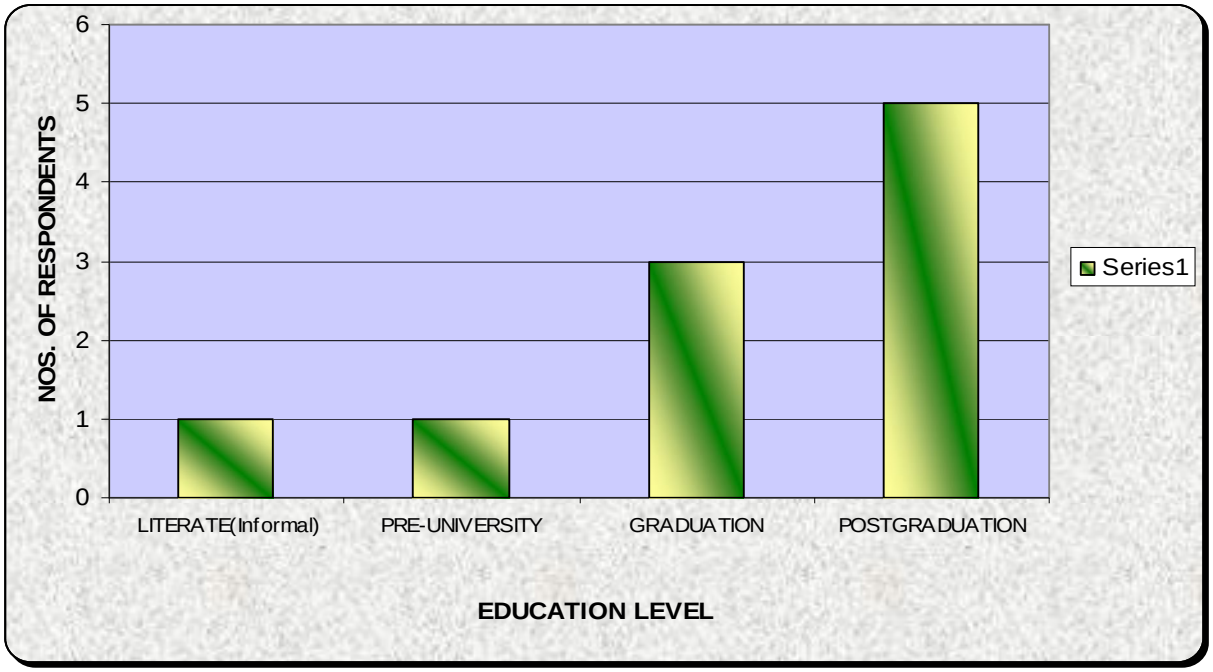


Figure 5.3 Educational statuses of the respondents

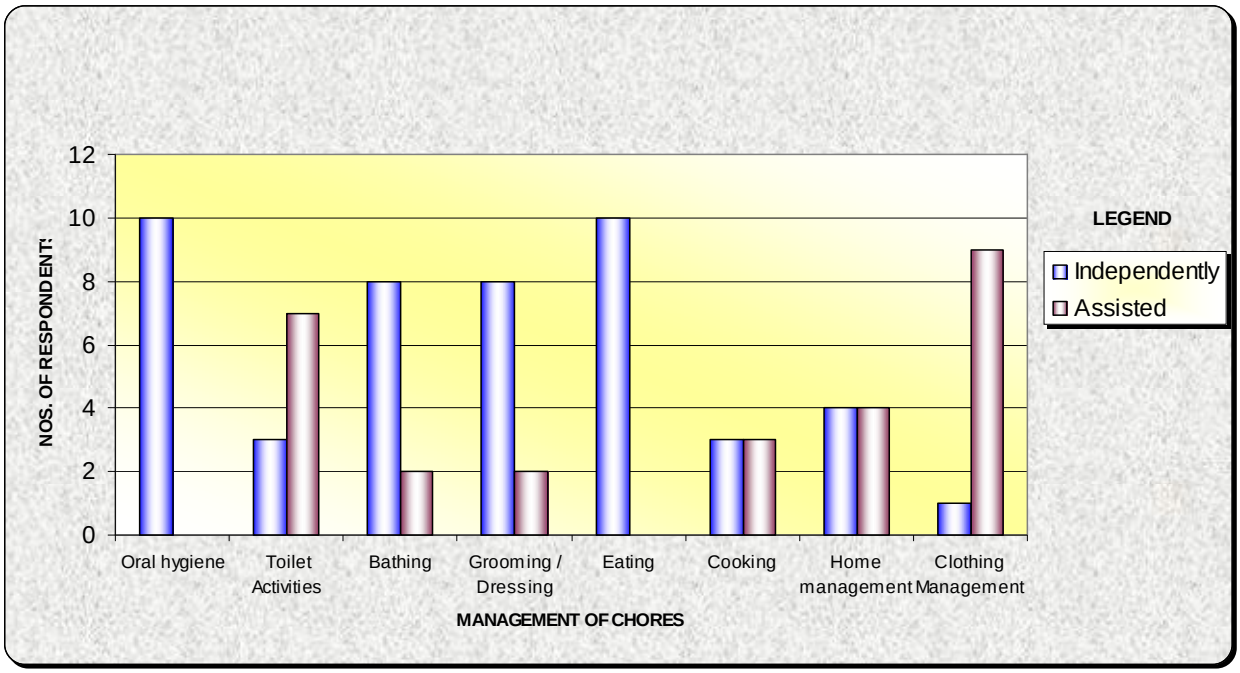


Figure 5.3 Management of routine activities by respondents

5.2.3 Management of routine chores by the respondents

The habit of managing everyday jobs by the respondents with the assistance of family members or independently is shown in Table 4.3 and Figure 5.3. Results reveal that almost all the individuals were dependent on family support for performing their life supporting activities. This may be due to difficulty in accessing either various parts of the home where these activities need to be performed. The study reported by Holicky (2008), coincides with the outcome of this research which says that wheelchair users are dependent on family support due to the presence of various physical barriers within and outside the home.

5.3 Living arrangements and Views of respondents on accessibility to facilities.

Information gathered with regard to the housing arrangement and adaptations made in the home, accessibility features in different functional areas and problems in these facilities are discussed below.

5.3.1 Housing arrangement and adaptations in the home

The housing arrangement and adaptation made in the homes can be recalled from the Table 4.4.and Fig 5.4. Wheelchair dependents were found to live in independent homes and in apartments in equal number and this fact prove that they are accommodative to adaptations at the home which facilitates mobility. It is also motivating to note that residents irrespective of physical limitations, wished to live in ownership houses even though it is an apartment. (Lund and Foord, 1999). This may be to cope up with the increasing demand on housing in fast growing cities like Hyderabad.

