FACULTY OF TECHNOLOGY

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FINAL PROJECT REPORT

PROJECT TITLE: DESIGN OF APPROPRIATE DRY TOILETS FOR CHILDREN AND THE DISABLED

SUBMITTED AS PARTIAL REQUIREMENT FOR THE AWARD OF BACHELOR OF SCIENCE DEGREE IN CIVIL ENGINEERING OF MAKETRERE UNIVERSITY

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DEDICATION

For Augustine Akoch, Gerefasio Engoru, Gaudensio Eliau, Mary Ailo, Francis Echodu, and Michael Edigu I sometimes think, but the destiny is one. Even for the greatest men in history.

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ABSTRACT

ECOSAN is a relatively new concept that is based on the separation of human waste into its components, the products then being sanitized and reused ('sanitize-and-recycle'). The Ecosan principle has been used in a remote way hundreds of years before this current refinement in countries such as China and India. This sanitation system has been looked at as the ideal system with potential benefits of recycling of products. Ecosan toilets should be used by all the members of society including children and the disabled. However, inherent problems in the current construction of the Ecosan toilet may limit its usability by these two groups.

The main objective of this project was to design appropriate Ecosan dry toilets for children and the disabled. To come up with a satisfactory design, various methods were used. These included a visit to Kabale and Kisoro, areas presently with high Ecosan usage, and to various institutions concerned with disabled and children, Questionnaires and interviews, checklists and workshops/conferences and an extensive literature search.

Review of literature covered accepted practices according to Design Codes such as BS 8300:2001 (Design of buildings and their approaches to meet the needs of disabled people), Americans with Disability Act Accessibility Guidelines (ADAAG), United Nations-Design Manual for a barrier free Environment, and others.

The findings revealed that children suffer from inappropriate facilities such as large squat holes, steep steps and generally an unfamiliar technology. Disabled persons suffered from inaccessibility of toilet rooms, inappropriate facilities (steep ramps, small rooms etc) and lack of provision of extra support.

Based on these findings, a suitable toilet for children and the disabled was designed and a prototype constructed. In addition, an Ecosan chair for use in homes for weak persons, sick persons, the elderly and all such cases was suggested. The Ecosan pedestal, as proposed, must be different in Architecture from the Water closet due to the different functional requirements of the two systems. It is expected that the suggested modifications when implemented will eliminate the problems cited for disabled and children. Further research however needs to be undertaken in relation to the Ecosan pedestal and for suitable sitting pedestal for children.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PHOTOGRAPHS

ANNEX

1. Drawing 1: Adult Disabled Person's Toilet
2. Drawing 2: Children's Toilet
3. Drawing 3: Ecosan Chair for Disabled Persons
4. Photograph of Disabled Persons Toilet Model
5. Photograph of Unsafe Design of Entrance to Toilet
6. Copies of Questionnaires

CHAPTER ONE – INTRODUCTION

1.1 BACKGROUND AND JUSTIFICATION

The sanitation practices that are promoted today fall in one of two broad types: 'flush and discharge' or 'drop and store'. Flush and discharge has been regarded as the ideal technology especially for urban areas. Many of the cities in the developing countries though, cannot afford the necessary resources in terms of money, water and institutional capacity, to provide a flush and discharge system (UNDP, 2003). In an interview with UNDP, the president of Uganda H.E Yoweri Kaguta Museveni put an estimate of US$ 1.5 billion for provision of 100% water coverage by 2015. He also agreed that this is an enormous amount of resource for a single sector of a poor economy (choices magazine).

ECOSAN is a relatively new concept that is based on the separation of human waste into its components, the products then being sanitized and reused ('sanitize-and-recycle'). The Ecosan principle has been used in a remote way hundreds of years before this current refinement in countries such as China and India. This sanitation system has been looked at as the ideal system and has been adopted not only in developing countries, but also in developed countries.

The Ecosan system is still under development and various other factors are being evaluated with an aim of reaping the potential benefits of the system. One such factor is its usability for children and the disabled. Being common members of society, Ecosan should also be modified to be easily usable by these two groups. These problems must be solved if the ultimate benefits of the system are to be realized. This is because the use of separate sanitation systems (as depicted in the primary school in Photograph 1) will result into both undesirable costs in treatment and to potential contamination of water sources with dire consequences, which this new sanitation concept is after all designed to address.

An all user Ecosan system will result in improved and cost effective sanitation, less need for help to children and the disabled while using it, less likelihood of needing a separate system such as flush and discharge to be used by children and disabled and therefore less likelihood of faecal contamination of water, and economy.

Photo 1-1: Kikungiri primary school, Kabale District where problems of use has forced children Nursery to P4 to use pit latrines whereas higher classes use the Ecosan toilet to the left

1.2 STATEMENT OF THE PROBLEM

The Ecosan system is being adopted as one other alternative sanitation concept with potential benefits of recycling of products. The dry toilets are supposed to be used by all the members of society including children and the disabled. However, inherent problems in the current construction of the Ecosan toilet may limit its usability by these two groups. Some of these problems have been cited to include access by disabled persons, need for support in preparation for use and after use by the disabled, and large-hole size when in use by children. A thorough investigation needs to be carried out to fully understand the user dynamics of the dry toilets with respect to these two user groups. This study is therefore aimed at designing suitable Ecosan toilets for children and disabled persons.

1.3 OBJECTIVES

The main objective of this project is to design appropriate dry toilets for children and the disabled.

The specific objectives are:

a) To investigate the problems restricting disabled people and children from using the available dry toilets with emphasis on Ecosan systems
b) To determine the cause of the problems in a) with respect to structural or otherwise construction of the current system
c) To use the results from a) and b) above to produce adequate modification(s)
d) To produce design layouts depicting the visualized system
e) To construct a prototype of the suggested dry toilet system
f) To estimate the construction costs for the constructed sanitation system

1.4 REPORT LAYOUT

This chapter has highlighted the factors that led to the subject of this report, the problems, and the objectives of the project.

Chapter two reviews literature relevant to the subject of this report. A brief discussion of sanitation systems in use, and details each of the dry sanitation systems is given. Ecosan toilets are considered in detail throughout the report. Also, the loosely used term, 'disability' is defined in the way useful for design. Information from design codes, relating to children and disabled persons facilities is included and constitutes a useful basis for the methods adopted in determining the dimensions for design.

The methods used to investigate the problems of the current system are described in chapter three and the results obtained by these methods are presented and discussed in chapter four.

To complete this project, although not mentioned in the project title, a design of a suitable urinal is also included. This is considered important for disabled male persons in that women can urinate inside the urine diversion of the Ecosan toilet. This aspect has also been given due consideration in the literature.

Finally, conclusions and recommendations from this project are given in chapter six.

The Annexes include the copies of questionnaires used and the design layout drawings suggested. Three designs are presented. These are:

a) Drawing of disabled persons toilet
b) Drawing of children's toilet
c) Drawing of Ecosan toilet chair for disabled persons or weak, elderly or sick persons where sitting toilet has not been built

CHAPTER TWO – LITERATURE REVIEW

This chapter examines available literature on the subject of toilets for children and the disabled. To ensure that the material content is both technical and acceptable by engineering principles, most of the literature has been obtained from design standards and technical publications.

2.1 SOME DEFINITIONS

Sanitation: This is the science and practice of effecting healthy and hygienic conditions, study and use of hygiene measures such as drainage, ventilation, portable water supply, sewage treatment, storm and sullage drainage etc. (World Bank group, 2001).