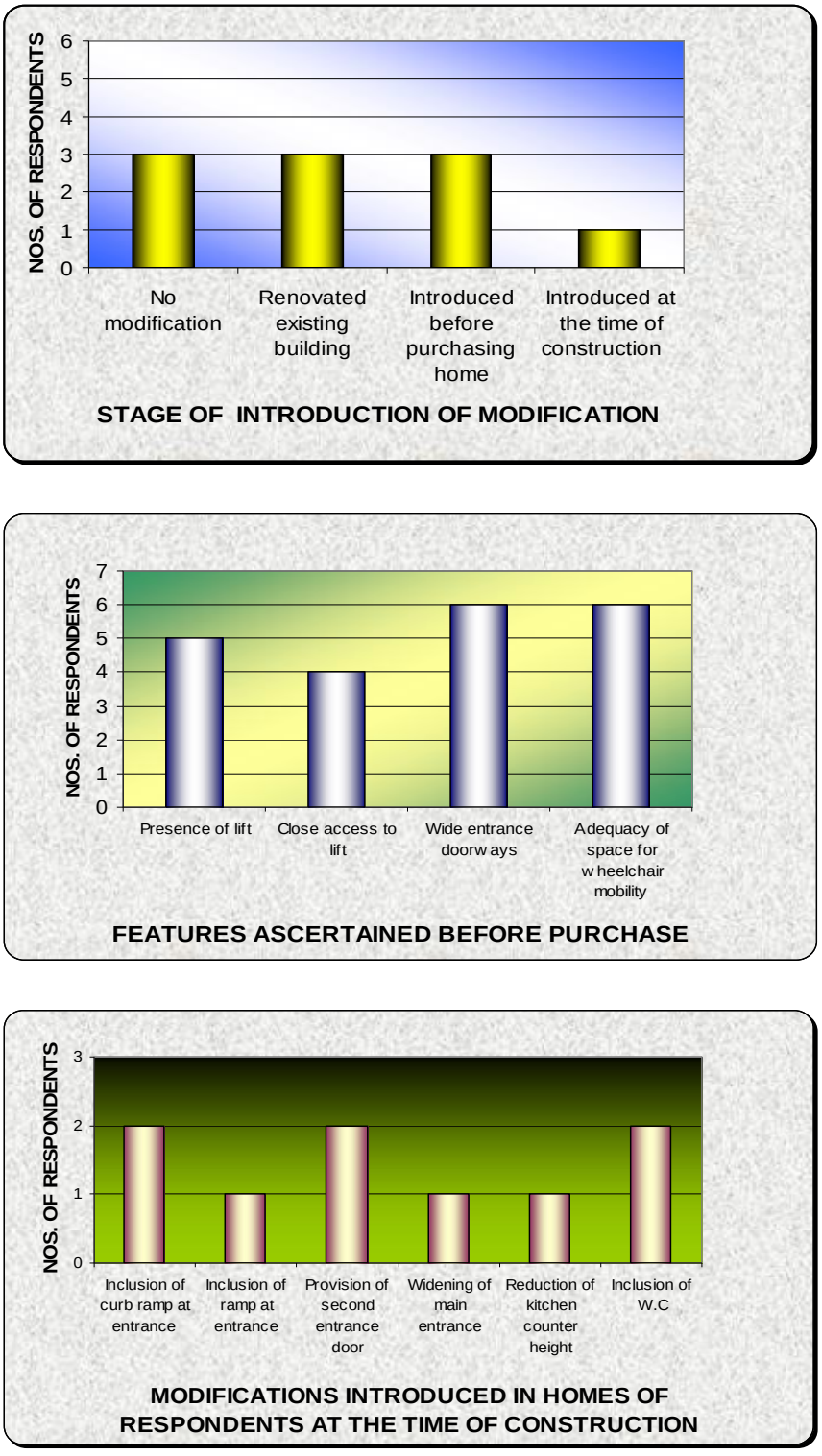


Figure 5.4 Showing Housing arrangement and adaptation in the building design

Among the 10 respondents, 3 were residing in the homes which were not modified at all. Others lived in the houses which were either renovated after construction or purchased with a few accessibility features**.** With the increasing availability of apartments in Hyderabad city, at least 3 wheelchair dependents opted to live in the high-rise buildings as the architects were willing to take up customization to meet users' needs. Hence, few modifications in the structure were ensured before occupying the new homes. In the case of independent houses, it was observed that family's economic condition, availability of space in and around the house and interest of family members influenced families to incorporate modifications in the exterior and interior to meet the needs of family members on wheelchair. This analysis proves that most of the families have concern for their disabled family members to facilitate them to live comfortably.

One of the individual house which was an old ancestral home and two other houses in multi-level buildings were not introduced with any modifications or renovations. This may be due to poor economic condition, sentiments attached to old ancestral homes; space and design constraints. This situation coincides with the views of Zutshi (2004) who stated that in Indian scenario, disable population adjust themselves to live in any condition.

5.3.2 Accessibility to facilities and views of respondents

Analysis on living arrangement accessible to the respondents, their satisfaction and reasons for dissatisfaction are as follows.

5.3.2.1 Approach to Home from Outside

Table 4.5 and fig 5.5 presents a clear picture of the provisions for access by family members on wheelchair. All the houses except one had entrance gate, driveways, walkways to find entry into the home. Improper slope and gate design at entrance, width of walkways and undulated flooring, inadequate space for wheelchair maneuverability from parking area were some of the reasons for dissatisfaction in the approach area. This is in conformity with the view of Darrel (2005)

The width, inclination and lack of hand grip were some of the problems related to ramp and curb ramp. Studies on ramp and curb ramp design (Cappozo.et.al, 2005) and Sanford, et.al. (1996) reveal that many wheelchair users faced difficulty with improperly designed ramp.

Six respondents had problem in accessing main entrance door due to the presence of threshold and the design of doors like type of door and door swing and door width. Study reported by De Medici, (1997) states that presence of barriers in doorway causes inconvenience to the wheelchair users.

From the above analysis it can be inferred that lack of knowledge about the wheelchair user's anthropometry and physical limitation of wheelchair users may be the reasons for not giving importance to design issues.

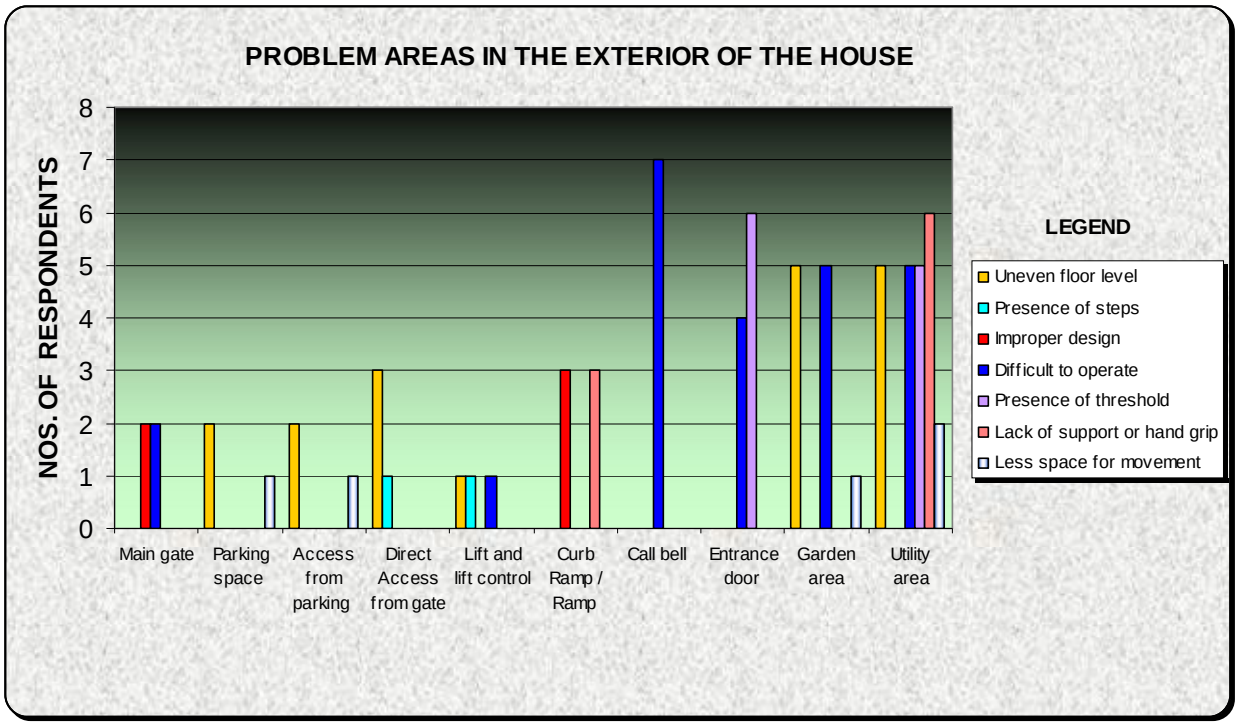
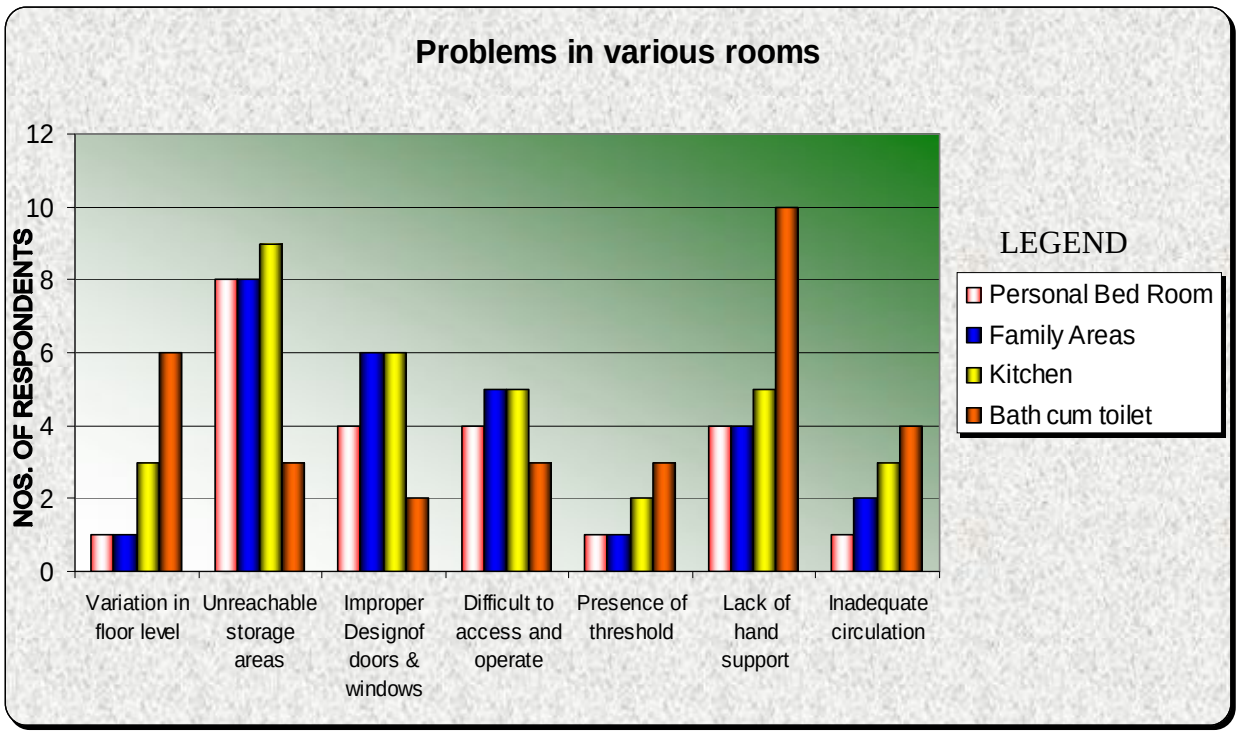


Figure 5.5 Problem areas and reasons for dissatisfactions at approach area outside the home

Figure 5.6 Reasons for dissatisfaction with living arrangement inside the Home



5.3.2.2 Personal Room (Bed)

A convivial observation from the study was that every respondent had a personal room and seven among them had an attached bath and W.C.

From the table 4.6 and fig 5.6 it can be seen that with regard to their satisfaction with the prevailing arrangements, all respondents except one the others were satisfied with the door design. The only respondent who was dissatisfied with the door provision said that it was due to the presence of very high threshold in the doors that connected his room to others, variations in floor level, design of door and its position.

Position of latches in windows also prevented their access to operate it, as this was above the reach level. The windows were also difficult to access by 6 of them as the furniture was placed in front of windows. Storage provision was not satisfactory as this was not possible to be reached and they had to depend on other family members in accessing and managing their clothes. If the design of the storage shelf can be modified keeping in mind the users' anthropometry, it may result in better satisfaction.

5.3.2.3 Family areas

From Table 4.7 and figure 5.6 it can be seen that all the respondents were having easy access to door to operate it except one because of presence of threshold and difference in plinth level. However, within the room all the respondents were having space for various activities, while eight were satisfied with the free circulation space within the room, two expressed their dissatisfaction because the rooms were small in size and the furniture arrangement in it reduced the free circulation space.

Six respondents were unable to access top few shelves in storage areas in living and dining areas as these were beyond the reach. In this room 6 respondents were not satisfied with window location and the design and location of levers. These facts also reflect the importance of users' needs in the design of dwelling.

5.3.2.4 Kitchen

From Table 4.8 and Figure 5.6 it can be seen that the kitchen was accessed by all the five female respondents and one male respondent. All of them were satisfied with space available for various activities and circulation space to reach every area in it. Only two respondents were satisfied with the kitchen counter, storage shelves, access to sink and the knee space below the counter. The remaining 4 were not satisfied as they did not have clearance space and reaching heights. However with regard to the presence of window to control light and breeze, only one was satisfied among six respondents. The rest five were dissatisfied as the latch control was present beyond the reach. These facts confirm that women had problem in working in kitchen and had to face number of constraints.

5.3.2.5 Bathroom

From the table 4.4d and Figure 5.6 it can be observed that except one of the respondents all of them had access to attached bath and W.C. Out of the 10 respondents, only six were satisfied with the door features and the rest were dissatisfied because of presence of threshold and narrow doorway. With regard to circulation space two were not satisfied because of inadequate maneuverable space. and slippery flooring. It was interesting to note that eight respondents were satisfied with the type and placement of bathroom faucets as they were within their accessible range.

With regard to water closet six of the respondents had accessibility to Indian water closet and rest had western closet. None of the respondents were satisfied with the arrangement of toilet pan, due to lack of support in the wall for getting up from toilet seat and floor level difference within toilet. Seven of them were also dissatisfied with the storage areas for soap / shampoo as this was beyond their reach. None of the respondents were satisfied with the position of mirror level as it was beyond view range.

From the above analysis of the problems faced by the respondents at home, there were many areas in the house which were not compatible for the use like the differences in floor level, unreachable height and distance, problems in the design of door, window, storage provisions, inadequate circulation space to move and access different areas and objects, lack of hand grip in toilet and lack of knee clearance space in kitchen. These findings are close to the particulars revealed by Mahesh (2007)

5.4 Suggestions given by respondents for improving accessibility features

Respondents views for overcoming the barriers or problems faced on day-to-day basis are taken into consideration as suggestions. These were used as a direction for while developing the design solutions to improve their accessibility within their home were. The suggestions given by the respondents are discussed below.

5.4.1 Suggestions for improving access at outside the Home

The suggestions proposed by the respondents for improving the access were introduction of curb ramp in place of steps at the entrance, renovation of inaccessible curb ramp with reduced inclination and provided with hand rail, relocation of switch controls for light and call bell to a reachable height, removal of collapsible iron door to sliding door, removal threshold from main entrance door, equalizing the lift floor level with corridor floor level and incorporate access to garden with wide and even pathway.