Ecology: This is a science that deals with the interaction between the living and non-living factors of the environment (Van Dyne, 1969).

Ecosystem: This is defined as a complex of organisms and environment forming a functional whole (Van Dyne, 1969). Therefore, an ecosystem results from the integration of the living and nonliving factors of the environment for a defined segment of space and time.

Ecological sanitation: This is a sanitation system based on an ecosystem approach and treats human urine and faeces as a valuable resource to be recycled (Esrey *et al,* 1998).

Children: According to the constitution of the Republic of Uganda chapter 4, article 34, clause 5, 'children shall be persons under the age of sixteen years.' In technical design of facilities, children are taken up to the age of twelve (12)(Reutersward, 1995).

Disabled: According to the 2002 Uganda population and housing census, a person with a disability is defined as one 'who is limited in the kind of or amount of activities that he or she can do, because of ongoing difficulty (ies) due to a long-term physical condition or health problem that has lasted six months or more. This includes all those difficulties that are expected to last more than six months' (Nabukhonzo, 2003).

2.2 SANITATION SYSTEMS

Two major types of sanitation systems are usually distinguished. These are on-site/on-plot sanitation and off-site/off-plot (also called conventional) sanitation system. In Uganda, more emphasis however is

on on-site sanitation especially dry sanitation and specifically ecological sanitation (Ecosan toilets). Their usability by disabled persons and children will be dwelt upon in the next sections.

2.2.1 ONSITE SANITATION

In this method, the final location of waste disposal occurs on the same site as the waste production. There are two basic human waste disposal systems under on site sanitation. These are, the wet system/conventional system and the dry system/non-waterborne system.

2.2.1.1 Wet System/Conventional System

It comprises water closets (WC), cistern flush, septic tanks, sewers, aqua-privies, vaults etc. This system is also described as 'flush and discharge' and has been described as the ideal system for urban areas (Esrey *et al*, 1998). In Uganda, this is the basic system for urban areas although only 8% of homes in urban Kampala have a flush and discharge system (choices magazine, 2003). Many of the cities in developing countries cannot afford the necessary resources in terms of money, water and institutional capacity, to provide a flush and discharge system (Esrey *et al, 1998*).

2.2.1.2 Dry System

This is non-water borne sanitation system. Included here are pit latrines and trenches ('drop and store') and some ecological sanitation toilets (dry) or 'sanitize and recycle'. Pit latrines are widely used in sub-urban areas of Uganda. The technologies 'drop and store' and 'sanitize and recycle' can be used in both urban and rural areas.

2.2.2 SEWERED SANITATION

This system involves a network of pipes for collection of wastewater from the community and transportation from the source to a centralized treatment plant and/or final disposal area. Sewered sanitation has been used in most cities in the world. It is estimated that about 90% of the sewage in cities in developing countries is discharged untreated, polluting rivers, lakes and coastal areas (Esrey *et al*, 1998). Lake Victoria is also currently suffering from nutrient overload and toxic algae blooms suspected to be a consequence of discharge of poorly treated sewage (LVEMP, 1996).

Because this system uses water as the discharge and transport fluid, it is also costly in terms of capital and maintenance costs. The same study by Esrey *et al* established that some 80% countries with 40% of the world's population are already suffering from water shortages at some time of the year.

Because of the cost and negative environmental implications of wet sanitation systems together with their disposal systems, dry sanitation systems are most commonly used both in rural areas and in sub-urban areas of the world where a significant population of the urban dwellers live. UN habitat (2003) puts the proportion of slum dwellers in Africa at 72%.

2.3 DRY SANITATION/NON WATER-BORNE SYSTEMS

There are two main dry toilet systems, the pit latrine and the ecological sanitation systems. The distinguishing factor is that pit latrines allow urine and faeces to mix and then indefinitely stored. In Ecosan systems because of separation, small volumes of faecal matter per capita per year need storage thus reduction in volume of storage. Because also Ecosan should avoid intrusion by ground water and storm runoff, it is constructed above ground. Therefore, there is less likelihood of contamination of groundwater. Ecosan most importantly allows the re-use of the constructed system, which is important in congested areas where land is unavailable for expansion, which is necessary when pit latrines are used. In this respect, it is termed 'sanitize and recycle' whereas the pit latrine allows for indefinite storage, thus 'drop and store'. Both systems are now discussed in detail below.

2.3.1 THE PIT LATRINE OR 'DROP AND STORE'

These are the commonest and most simple sanitation options in rural areas and in suburban areas in Uganda. The pit latrine also has many modifications as discussed below.

2.3.1.1 Traditional Pit Latrine

This is the commonest pit latrine. It is a hand-dug pit in the ground of suitably large volume to serve for between 4 to 15 years with 10 years being desirable. Because of this volume, deep pits are required thus a lot of digging. Collapse of the soil has happened in some locations in Uganda with fatalities. For instance, on July 13th 2000, two brothers died instantly when they were buried alive in a pit latrine they were digging at a school within Kampala city (New Vision).

The pit is covered with a suitable wooden or concrete slab to prevent collapse. The slab can be pre-cast and acts as the floor and supports the superstructure. The pit latrine is illustrated in Figure 2.1.

Various other modifications of the pit latrine exist to suit particular situations. These include the Ventilated Improved Pit latrine (VIP), Compost pit, the elevated pit latrine, and the Reed Odourless Earth closet and bucket latrines. These are briefly discussed below.

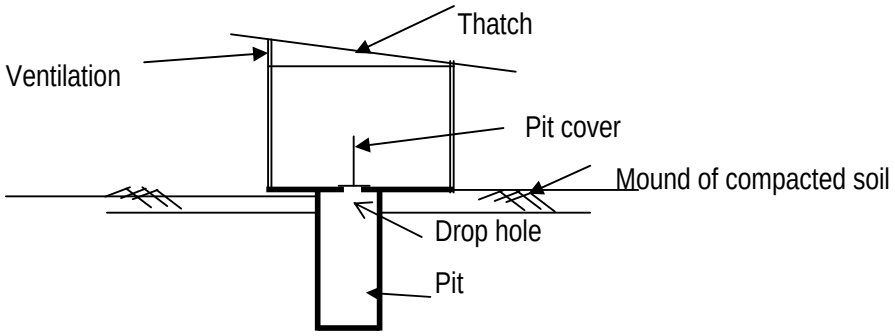


Figure 2-1: Pit Latrine

2.3.1.2 The Ventilated Improved Pit latrine

The ventilated improved pit latrine (VIP) incorporates a vent pipe to control both flies and odor nuisance due to improved ventilation

2.3.1.3 Compost pit

This is a composting latrine. This kind of latrine has been used in china and India where night soil has been used as a resource in gardens.

In composting latrines, before the pit is used, its floor is covered with a layer of ashes or lime. These absorb moisture and prevent faeces from sticking to the floor when being removed. Addition of a weight of ashes equivalent to a third of the weight of faeces eliminates all the smell due to hydrogen sulfide and ammonia. Wood ashes also promote the killing of *askaris*. Composting and addition of ash is one of the principles of Ecosan toilet systems discussed later.

Composting latrines can be single vault or double vault. The double vault latrine has a large vault divided in to two components each covered by a slab with a squat hole. Alternate emptying of the vaults is done every six to twelve months.

2.3.1.4 The Elevated pit latrine

Where excavation is rendered difficult because of rocky ground (parts of Rukungiri, Kisoro districts) or loose collapsible sands (parts of Katakwi town council) or water logged conditions (lowlands of Bwaise etc in Kampala), the latrine is constructed above the ground, allowing for a ladder/steps for ascending to the defecation point. Figure 2.2 shows the elevated pit latrine.