From Table 4.5.1 it can be seen that eight respondents suggested the need for reduction of switch board height for easy reach. Four respondents had given suggestions for removal of threshold from entrance door and incorporation of wide and even pathway to the garden. These suggestions are found to be similar to the suggestions given by Shilpi and Mallikarjun (2000), Mona (2000), Sanford (1996), Lars (1986), who stated that the surface of an accessible pathway should be smooth, continuous, non-slippery and even.

Two of the respondents wanted to renovate the curb ramp inclination and increase the width of it, while the only respondent who had the ramp to connect the gate to main building wanted the hand railing. Two more respondents wished for replacement of steps with ramp. This suggestion coincides with the facts suggested by Canale.et.al, (1991) and Cappozo et.al (1991) and Sanford, et.al. (1996). They have suggested that for a 1-meter ramp length, allowable maximal incline was 15%; up to a 3-meter ramp length, the maximal incline was 10%. Sanford et.al (1996), Robert (1992), Grosbois (1991) who worked on the research on ramp said that all ramps should possess handrails with 30–50 mm of diameter for easy gripping.

5.4.2 Suggestions for improving access within the Home

Suggestions received for improving the internal convenience were wide single shutter door for free mobility, removal of thresholds in all doors, removal of second door shutter from the door frame, change in the position of door handle and latches to a reachable height, leveling the floors to match with other rooms, provide shelves that can be reached and used, inclusion of storage shelf handles at reachable and convenient height, rearrangement furniture for unimpeded circulation, relocation the switch controls to reachable height, alter the location of window latches from top to bottom, replacement of bathroom faucets with long handle type, lowering the height of bathroom faucet, evening different floor levels in bath and toilet area to one level, replacement of floor level squatting pan with western commode, provision of hand support for grip near shower and commode, reduce the height of wash basin for easy access, reduce the height of mirror for self grooming, change flooring material to anti skid variety to prevent accident. These suggestions are found to be similar to the suggestions given by Shilpi and Mallikarjun (2000), Mona (2000), Sanford (1996), Lars (1986) who suggested the need for compatible solutions for wheelchair users.

According to table 4.5.2 maximum numbers of suggestions were given for the improvement of access in bath and toilet area like provision of grab bar, wall mounted W.C and non slippery flooring. These suggestions also coincide with the recommendations by Joseph, (1990) Dansk (1984), and.(Cappozo et.al,1997) that bath and toilet area should be fitted with grab bars near toilets and shower area at a height between 0.85 m and 0.95 m from the floor.

5.7 Design solutions to improve accessibility in residential interiors

To evolve design solutions to the problems stated by the respondents in their homes and suggestions proposed by them for improving accessibility, various guidelines and standards suggested by different authors and authorities were taken as the theoretical support. This includes the Guidelines from Office of the Chief-Commissioner for persons with disabilities.-India (2005), ADA Compliance Guide, USA (1991), American National Standards Institute New York (1986), Central Coordinating Committee for the Promotion of Accessibility for the Disabled,(1988), The Canadian Paraplegic Association(1989), Netherlands Ministry of Transport and Public Works(1986), Denmark Ministry (1972) and also from the research outcomes of different authors like Mona,(2000), Karanti, (2000), Shilpi and Mallikarjun(2000), Pinto et al (1997), Grosbois, Louis. (1991), Park Sharon and Joseph,(1990) Manitoba Division(1989), Lars Reutersward(1986), Dansk,(1984), Woodson,(1981), Goldsmith,(1976), Beckman,(1976) and Copenhagen (1974) (Kirvesoja et al., 2000; Pinto et al., 2000), The solutions proposed to overcome different problems were presented in the form of tabulated statement. This covered the particulars on the problem areas in the residential buildings, suggestions given by respondents, recommended guidelines and standards and the proposed solutions.

Table 5.1 Problem areas/features reported in residential building, suggestions given by respondents, recommended building design guidelines and proposed design solutions.

Problem areas reported in the study	Design solutions suggested by the respondents	Recommendation Design Guideline/standards	Proposed Design solutions
Driveway/Parking	Wide drive way with no floor level difference and should be easily accessible from main entrance of the house	-Shelter parking from rain, - Grades ≤ 1:20 - Avoid changes in level (steps) where possible - Provide an access aisle	Accessible parking spaces near the buildings with recommended width of 3.90 m, access aisle of 1.20 m wide in between two ordinary parking spaces, 3.60 m wide drop-off area,
Ramps (Exterior)	Replace steps at entrance with curb ramp or ramp with hand rail with proper grip. Reduce the angle of inclination of curb ramp/ramp and provide hand rail	- Rise ≤ 30" (at 1:12 slope) - Length ≤ 30' (slope > 1:20) - Width ≥ 3' (for 1 wheelchair) - Width ≥ 5'4" (for 2 wheelchairs) - Slope ≤ 1:20 (never > 1:12) - Cross slope ≤ 1:50 - Handrails for ramps > 1:16 - Handrails extended 1' beyond top and bottom of ramp - Slip-resistant surface -Color contrast at changes in level -Lighting ≥ 50 lux at floor level and 300 lux at top and bottom of ramp	Accessible, well illuminated, non-slip ramps of minimum 0.90 wide with 1:20 steeper slopes having both side railing mounted at a height between 0.85 m and 0.90 m The curb ramp of 1.20m and having slop 1:12 should be provided at level differences between the drive way surface and pathway level.
Walkways	Wide even flooring without floor level difference, well illuminated	- Surfaces firm, even and slip-resistant - Pathways 5' wide - Site grades (used by pedestrians) ≤ 1:20 - Site grades in pedestrian routes ≤ 1:12 - Lighting ≥ 50 lux - Hand rails shall be provided for ramps/slope ways - Lighting ≥ 300 lux on all changes in level	Width of walkways should be- 5 feet, exclusive of curb and obstructions.
Main Entrance	No level difference between exterior pathway and entrance, wide doorways, no door threshold, easily operable door latch within reach	-Door threshold ≤ 0.5" - "good overall lighting" for security - Shelter entrance from the elements - Provide easy to see, lighted doorbell - Construct/raise porch to be level with interior floor surfaces - Provide focused lighting at door handle and lockset	Minimum of 32 " wide doorway with door threshold of < .5", preferably Non-skid flooring and grab-bars near door to hold on, provision of light-switches close to door

Problem areas reported in the study	Design solutions suggested by the respondents	Recommendation Design Guideline/standards	Proposed Design solutions
Interior Doors/Doorways	Wide doors with no threshold and should be easy to open. In bathroom sliding door is preferred	-Doorway opening ≥ 32" - Door handle height 30-36" - Lever style door handles -Width = 36" -Height = 80" -Threshold height = 0.5" - Lever or loop style handle - Handle height 4'6" -Sliding door made of opaque materials -Handles obvious and of different color to the door -Use lighting to increase color contrast between door and surroundings -Install swing away door hinge in narrow doorways -Easily operable locking mechanism - Include secondary "peep" hole at lower level (for shorter or seated people) - Provide auxiliary door handle to facilitate closing	An accessible, threshold free sliding door with opening of at least 4' for exterior and 32" for interior door should be provided. The door handles and Locks should be mounted at a height between 3' and 4' from the floor surface. Where ever possible automatic doors should be provided for any kind moving aid users.
Wardrobe/ Closet /Storage	Easy to access shelves within reach and preferably with easy to slide sliding shutters	-Use adjustable shelves and hanging rods -Loop handles on doors -Properly illuminate closet -Closets deeper than 18" should have door opening of 32" -Shelf height 39-63" -Provide at least 4' between bed and closet (5' preferred) -Hanging rods ≤ 5'6" high - Provide D-type handles on cupboards and drawers	Shelf height – maximum up to 6'3" and storage partitions height between 12" (300mm) and 5'5" (1400mm),locate bottom shelf of upper cabinet at 4'8";andutilize drawers that fully pull out; wall cupboards above 14" of work counters
Flooring	Even and non skid flooring	- All hard surfaces should be non-skid -Eliminate changes in height between floor transitions If flooring is to carpeted: -Select firm carpet of 36-oz., 1/8" gauge, 100% nylon, 1/2 cut pile with 0.5" maximum pile height -Carpet edge transition heights should be ≤ 0.5"	Hard flooring material with skid-resistant and non-glare floor surfaces without any variations in floor level within and between rooms.
Hallways	Unobstructed hallways without bevels in place of steps where ever the level differences is present	Ceiling Height ≥ 7' Width within ≤ 6'	Obstruction free, 1.80m wide, non-slip and even corridor should be provided. Wherever difference in levels is inevitable, it should connect with curb ramps.
Switch controls	Should be present within reach and easy to operate	-Height 36-48" -Use rocker, or touch sensitive switches -Use remote controlled switches to turn on and off consumer products (e.g. lamps).	Switch board Height 33-43" with toggle switches.