2.3.1.5 Bucket latrine

This is the oldest and most unhygienic method of human waste disposal. This method was extensively used in America and Europe. The bucket usually of galvanized iron or plastic has a handle for lifting and carrying. Usually two buckets are available so that an empty one replaces the filled one.

Other pit latrines are modified to improve hygiene. These include:

- The san plat (sanitation platform) which has a tight fitting lid to improve hygiene
- Reed Odourless Earth Closet (ROEC), which is an offset pit latrine. The pit can be used as a composting chamber. It is also provided with a vent pipe for ventilation.

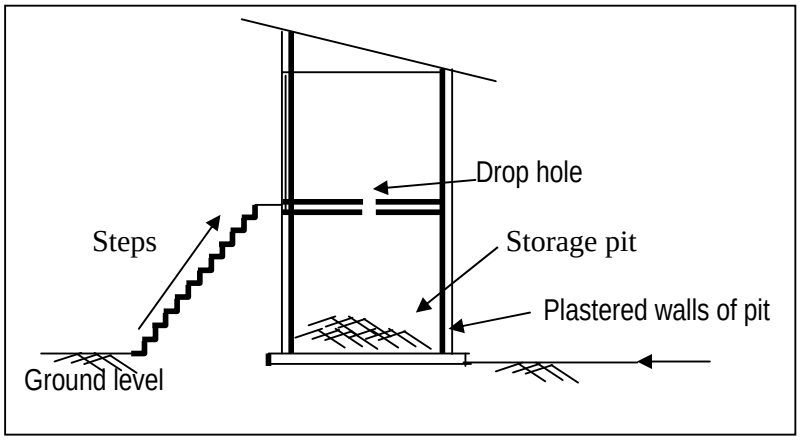


Figure 2-2: The Elevated Pit Latrine

2.3.2 'SANITIZE AND RECYCLE'/ECOSAN SYSTEMS

Ecological sanitation is an alternative to the conventional sanitation systems. It attempts to address the shortcomings of the traditional systems. It is based on an eco-system concept. A typical Ecosan toilet is shown in Figure 3. The advantages and functioning of this system can be found in any book containing literature on it. The basic design of the system in relation to usability will be discussed in detail in the following sections.

2.3.2.1 Ecosan toilet design

According to the DWD design manual, South-western Towns Water and Sanitation Project (SWTWSP), the toilet consists of three basic components.

a) A pedestal or squatting pan, or sitting pan
b) A slab and a chamber/vault
c) And sometimes a superstructure (if it is sited outdoors)

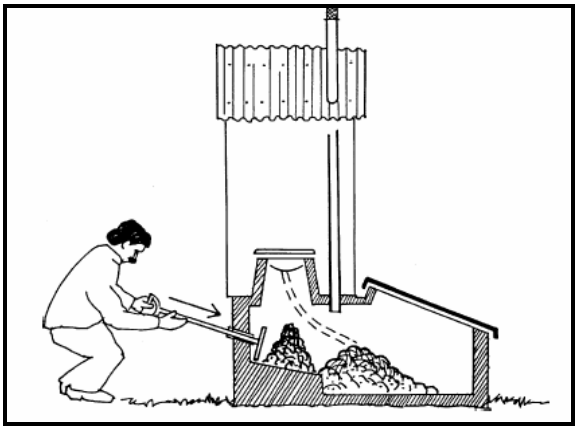


Figure 2-3: Typical Ecosan toilet (Source: Esrey et al. Ecological Sanitation. Sida, Stockholm)

The Ecosan toilets are basically of two types according to the process of sanitization of faecal matter (composting or dehydration). These types are modified to suit different situations and are of different designs (the device), single or double vault, urine diverting or non-urine diverting, solar heated or non-solar heating. Device refers to the on-site structures specifically built for defecation and urination (Esrey *et al,* 1998). The same device can use a different process.

2.3.2.2 Composting Type Ecosan Toilets

Composting is a biological process in which, under controlled conditions, bacteria, worms and other types of organisms break down organic substances to make humus, a rich, stable medium in which roots thrive (Esrey *et al,* 1998). In a composting toilet human excreta, along with additional bulking agents such as vegetable scraps, straw, peat moss, wood shavings or coconut husks, are deposited into a processing chamber where soil based micro-organisms decompose the solids, as eventually happens to all organic material in the natural environment.

2.3.2.3 Dehydrating Type Ecosan Toilets

In a dehydrating toilet the contents of the processing vault are dried with the help of heat, ventilation and the addition of dry material. The moisture content is as quickly as possible brought down to below 25%. At this level there is rapid pathogen destruction, no smell, and no fly breeding.

This section has discussed the basic principles and construction of Ecosan toilets. The toilet is similar to the elevated pit latrine in being accessed by stairs. It is also similar to the composting latrine, which uses composting process in destruction of pathogens. Finally, sanitized matter is recycled.

Important to this study is dry toilets usability by children and disabled persons. The following sections approach each of these users individually. Since children can also be disabled, aspects relating to disabled person's facilities will also apply to children's facilities.

2.4 DRY TOILETS FOR CHILDREN AND THE DISABLED

Whatever, system of Ecosan is adopted, the system location rules should ideally remain the same, namely that the system should be built on the surface. This ensures ease of emptying of the sanitized products and avoidance of contact of 'sanitizing matter' with storm runoff or ground water table, which would result in contamination.

Construction of a chamber above ground therefore entails the use of stairs for access. This potentially causes problems for disabled people (on wheel chairs) as will be seen in the literature on disability shortly. This isn't the only undoing of the system; the literature below describes the objective of this project in detail.

2.4.1 DRY TOILETS FOR CHILDREN

Esrey *et al* (1998) mentions the problem of the large size of seats and slabs, which sometimes pose special problems for small children. He mentions some design options so that a smaller seat can be pulled down over the larger basic seat riser.

Burra *et al* (2002) while discussing the construction of community toilet systems explained why a block of children's toilets was included. In part it was because children always lose out to adults when there are queues for a toilet (so they often defecate outside because they cannot wait), and in part because many young children are frightened to use conventional latrines. The children's toilets were specially designed for children's use, including such features as smaller squat plates, handles (to prevent over-balancing when squatting) and no large pit openings. In many toilet blocks, there were also toilets designed for the elderly and the disabled.

It is apparent that the biggest problem affecting the use of dry toilets by children is large size of squat plates/sitting (for this case). In addition there is need for inclusion of support devices just as is the case for disabled persons discussed later.

The critical aspects for design are therefore the sizing of the squat holes and the location of support devices. These are broken down in to age groups. This design will be beneficial where children can use toilets according to class for instance in primary schools (United Spinal Association, fall 2003).

2.4.1.1 Design elements for children's toilets

ADAAG (Americans with Disability Act Accessibility Guidelines, 2002) for children's facilities uses the term 'constructed according to children's dimensions and anthropometrics', and explains that this 'means where the construction of a facility reflects the size and dimensions, reach ranges, level of strength and stamina, or other characteristics of children'. Table 2-1 below summarizes the forward and side reaches for children in the given age groups.

Table 2-1: Forward and side reach of children

Age Group	High reach (not more than)	Low reach (not less than)
2 – 4	915 mm	510 mm
5 – 8	1015 mm	455 mm
9 – 12	1120 mm	405 mm

(Source: ADAAG, 2002)

2.4.1.1.1 Height of mounting of sitting toilets

Sitting toilets are necessary if a facility is deigned for disabled children as will be seen in the literature for disabled people later. In that case, the dimensions for the sitting toilet can be correlated to those suggested by ADAAG for water closets given below. However, because of the suggested location of the water closet necessary to give manoeuvring space, the location of the dry toilet (in Ecosan) may have to be readjusted.

Table 2-2: Toilet and support devices location

Age group (yrs)	Toilet centreline (mm)	Toilet seat height (mm)	Grab bar height (mm)	Dispenser height (mm)
2 – 4 (Nursery)	305mm	280-305	455-510	355
5 – 8 (P1 – P4)	305-380	305-380	510-635	355-430
9 – 12 (P5 – P7)	380-455	380-430	635-685	430-485

(Source: ADAAG, 2002)

Where squatting toilets are used, the critical dimension will therefore be the size of the squat hole. Support devices will be necessary and due to the lower squat position of the child, these will not be located at the same height as for the sitting toilet above.

However, ADAAG also recommends the dimensions given in Table 2-3 as appropriate when designing for more than one age group. For financial reasons, this modification can be applied rather than the former.

Table 2-3: Modification to table 2-2

Age group (yrs)	Toilet centreline (mm)	Toilet seat height (mm)	Grab bar height (mm)	Dispenser height (mm)
2 – 8	305	305	510	355
5 – 12	380	380	635	430

2.4.1.1.2 Toilet space

Accessible toilet spaces are required for use by children and older disabled persons. Figures 2-4, 2-5, 2-6 show the minimum required clear floor space for adult toilets depending on the approach. The same floor spaces are recommended for children's toilets. The modification is in the location of the water closet from the closest wall. This should be a minimum of 12" (305mm) and maximum 18" (455mm).

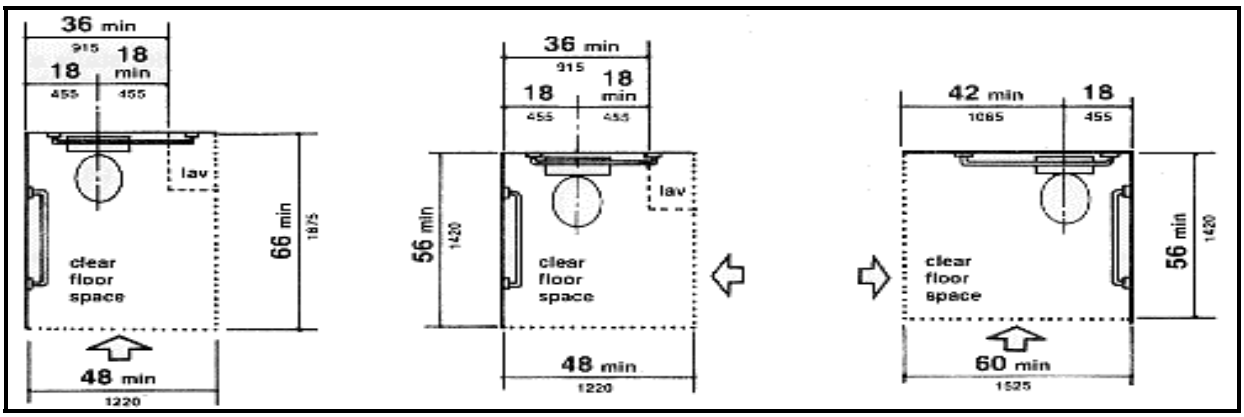


Figure 2-4: Front transfer Figure 2-5: Diagonal transfer Figure 2-6: side transfer

(Source: ADAAG, 2002)

2.4.1.1.3 Size and Location of Support Devices

Figures 2-7(a) (b) show the locations of support devices for adult disabled person's toilets. The location of these devices for children's toilets is in conjunction with the dimensions given in Table 2-2 or 2-3 as applicable. It should be kept in mind that a child just like a disabled person requires support in a toilet.

A grab bar clearance of 38mm from wall is required to prevent injuries resulting from arms slipping through the opening. A circular grab bar of diameter 32 to 38mm is recommended although other suitable shapes are also acceptable (United Nations, 2003). The Architectural Access Board (1996) additionally recommends a grab bar of diameter 25mm for nursery (2-4yrs) children.

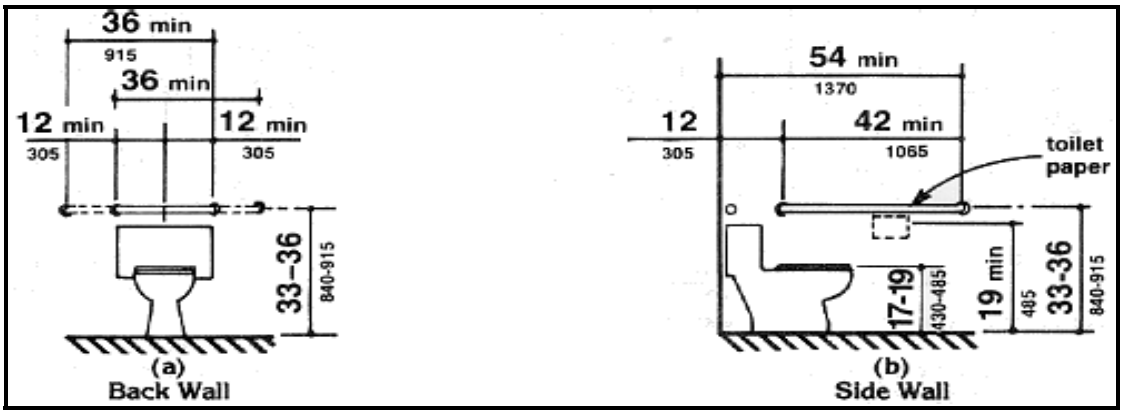


Figure 2-7: Location of support rails in disabled person's toilet

2.4.1.1.4 Access to Toilets

Access to toilets is provided by means of ramps to enable disabled children on wheel chairs get into the toilet. However, ramps will be narrower than used by adults. Commonly, children access is by means of stairs. To provide for support, railings should be provided at a height of 0.6m. Spacing between the vertical and horizontal bars of railings should be narrow for the safety of children (Accessibility Design Manual, 1996).

2.4.1.1.5 Size of Toilet Seat/Squat Hole for Children

In order to determine the size of toilet seat (sitting toilet) or hole (squatting toilet), it is suggested that the anthropometrics of children (2-12yrs) be analysed. Because this is a complex topic, researches that have been earlier undertaken may have to be looked into. Snyder *et al* (1975) carried out research on children's body dimensions. Outlining the complexity of the subject, he wrote 'There is considerable literature on infant or child height (stature or crown-rump; crown-heel) and weight, particularly in clinical references. But even for these measurements, data have often been taken by several different measurers in the same study, and often there was found to be questionable accuracy'. Further, often complex and costly equipment is used. Moreover, 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 time (United Nations, 2003). For the purpose of this project, the key subjects in body size studies are defined below:

Anthropometrics: The study of human body measurement especially on a comparative basis (Merriam-Webster dictionary). It is the measurement of the physical body, such as height and weight, chest and head circumferences.

Ergonomics: An applied science concerned with designing and arranging things people use so that the people and things interact most efficiently and safely – also called human engineering (Merriam-Webster dictionary).