Problem areas reported in the study	Design solutions suggested by the respondents	Recommendation Design Guideline/standards	Proposed Design solutions
Kitchen work surface/counter	Should be within reach with knee clearance space without any difference in floor level and without any obstruction of base cabinets in work areas	Counter Height- 2'6"-3' MAX. Provide 1' wide counter surface on either side of range (at same height) Below range (wheelchair access) knee space of width 2'6"; and height 2'8" max Rolling out base cabinets Lower shelve of over head cabinets up to 5'6" max - Refrigerator side-by-side model refrigerator with doors to open 180°	Kitchen counter height should be up to 2'8" max, with depth of 2' max. Knee space below counter should be of 2'6"x2'6" Kitchen cabinet should have pull-out shelves with easily operable doors or with auto-close functionality. Present except below cooking range counter. And over head cabinets should be placed at an height of 5'4" from floor. Smoothly gliding garbage bins
Sink/Faucets	Should not be deep ,faucets should be within reach	-Use lever style handles; -Sink depth ≤ 15" -Consider adding a removable front and bottom cabinet below sink to accommodate wheelchair access, Knee space width -2'8" , height-2'6"	Faucets with long handles, Sink depth ≤ 1' Knee space below sink should be of min. 2'6" and height of 2'6" min. Round all edges to prevent discomfort and/or injuries
Bath/Shower	Easily accessible shower with grab bar, and faucets with in reach.	- Lever style handles -Include removable seat -Include reinforcements for future grab bars -Provide hand-held shower head -Use lever handles where possible. -Use one handle for hot and one handle for cold and mark appropriately. -Install two sets of faucet handles located at 21" and 42" (above tub floor) if possible, otherwise, set height at 32". - Locate grab bar (horizontal) 30" above floor -Install vertical grab b a r -Slip-resistant bathtub floor(fig-2.25) -Hand-held shower head with adjustable positioning	Use of lever handles where possible. Use one handle for hot and one handle for cold and mark appropriately. Elongated faucet handles located between 40" from floor Extra-wide doorways with no thresholds, Lever handles on doors instead of hard-to-turn knobs. Ample Lighting without glare.
Toilet	western toilet with grab bar should be introduced, with faucets located adjacent to toilet pan.	-Clear space requirements: Width ≥ 30" Space in front ≥ 24" -Locate 18" from side wall -Provide reinforcement for future placement of grab bars -Install offset flange to allow future movement of toilet(by up to 3" -Top of toilet seat = 18" above floor	Wall-mounted water closets with seat height between 0.45m to 0.50m from the floor along with wall mounted grab bar at a height between 0.85 m and 0.95 m from the floor in the toilet should be provided. If provision is made for Bath cum toilet then diameter should be1.5m.

The design solutions proposed in the above table statement were taken as a guideline to evolve floor plans and perspectives in AutoCAD 2007. The plans which form part of the guidelines give the minimum size required for the various rooms in any wheelchair dwelling. They are only indicative to show how the dimensions are arrived at. When rooms in the dwelling are combined, such as the living and dining rooms, kitchen, bedrooms and bathrooms, then the minimum space requirements for a dwelling can be arrived at.

Design solutions for Entrance and Exit: Figure – 5.8 shows the plan and perspective view. Features included were -

- Entrance gate: 48” – 60” with overall lighting for security.
- Pathways/Walkway: 48” - 60” wide
- Driveway/parking: Sheltered from rain, Avoid changes in levels (steps) with an access aisle of 60” wide
- Curb ramp/Ramp slope:<1:20 (never >1:12) i.e. 20” ramp for every 1” of vertical)
- Ramp Material : concrete – Firm, even and slip-resistance surface
- Ramp Railing: 32” to 36” high hand rails that extend 1’ beyond ramp rise
- Ramp width: 36” wide (more if entering from an angle)
- Ramp length: Max 30 feet. It needs to change direction if it is longer than 30’. With a change of direction, a level platform or landing should be used.
- Porch or verandah: Minimum 5'x 5' sheltered surface with even, firm and non-Skid flooring and adequate general lighting
- Door threshold : ½” or less threshold edge height
- Electrical switches: 3’- 4’ above ground
- If there is no room for a ramp and/or the ramp is too steep or unsafe, a vertical lift or elevator may be used.

Design solutions for Personal Room: Figure – 5.9 and 5.10 shows the floor plan and perspective view of personal room. The features included were:

- Room Size: 90 – 120 sq.ft for single adult;192-288 sq.ft for married couple
- Ceiling height: > 7’-6”
- Doorways: 32" minimum distance between frames
- Threshold: Thresholds of with threshold ramp, bevel, or recess
- Door Handle: 36" High from floor with levers
- Storage shelves/wardrobe: Height 39 – 64”; Depth 18”; Hanging rods < 56” high,
- Adjustable shelves and hanging rods, sliding shutter with loop handle; properly illuminated
- Floors: Leveled flooring anti-skid finish, If carpeted it is suggested with low pile
- Circulation path: Hallways with width 36 to 48”; 4’-5’ between bed and closet
- Switches controls: Toggle switch mounted at 40" height from floor
- Furniture – Along the walls without interfering with wheelchair passageway; Bed with Firm mattress - 22" from floor optimal for transfer from wheel chair, 3' on either side of bed for wheel chair transfer
- Work area: Table surface should be with at least 29" leg clearance
- Communication controls: Accessible in both bedroom and bathroom

Design solutions for Attached Bathroom cum Toilet Figure – 5.9 and 5.10shows the plan and perspective view of bathroom cum toilet. The features included were:

- Space requirement: Ceiling height > 7’; clear space for wheelchair; maneuverability and access to every facility; If provision is made for Bath cum toilet then diameter should be 1.5m. Width > 30” Space in front > 24”

- Bath shower: Roll-in shower - 5'x5' optimal space with beveled threshold for separating wet area; Drain in far corner, 1" lower than bathroom floor ; Grab bars on showerhead, wall and adjacent wall 30 to 32" from the floor ; Soap dish 30 to 36" from floor, Lever type handle, hand-held shower, two sets of faucet handles located at 21-42”, Slip-resistant flooring and removable seat
- Bathtub - 2½' of transfer space on side for transfer/bench with Hand held shower and Grab bars at 2’ long and 36" high mounted on reinforced wall
- Western closet: Wall-mounted water closets with seat height 16" – 18” from floor;
- Space for transfer: 30”-36” space on one side for independent or assisted transfer, depending on height. With wall mounted grab bar at a height between 30”-36” from the floor
- Wash Basin – 30” - 34" from floor, knee space underneath with insulated pipes; lever type faucets mounted on counter space and fitted with low level mirror, rounded all edges to prevent discomfort and/or injuries
- Storage Closet- Sliding doors, with rods 4' or less from floor
- Flooring: Even, non-skid flooring
- Switch controls: 2’-4’ above the floor level