Therefore these two subjects relate body size/shape to the design of appropriate facilities, which is desirable in this case for children. Literature about suitable toilet size has not been met. The suggestions that the squatting-hole size for children's toilet should be small have been encountered (see for example Government of India, 2004). However, there has not been found any formula or scientific basis upon which the size of sitting toilet/squat-hole of toilet for a particular group can be based. Apparently therefore, the size is determined by judgment, experience or experimentation.

2.4.1.1.6 Other considerations

These include suitable size of access steps for children. The British Columbia, Ministry of Education, skills and training (1995) suggests risers 125-175mm high and treads 300mm wide.

This section has highlighted the necessary modifications required to make toilets suitable for use by children and the need for support devices. In the case of Ecosan toilets, modifications will be necessary to this Water Closet approach. For the case of disabled children, sitting is necessary, making it similar to the water closet. For children who can squat, support devices are still necessary although at lower heights than those mentioned here. Further, reduction of sizes of holes is necessary. The following section discusses disability.

2.4.2 UNDERSTANDING DISABLED PEOPLE AND LIMITATIONS

The scope of the disability group is often not clearly understood. Consequently, existing estimates of physical disability prevalence vary (WHO, 1990). Consistent and useable estimates of disability prevalence are needed to facilitate service planning. In the particular case of design of dry toilets for disabled, an estimate of the users is of paramount importance to the designer.

2.4.2.1 Definition and classification of disability

The word disability can be particularly confusing, as it has tended to be used in different ways. A classification approach can be used to delineate different disability groups (physical, intellectual, etc.) within disability generally.

The International Classification of Impairments, Disabilities and Handicaps (ICIDH) was published in 1980. The 1980 ICIDH used 'disability' to denote 'any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being'. The draft ICIDH–2 (2001) provides a basis for classifying the 'consequences of health conditions', defined as 'any disturbance in terms of functional changes associated with health conditions at body, person and society level'. This underlying concept distinguishes disability from diseases, disorders, injuries and health-related problems (classified using the International Statistical Classification of Diseases and Related Health Problems (ICD)). It also distinguishes disability from social disadvantage unrelated to health conditions.

The conceptual framework of the draft ICIDH–2 consists of three dimensions plus contextual factors. Each dimension focuses on a particular aspect of the disability experience.

- Impairment focuses on any loss or abnormality of body structure or function e.g. loss of a limb, vision.
- Activity (replacing the term disability in the 1980 ICIDH) relates to the nature and extent of functioning at the level of the person e.g. taking care of oneself
- Participation (replacing the term handicap in the 1980 ICIDH) reflects the nature and extent of a person's involvement in life situations at society level (participation in community activities), and reflects the interplay between impairments, activities, health conditions and contextual factors (e.g. physical and social environmental factors) (WHO, 1997).

Activity limitation and participation restriction are the terms used to describe negative experience in the activity and participation dimensions, respectively.

The three dimensions are distinct but interrelated. On the one hand, negative experience related to any one dimension can be considered to constitute disability. On the other hand, disability can be viewed as a 'multidimensional' phenomenon (WHO, 1997). ICIDH definitions are summarized in Table 2-4 below.

The World Health Organization makes a distinction between the concepts of impairment, disability and handicap simply as follows:

- Impairment is a damage, illness, etc.
- A disability is a reduction in a person’s capacity, as a consequence of impairment

- A handicap is the limitation, caused by the impairment and disability, to a person in daily life. A handicap is thus not primarily related to the properties of a person. A disabled person becomes handicapped when physical or societal conditions prevent him/her from leading a normal life.

An accessible environment therefore means that persons with disabilities are not unduly excluded from using it. To design for easy access means to reduce the number of persons that are handicapped.

Table 2-4: Working definitions of terms relating to disability

Term	Definition
Draft ICIDH–2 dimensions	
Impairment	(In the context of health condition) A loss or abnormality of body structure or of a physiological or psychological function.
Activity	(In the context of health condition) The nature and extent of functioning at the level of the person. Activities may be limited in nature, duration and quality.
Participation	(In the context of health condition) The extent of a person's involvement in life situations in relationship to impairments, activities, health conditions and contextual factors. Participation may be restricted in nature, duration and quality.
Context	Includes the features, aspects, attributes of, or objects, structures, human-made organizations, service provision, and agencies in, the physical, social and attitudinal environment in which people live and conduct their lives.
1980 ICIDH dimensions	
Impairment	(In the context of health experience) Any loss or abnormality of psychological, physiological or anatomical structure or function.
Disability	(In the context of health experience) Any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being.
Handicap	(In the context of health experience) A disadvantage for a given individual, resulting from impairment or a disability, that limits or prevents the fulfilment of a role that is normal (depending on age, sex, and social and cultural factors) for that individual.

Source: ICIDH-1980, ICIDH-2, 2001

2.4.2.2 Prevalence of Disability

Comparisons using the United Nations Disability Statistics Data Base (DISTAT) data show that estimates of disability prevalence range from 0.2% to 20.9% among the 55 countries studied (Chamie, 1989). This large variation is mainly attributed to differences in operational definitions and approaches to measurement and estimation. Surveys using impairment-focused screening questions produced the lowest prevalence rates, ranging from about 0.3% to 5.0% of the general population. In contrast, surveys using activity-focused screening questions yielded the highest prevalence rates, ranging from about 7.1% to 20.9% (Chamie 1989, WHO 1990).

Table 2-5 gives the percentage of Uganda's population with disabilities according to the 1991 census. Questions used for the assessment were impairment based (DISTAT).

Table 2-5: Percentage of persons with disability by age and sex in Uganda

All areas	Male	Female	Total
Total	1.3	1.0	1.2
0-14	0.8	0.6	0.7
15-59	1.6	1.0	1.3
60 +	4.6	3.7	4.1
Total of disabled population = 7.3%.			

(Source: The 1991 Population and Housing Census, Analytical Report, Vol II - Socio-economic Characteristics, 1995)

2.4.2.3 Physical Disabilities

There are several categories of physically disabled persons. The main are those with difficulties related to moving, seeing, hearing and/or speaking. The group with moving difficulties benefits the most from barrier free design both in and around buildings (Reutersward, 1995). Physically disabled people can be distinguished in two groups, those who use a wheelchair or similar, and those who are ambulant but might use walking aids or other supports.

The disabled, confined to wheelchairs or similar, need to be able to approach the toilet and move inside it freely (United Nations, 2003). The chair needs adequate space for manoeuvring. Steps should not obstruct it. The disabled should be able to manage the toilet without help. There is also a need for ramps, as an alternative to stairs, for vertical transfer.

Ambulant persons might be unsteady and cannot walk long distances. They are dependant on adequate space and on extra support, such as handrails, and resting places. Many of them prefer steps, in contrast to those in wheelchairs, as there is no risk of overbalancing when descending down the steps (Reutersward, 1995).

2.4.2.4 Design Guidelines

According to Reutersward (1995), Architectural design alone cannot provide for an un-compromising independence for all disabled persons. Architectural design is best suited to alleviate difficulties experienced by those with moving difficulties, followed by those with seeing and hearing or speaking difficulties.

2.4.2.4.1 Access for People With Difficulties in Moving

The design for people with moving disabilities is related to making the environment accessible to people confined to wheelchairs (or similar) and ambulant people using other walking aids. To people using

wheelchairs the dimensions and characteristics of these are essential for making the environment barrier free. The dimensions that control accessibility are detailed below.