Design solutions Family Space: (Living, dining and bedrooms of family members): Figure – 5.11 shows the plan and perspective view of family areas. The features included in this area were:

- Room Dimensions: Floor area for single purpose room > 120 sq.ft ; with other rooms > 70 sq.ft Ceiling Height > 7”;
- Hallways: Passage width 36 to 48”; Passage free from furniture and equipment
- Door: Minimum width 3’ and Height 6’8”
- Threshold: 0.5” Replaced thresholds with threshold ramp, bevel, or recess
- Doorways - 32" minimum distance between frames

- Door Handle - 36" from floor with levers
- Windows: Operating levers at 2’-6” ; clear space to access levers
- Floors - Anti-skid flooring, If carpeted it is suggested with low pile
- Switches controls- Toggle switch mounted at 40" height from floor
- Storage Cabinets – Storage shelving within the range of 56” preferably with sliding shutter with loop handle

Design solutions for Kitchen: Figure – 5.12 shows the plan and perspective view of kitchen. The features included in this area were:

- Room Dimension: Width 10’; Length 10’ and Height >7’ Gallery or two-wall kitchen with optimal turning radius of 5' x 5' within the kitchen counters
- Countertops- 30 to 33" from flooring is the optimal height for counter tops with 27 to 29" knee clearance
- Sink/faucets – Sink depth < 6.5” Faucet with lever style handle placed within 34" or less from the floor
- Cabinet/Storage system: Pull out shelves with height 63’’ from floor level with Cupboard height between 12" and 55" .Location of bottom shelf of upper cabinet should be at 48". For the Wall cupboards it should be14" above counters with D shaped handles on cupboards and drawers.
- Lighting: Direct lighting on work surface
- Door: Minimum width 3’ and Height 6’8”
- Threshold: 0.5” Replaced thresholds with threshold ramp, bevel, or recess
- Doorways - 32" minimum distance between frames
- Door Handle - 36" from floor with levers
- Windows: Operating levers at 2’-6” ; clear space to access levers
- Floors - Anti-skid flooring
- Switches controls- Toggle switch mounted at 40" height from floor
- Refrigerator -Side by side sliding model is preferred instead of swing open type.

The design solutions were presented in computer graphic AutoCAD software in the form of plans and perspectives for each functional area was evolved based on the suggestions given by the respondents the study and by taking into consideration the recommended standards and guidelines suggested by various authors and authorities, that was reviewed as a part of this research. The model house plan was evolved by combining the dimensions of each functional room/requirement.(Figure 5.13) The plan includes the details of furniture layout, internal and external circulation, layout switch controls. The model plan proposed in this study shows the presence of every accessibility feature required in a dwelling meant for wheelchair users to overcome the problems in residential buildings environment like steps, threshold or access to main entrance, landing surface in front of threshold, entrance gate to building and interiors, ramp, pathways, curb ramps, lifts/elevators and corridors in all the functional areas of the house like personal room, family room, kitchen, bath and toilet, drive ways and parking.

CHAPTER VI

SUMMARY AND CONCLUSION

There are a growing number of people with disabilities in the world today with various causes of impairments. A barrier free environment is a vital aspect to give them independence, as this can substantially increase the options for establishing ones' own routine of daily living and working potential without additional assistance. This also helps in making the life easier, convenient and pleasant to every user whether it is a child in a wheelchair because of multiple sclerosis or an older adult with arthritic joints or the disabled. These special needs can be met by barrier-free design and construction. Today's modern homes in cities and towns may be convenient and fascinating places for living and working for many, offering a great variety of opportunities and experiences, but for the disabled persons, such built environments are full of uncertainties, anxieties and dangers. A home that is designed to fulfill the needs of disabled especially those who are orthopedically challenged should safeguard their interests and welfare. Hence the present study on "Designing functional residential interiors for wheelchair users." was proposed with the following objectives:

1. To observe the existing residential building design features in the homes of wheelchair users.
2. To explore the views of wheelchair users on the functionality of the existing design features
3. To evolve appropriate interior design solutions through computer graphic models for the wheelchair users.

The ex-post facto research design was adopted in this investigation to explore the views of wheelchair users on the building design features and different areas present in their respective residential buildings and their valuable suggestions were considered to evolve suitable design features. Through purposive random sampling method, the Hyderabad city, capital of Andhra Pradesh was identified for conducting this research. Respondents for the research were identified through the purposive random sampling procedure. These respondents were identified with the help of medical doctors of orthopedic hospitals and physiotherapy centers who have been extending their services to them till date.

As the research was focused to study the prevailing living arrangements of the wheelchair users and the problems faced by them in their own homes in managing their daily chores, 10 adult wheelchair dependents, who were the victims of birth defects, cerebral palsy, paralysis or accident, were contacted personally. An interview cum observation sheet was used as a tool to explore the information related to the study. The information thus gathered was presented as case studies. Inferences on wheelchair users' problems and suggestions were drawn by consolidating and analyzing the collected information. Review of literature on the design guidelines and standards reported by various authors and authorities was used as theoretical support to develop design solutions to the problems. The research outcome is as follows:

General Profile of Respondents:

- Four out of ten respondents were affected by polio and while another four were victims of accident. Two other members were suffering from cerebral palsy and paralysis. The body part that restricted their mobility was lower limbs in all the cases. Six respondents among them also had problems with upper limbs and deformed facial bones.
- The respondents who were suffering with polio and cerebral palsy had prolonged wheelchair dependency while the rest who were the victims of accident or paralysis attack were found to be on wheelchair for a period of less than 10 years.
- Out of 10 respondents, 7 were young adults in the age group of 20-30 yrs and the rest were in middle age group of 30-50 years. In total, 4 respondents were married, of whom three were female members. All the respondents had the support of either parental or conjugal family except one, who opted to live independently.
- Five respondents irrespective of gender were either graduate or post-graduate, while three were pursuing higher studies. But physical limitation came in the way of higher education for two respondents who were affected by cerebral palsy and accident.
- Out of ten respondents, four were dependent on family for financial support. Three respondents were managing their own family enterprise and one was employed outside the home. Except one respondent, all the others belonged to middle or upper-middle income group family.

- With regard to management of daily chores, seven respondents needed assistance in toilet activities and clothing management, while two persons required assistance for activities like bathing and grooming. Cooking and home management was taken up by all the five female members and one male member either independently or with assistance.

Living arrangements and views on accessibility to facilities

- Physical limitations of family members did not come in the way in the choice residential dwelling for living. An equal number of respondents lived in own independent houses or apartments. Five respondents were found to dwell in houses which were constructed in the last 10 years and out of these, three were apartments. Four of the independent houses were constructed more than 10 years back and among that one was an ancestral home which was found to be constructed over 50 years back.
- Three respondents were living in the homes which were not modified to meet the needs of respondents. Three more respondents resided in the houses which were renovated after construction while another three occupied the houses after ensuring few features before purchasing. All the apartment dwellers took care of access to lift provision before occupancy, adequacy of space for wheelchair maneuverability within the home and wide doors for entry and egress. Independent houses were introduced with few adaptations like inclusion of curb ramp or ramp at entrance, reduction of height of kitchen platform and introduction of western commode in the toilet.

Accessibility to facilities and views of respondents

Outside the Home

- Seven respondents had access to main entrance directly from gate and three among them were dissatisfied due to uneven walkway or presence of steps. Three respondents had the provision of ramp or curb ramp, all of them felt it was difficult to use without the hand grip to take support, as the inclination was too steep.
- The study showed that nine respondents had space for parking either two or four-wheeler within the compound. Three respondents accessed entrance through portico, among them two dissatisfied, as there was variation in floor level and less space for wheelchair mobility.
- Presence of threshold at the main entrance and inaccessible switch board for call bell were stated by 6 and 7 respondents respectively.
- All were dissatisfied with the access to garden or utility area, because of variations in floor level, presence of threshold and uneven walkway.

Inside the Home

- **Personal (Bed) Room:** All the respondents had a personal space for all their activities but two among them stated that there was inadequate space for circulation. Except for one respondent, all were satisfied with the door dimension. Two among them were dissatisfied as its door had threshold and the room was at a different floor level. All of them had windows with latch for control, but only four were satisfied with the design

and the rest were dissatisfied as it was unreachable and difficult to operate. Similarly everyone had the storage provision for clothing and other belongings, but nine among them were discontented with this provision as the design was inconvenient to access totally and the shutters were difficult to open due to inadequate space. Access for emergency communication like telephone and intercom was provided in all the houses, but for six respondents it was located at an unreachable height and was hence difficult to operate

- **Family room:** All the respondents had an easy access to family areas like living and dining areas except one. Within the home all the ten respondents had ample space for wheelchair maneuverability. Eight respondents were satisfied with free circulation space present within the rooms, but two are dissatisfied because of presence of furniture.
- **Kitchen:** This was accessed by all the five female respondents and one male respondent. All of them were satisfied with space available for various activities. Only two respondents were satisfied with the kitchen counter, storage shelves, access to sink and the knee space below the counter. The remaining 4 were not satisfied as they did not have clearance space below work counter and reaching heights. However with regard to the latch position on window, five were dissatisfied as it was present beyond the reach.
- **Bath cum toilet:** Except one respondent, all of them had access to attached bath and W.C. Five of respondents had access to western toilet,

all of them were unsatisfied in using toilet without hand support. Indian water closet was found to be most difficult area by all the five respondents due to problems like difficult to use, lack of support while using and floor level variation. With regard to circulation space two were not satisfied. Eight respondents were satisfied with the type and placement of bathroom faucets. Two were dissatisfied with location of faucet and difficulty in operation and they had to depend on family members. This apart, presence of door threshold, unreachable switch boards, towel hanger and mirror were some of the problems by nearly 3 to 8 respondents.

- All the participants reported their partial satisfaction with adaptations introduced in the home. Everyone had problem in accessing toilets and may in bath area, personal room, kitchen and approach area outside the house. Detail analysis of every feature in the home revealed their dissatisfaction with provisions like ramp, curb ramp, door design, kitchen counter, storage shelves, circulation path, toilet, bath, position of faucet and due to the problems like difference in floor level, presence of threshold, narrow doorways, inaccessible storage areas, switch controls, kitchen counter and faucet, inaccessible toilet and bath area. Respondents of the study gave their personal suggestions to overcome these barriers in their homes.

Suggestion proposed by respondents to overcome barriers

Exterior of the building

- The suggestions proposed by the respondents for improving the access were introduction of curb ramp in place of steps at the entrance, renovation of inaccessible curb ramp with reduced inclination and provided with hand rail, relocation of switch controls for light and call bell to a reachable height, removal of collapsible iron door to sliding door, removal threshold from main entrance door, equalizing the lift floor level with corridor floor level and incorporate access to garden with wide and even pathway.
- Study reveals that three respondents had suggested for renovating the curb ramp, while two had suggested for the introduction of ramp, removal of collapsible iron door with sliding door and leveling of the lift floor level with corridor floor level. However eight respondents had stressed on the need of relocation of switch control at a reachable height at entrance.

Interior of the building

Suggestions received for improving the internal convenience were wide single shutter door without thresholds, leveling the floors to match with other rooms, provide shelves that can be reached and used, inclusion of storage shelf handles at reachable and convenient height, rearrangement furniture for unimpeded circulation, relocation the switch controls to reachable height, alter the location of window latches from top to bottom, replacement of bathroom faucets with long handle type, lowering the height of bathroom faucet, evening

different floor levels in bath and toilet area to one level, replacement of floor level squatting pan with western commode, provision of hand support for grip near shower and commode, reduce the height of wash basin and mirror for easy access and self grooming, change flooring material in bathroom to anti skid variety to prevent accident. Maximum number of respondents specified for the improvement of access in bath and toilet area.

Design solutions for overcoming the barriers

To evolve design solutions to the problems faced by the respondents, the suggestions proposed by them for improving accessibility and various guidelines and standards suggested by different authors and authorities were considered. Design solutions proposed for different functional areas of the home are -

Approach to home from exterior

Entrance gate	:	48” – 60” with overall lighting for security
Pathways/Walkway	:	48” - 60” wide
Driveway/parking	:	Sheltered from rain, Avoid changes in levels (steps) with an access aisle of 60” wide
Curb ramp/Ramp slope	:	<1:20 i.e 20” ramp for every 1” of vertical) If there is room for a ramp and/or the ramp is too steep or unsafe, a vertical lift or elevator may be used
Ramp Material	:	Concrete – Firm, even and slip-resistance surface
Ramp Railing	:	32” to 36” high hand rails that extend 1’ beyond ramp rise
Ramp width	:	36” wide (more if entering from an angle)
Ramp length	:	Max 30 feet. Change direction if it is longer than 30
Porch or verandah	:	Minimum 5'x 5' sheltered surface with even, firm and non-skid flooring and adequate general lighting
Main Entrance Door	:	Minimum width 3’ and Height 6’8” without threshold preferably with sliding shutters
Door threshold	:	½” or less threshold edge height
Switches controls	:	3’- 4’ above ground

Personal Room

Room Size	:	90–120 sq.ft for single adult;192-288 sq.ft for married Couple,Ceiling height: > 7’-6”
Doorways	:	32" minimum distance between frames without threshold
Door Handle	:	36" High from floor with levers
Shelves/ wardrobe	:	Height 39 – 64”; Depth 18”; Hanging rods < 56” high, Adjustable shelves and hanging rods, sliding shutter with loop handle; properly illuminated
Flooring:	:	Leveled flooring with anti-skid finish. If carpeted should be with low pile
Circulation path	:	Hallways with width 36 to 48”; 4’-5’ between bed and closet
Switches controls	:	Toggle switch mounted at 40" height from floor
Furniture	:	Along the walls without interfering with wheelchair passageway; Bed with Firm mattress - 22" from floor optimal for transfer from wheel chair, 3' on either side of bed for wheel chair transfer
Work area	:	able surface should be with at least 29" leg clearance Communication controls: Accessible in both bedroom and bathroom

Family Space: (Living, dining and bedrooms of family members)

Room Dimensions	:	Floor area for single purpose room > 120 sq.ft ; with other rooms > 70 sq.ft Ceiling Height > 7”
Hallways	:	Passage width 36 to 48”; Passage free from furniture and equipment
Doors	:	Minimum width 3’ and Height 6’8” without threshold preferably with sliding shutters
Doorways	:	32" minimum distance between frames
Door Handle	:	36" from floor with levers
Windows	:	Operating levers at 2’-6” ; clear space to access Levers
Floors	:	Anti-skid flooring, If carpeted it is suggested with low pile
Switches controls	:	Toggle switch mounted at 40" height from floor
Storage Cabinets	:	Storage shelving within the range of 56” preferably with sliding shutter with loop handle