Table 2-6: Dimensions for accessibility requirements

Length of conventional wheelchairs	1100–1200 mm
Width of conventional wheel chair	600–700 mm
Manoeuvring space needed for wheelchair turning (circle Figure 14)	1500 mm diameter
Reach of persons in a wheelchair	Less than 400 mm from room corners between 700 and 1200 mm above the floor

(Source: Reutersward, 1995)

To suit all kinds of wheelchairs, rolling boards and ambulant persons, switches and other implements should thus be placed at a height of 900 mm and at least 400 mm from inside corners. This is in consideration of the ranges of reach given in the table above and shown in Figure 2-8.

The following design guides are used to determine accessibility of facilities and devices.

i. Doors

Problems with doors can be a result of one of the following design flaws

a) Narrow doorways
b) Doors hinged on the wrong side, thus hindering accessibility
c) Doorways with high thresholds
d) Heavy and hard-to-operate door leaves.

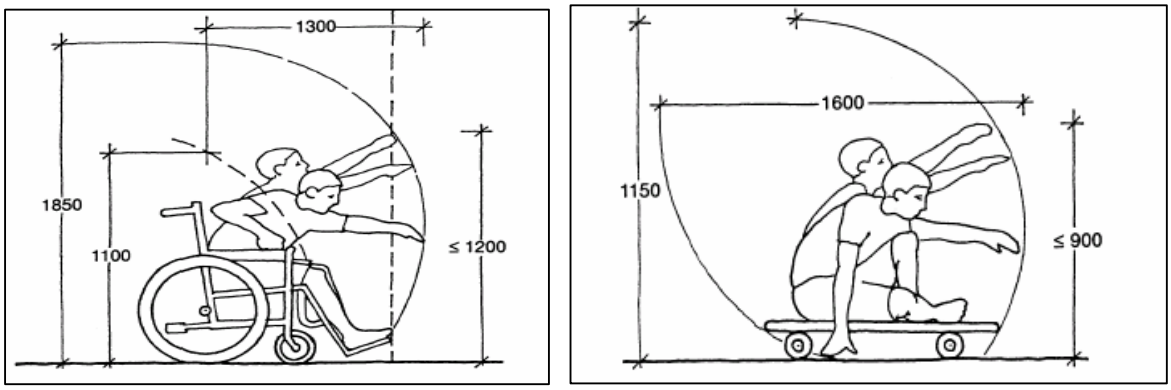


Figure 2-8: Ranges of reach for adults in wheelchairs and on rolling board (Source Reutersward, 1995)

Design aim: To facilitate the passage of a wheelchair user through toilet doors

General considerations: Accessible doors should be so designed as to permit operation by one person in a single motion with little effort. There should be a space of at least 300 mm on the wall next to the door handle for easier approach (Figure 2-9). An accessible door should have the following features: a sign, a door handle, an extra pull handle, glazing and a kick plate (United Nations, 2003)

Door opening: For exterior doors, the minimum opening is 0.90 m when the door is open (Figure 2-9). This allows for ambulant persons (Figure 2-11) and wheel chair passage (table 2-6). Doors should open outward unless sufficient space is provided within the toilet stall so that a person falling in the room will not block the door

Manual door hardware: Operational devices on doors, such as handles, pulls, latches and locks, should be easy to grasp with one hand. A vertical pull handle at approximately 900 mm from the floor level is easy to operate (Figure 2-10).

Handles: Lever-type handles, push plates or pull handles are recommended for swinging doors because they are easy to open. Round knobs are not recommended. Door handles should be located at a comfortable height between 0.90 m and 1.00 m from the floor surface (Figure 2-9).

Thresholds: Thresholds should be omitted whenever possible. If needed, they should be well designed not to form barriers to wheelchairs. The height of thresholds should not exceed 15 mm (Figure 2-10). They must be clearly defined, for example by contrasting colour, to the adjacent floor surface.

Signage: In public facilities, the function incorporating international symbols should be identified at eye level, i.e. between 1.40 m and 1.60 m

Colour: The door or the doorframe should be painted in a colour that contrasts with the adjoining wall, to facilitate its identification by visually impaired people.

ii. Ramps

Are a simple means of linking two levels. It is of great use for access by wheelchair, but cannot replace stairs. As suggested earlier (Reutersward, 1995), many ambulant persons prefer stairs. A ramp needs additional space that has to be planned for. A ramp should

- Have a gradient of 1:20 and not steeper than 1:12
- Have an alternative stepped approach if the gradient is more than 1:12

- Not take up a vertical rise of more than 500 mm in one lift
- Have a landing of 1.3 to 1.8 m between successive ramps with maximum inclination of 1:50.
- Be 900 - 1000 mm wide. 900 mm is an absolute minimum.
- Be provided with kerbs at the edges (75mm high or 50mm if handrails are provided) to prevent wheelchairs from rolling off. Kerbs when provided also guide sightless people using a long cane into travel paths.

It means here that a vertical rise of 1m at the entrance of a toilet must have a ramp 6m or longer. It is possible however; that some conditions may require shorter, steeper or no ramps at all. This will depend on the topography of the location. This must be determined on-site.

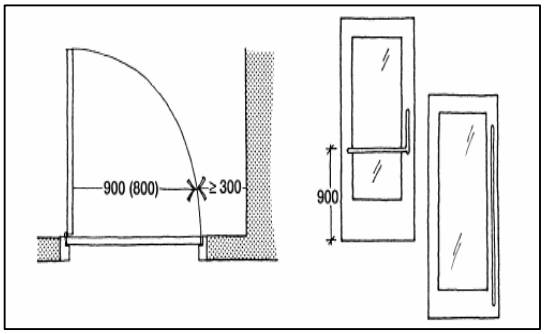


Figure 2-9: Door clearance and pull handle design

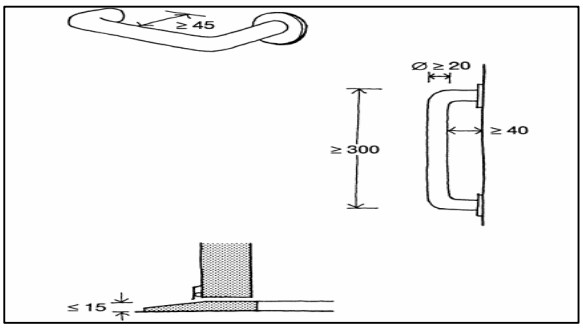


Figure 2-10: Door handle and threshold design

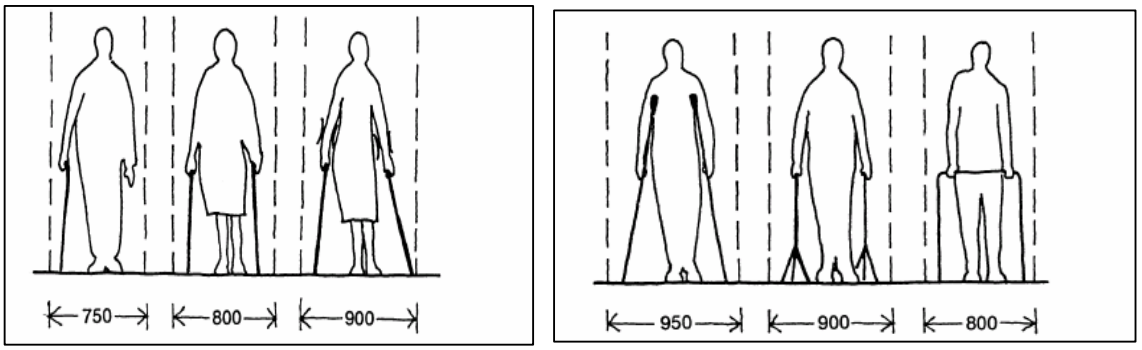


Figure 2-11: Typical widths for ambulant people using callipers and crutches (source: Reuterswaard, 1995)

Handrails: Should be provided on each side of any steep ramp. They should continue 300 mm beyond the beginning and end of ramp. The handrails should have a diameter of 32–38 mm and should be placed at a height of 900 mm. Another one should be at 700–750 mm for people confined to conventional wheelchairs (typical sections are shown in Figure 2-12).