Kitchen

Room Dimension	:	Width 10’; Length 10’ and Height >7’ Gallery or two-wall ,kitchen with optimal turning radius of 5' x 5' within the kitchen counters
Countertops	:	30 to 33" from flooring, an optimal height for counter tops with 27 to 29" knee clearance
Sink/faucets	:	Sink depth < 6.5” Faucet with lever style handle placed within 34" or less from the floor
Cabinet/Storage	:	Pull out shelves with height 63’’ from floor level with Cupboard height between 12" and 55". Location of bottom, shelf of upper cabinet should be at 48". For the Wall, cupboards it should be14" above counters with D shaped handles on cupboards and drawers
Lighting	:	Direct lighting on work surface
Door	:	Minimum width 3’ with 32" minimum distance between Frames; without threshold and door handle at 36" from floor’ Height 6’8”
Windows	:	Operating levers at 2’-6” ; clear space to access levers
Floors	:	Anti-skid flooring
Switches and sockets	:	Toggle switch mounted at 40" height from floor
Refrigerator	:	Side by side sliding model, instead of swing open type

Bathroom cum Toilet (Attached to personal bedroom)

Space requirement	:	Ceiling height > 7'; Clear space for wheelchair maneuverability and access to every facility; If provision is made for Bath cum toilet then diameter should be 1.5m. , Width > 30" Space in front > 24"
Bath shower	:	Roll-in shower - 5'x5' optimal space with beveled threshold for separating wet area; Drain in far corner, 1" lower than bathroom floor ; Grab bars on showerhead, wall and adjacent wall 30 to 32" from the floor ; Soap dish 30 to 36" from floor, Lever type handle, hand-held shower, two sets of faucet handles located at 21-42", Slip-resistant flooring and removable seat
Bathtub	:	2½' of transfer space on side for transfer/bench with Hand held shower and Grab bars at 2' long and 36" high mounted on reinforced wall
Western closet	:	Wall-mounted water closets with seat height 16" – 18" from floor; Space for transfer: 30"-36" space on one side for independent or assisted transfer, depending on Height, with wall mounted grab bar at a height between 30"-36" from the floor
Wash Basin	:	30" - 34" from floor, knee space underneath with Insulated pipes; lever type faucets mounted on counter space and fitted with low level mirror, rounded all edges to prevent discomfort and/or injuries
Storage Closet	:	Sliding doors, with rods 4' or less from floor
Flooring	:	Even, non-skid flooring
Switch controls	:	2'-4' above the floor level

The design solutions developed out of the research were presented in computer graphic drawings in AutoCAD 2007 software. Necessary plan and perspectives for each functional area of the house were evolved by taking into consideration all the dimensions proposed as solutions by incorporating the design solutions proposed in this study. Individual plans of functional areas were unified to create a model residential house plan. The plan includes the details of internal and external circulation, furniture layout, layout switch controls. This plan shows the presence of every accessibility feature required in a dwelling meant for wheelchair users to overcome the problems in residential buildings environment.

Conclusion

From this research it can be concluded that there is an urgency for improving residential building designs meant for wheelchair users to main-stream this section of population to lead a satisfactory and independent life. There are several ways of improving the residential design like - altering an existing house by introducing suitable modification, building an additional portion or buying a new home. The design solutions proposed in this research can be incorporated in the building design to increase the functionality of the living environment.

Implications of the study

- All the residential buildings that provide living environment for wheelchair family members can introduce these design solutions to minimize the physical and mental strain.
- Architects and Builders can implement these design solutions in the new buildings and in the renovation of old buildings for barrier-free living conditions.
- The result of the study may be given to the government as well as non government organizations, so that it may be implemented as a mandatory for all buildings meant for accommodation of wheelchair users.

Areas of future research

- A study may be taken with a large sample of wheelchair users and design solutions may be evolved for persons suffering with different ailments like population with limited functionality of upper limbs, lower limbs and sensory organs.
- A study on the feasibility of the suggested design solutions may be undertaken by incorporating in a new building and solutions evolved for further refinement.
- A study on the building environment in hotels or guest houses meant for accommodation of even wheelchair users as their residents may be taken up.
- A study on the feasibility of non-residential buildings like the establishments meant for educational, institutional and health care which accommodate disabled members of the society may be undertaken.
- A study on the access and egress requirements of wheelchair users in emergency conditions like the event of a fire in domestic settings could be taken up.

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INTERVIEW CUM OBSERVATION SCHEDULE
TO ELICIT INFORMATION ON
RESIDENTIAL DESIGN FEATURES OF WHEELCHAIR USERS

GENERAL PROFILE

1. Name, Residential address& contact number:
2. Cause and type of disability: Parts affected:
3. Years of dependency on wheelchair: Wheelchair type:
4. Gender: M/F Age ------ in years
5. Education:
6. Employment Status: Annual earning if any:
7. Annual income of family
8. Marital status: Type of family support:
9. Way of spending time through the day:
10. Management of Daily Chores

Activities performed	Managerial Practice		
	Independently	Partial Assistance	Total Assistance
Moving within the house			
Eating			
Bathing			
Toilet activities			
Cooking			
Clothing management			
Dressing/grooming			
Oral hygiene			
Hobbies			
Employment outside home			
Any other activities			

LIVING ARRANGEMENTS :-

11. Type of ownership: Personal / Rented

12. Residence type: Independent home / Apartment

13. Way of acquiring: Self-constructed/Purchased

14. Duration of stay in this house ---------- in years

15. Adaptation introduced if any in the house for convenience: yes/no

16. Type of modification taken up and when?:

18. Accessibility to following areas / rooms:

Areas/rooms	**Accessibility to various areas/parts**	**Satisfaction Yes/ No**	**If no, type of problems in accessing parts/areas**
Approach area to home			
Personal room/area (Bed Room)			
Family area- Living, dining etc			
Kitchen			
Bath Room			
Toilet			
Garden/utility area/balcony/Pooja			

19. Existing of features in the Approach area:

Design Features	Present / Absent	Dimension & details of Design	Satisfaction Yes/No	Reasons for dissatisfaction
Main Gate				
Driveway/ Walkway				
Parking space				
Entrance Door/gate				
Steps/ Curb ramp				
Knob / lever to open door/gate				
Call bell				
Access to garden				

Switch to operate lift				
Any Other				

20. Existing of features in interior of the house:

Design Features	Present / Absent	Dimension & details of Design	Satisfaction Yes/No	Reasons for dissatisfaction
PERSONAL ROOM				
Space for all activities and Furniture				
Circulation space				
Door				
Window				
Storage provisions				
Flooring				
Switch controls				
Internal communication-Telephone/intercom/bell				
Any other provision				
FAMILY ROOM				
Space for all activities and Furniture				
Circulation space				
Door				
Window				
Storage provisions				
Switch controls				
Internal communication-Telephone/intercom/bell				
Any other provision				
KITCHEN				
Adequacy of space				
Kitchen counter				
Door				
Window				

Circulation space				
Sink and faucet				
Storage provisions				
Flooring				
Switch controls				
Any other provision				
BATH & W.C				
Space for all activities and Furniture				
Circulation space				
Bathing provision				
Washing Provision				
Toilet Provision				
Door				
Window				
Faucet				
Storage provisions				
Flooring				
Switch controls				
Any other provision				
UTILITY AREAS				
Space for all activities				
Circulation space				
Door				
Window				
Storage provisions				
Flooring				
Switch controls				
Any other provision				

21. Suggestions for improving accessibility within and outside the home?