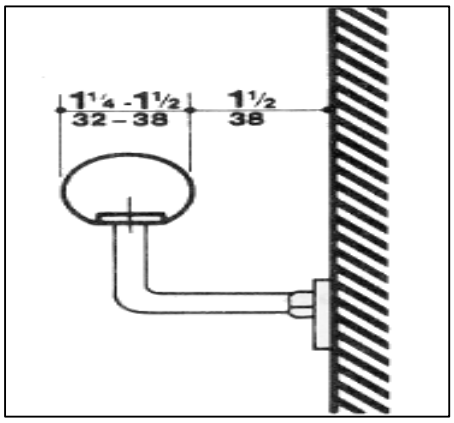


Figure 2-12: Design of handrails

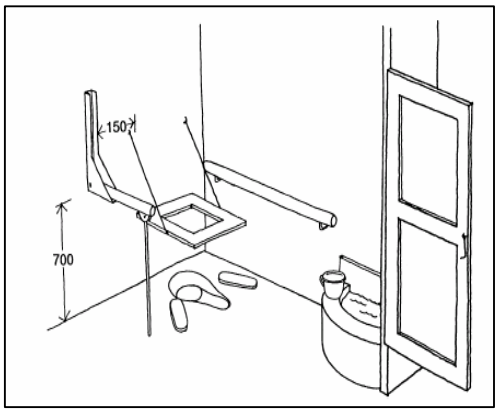


Figure 2-13: A fold-down seat over a pit latrine

(Source: Reutersward, 1995)

Because physically disabled persons can sometimes not squat, being able to sit is important. Ultimately, any toilet system with the intention of disabled use must allow for sitting. Reutersward (1995) suggests that for a pit latrine, arrangements can be made so that the disabled may use it more easily by a seat construction fastened in the wall to allow the person to sit comfortably, which can be tipped down from the wall when needed (Figure 2-13). Further, firmly fixed grab rails, about 35 mm in diameter and placed 700 mm above floor level, at both or at least at one side of the seat or pit (150 mm from the side of the seat) will help the individual to hold him/herself steady and to move from seat to wheelchair or simply to get up on her feet again.

However, a seat construction may be adopted that can be placed over the pit hole at a convenient height. The seat construction can be modified to suit Ecosan systems. This type of construction could be useful for individuals for whom the full inclusion of the details in this report in a toilet is uneconomical or for sick and weak persons at homes who may need to be supported while using the toilet. This avoids the disadvantages of having mechanical parts such as wear, breakage etc. hence causing accidents.

2.4.2.4.2 Internal Space

Problems arising are due to:

a) Insufficient allocation of internal manoeuvring space and
b) Poor design and positioning of fixtures and fittings.

According to BS 8300: 2001, the correct relationship of WC to basin and other accessories, and to the space required for manoeuvring, is critical in enabling disabled people to use the facilities independently or with minimal assistance. The standard talks about the space requirements for a conventional water closet. This idea can be applied to a dry toilet with similar operational requirements namely sitting for disabled people. The code specifies that an Accessible corner WC should be a minimum of 2200mm x 1500mm (compare with ADAAG: sec 2.4.1.1.2).

For Ecosan system where water is undesirable, fixtures for water are unnecessary. These may be placed outside for hand washing. The space requirements may therefore be lower than specified here by the code, but must still be governed by the need for manoeuvring space for a wheelchair.

The code also specifies the following considerations among others.

- A unisex facility enables assistance from either sex to attend to a disabled person. In public toilet systems, the attendant will possibly be of the desired sex thus this provision is not necessary
- Accessories, such as soap dispenser, toilet paper, paper towels, should be designed for single-handed use and should be readily accessible from someone seated on the toilet and from someone standing. A height between 0.50 m and 1.20 m from the finished floor level is recommended (see also sec 2.4.1.1.3).
- A mirror should be provided 600mm from floor level to a height of 1600mm.

Design aim: to provide sufficient accessible space inside toilets, with all fittings being within easy reach.

General considerations: Turning circles of 1.50 m diameter are recommended inside the toilet room to allow for full-turn manoeuvring of a wheelchair (Figure 2-14).

The ease of transferring from a wheelchair to a toilet seat depends on the approach. In general there are three different approaches: perpendicular or side approach, parallel or front approach and diagonal approach, as shown in Figure 2-15 (also refer to sec 2.4.1.1.2).

The parallel approach is easiest and is advised. The approach is dependent on the relative location of the toilet in public toilet stalls. Outer stalls may be approached from the side whereas the middle ones will be approached from the front or diagonally.

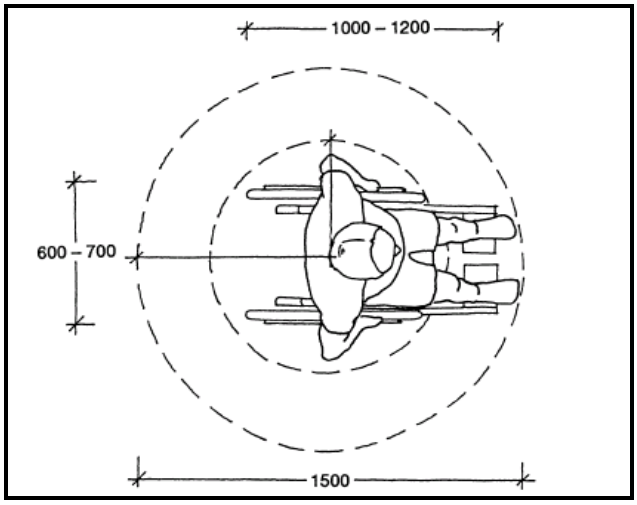


Figure 2-14: Floor space needed for manoeuvring a wheelchair (source: Reutersward, 1995)

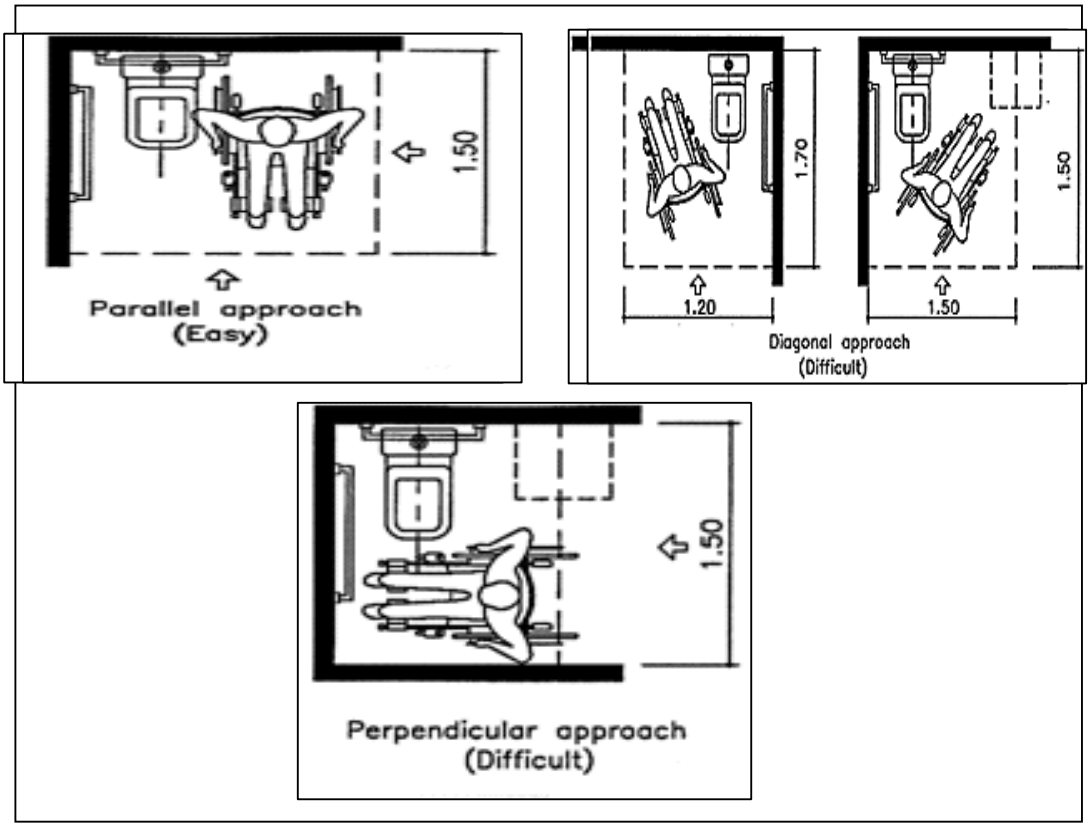


Figure 2-15: Approaches to a Toilet (Source: United Nations 2003)

For clarity the mechanisms of diagonal and side approaches are shown in Figure 2-16

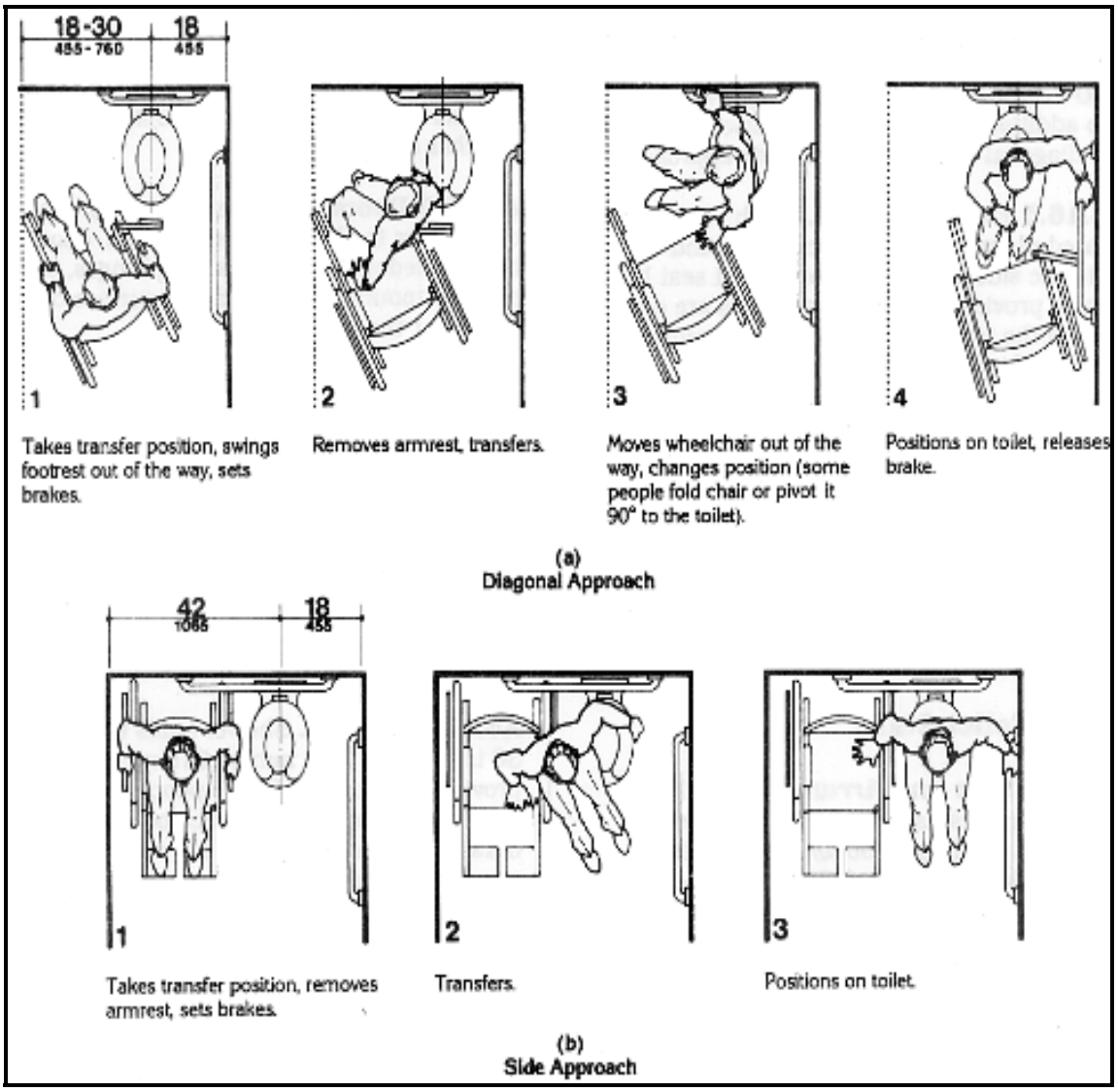


Figure 2-16:(a) diagonal transfer (b) side transfer (source: ADAAG)

2.4.2.4.3 Location of Support Devices

These are located in accordance to the dimensions already mentioned in section 2.4.1.1.3. The United Nations manual, BS8300: 2001 and ADAAG all talk about water closets (which are sitting toilets). The same principles can be adopted for sitting dry toilets, for hand washing sinks outside of the dry toilet, and for separate urinals. Additional requirements are summarized below.

1) Water closets

- The height of the toilet seat should be between 0.45 m and 0.50 m from the finished floor level.
- The distance between the centreline of the toilet seat and the adjacent wall, if provided with a grip bar, should be between 0.45 m and 0.50 m.

- Grab bars should be mounted on the wall behind the toilet, and on the sidewall closest to the toilet, or mounted on the floor at the edges of the seat.
- Grab bars should be mounted at a height between 0.85 m and 0.95 m from the floor.

2) Urinals

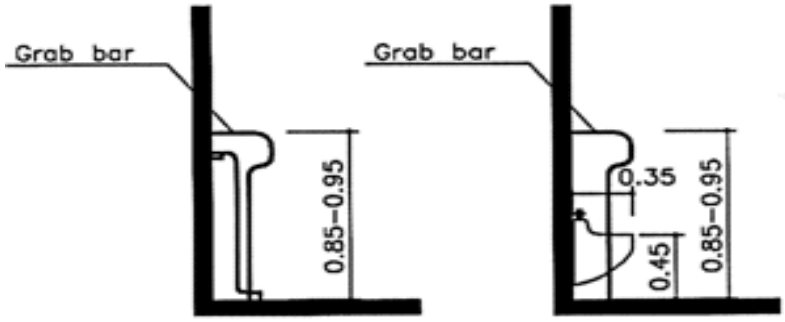


Figure 2-17: Typical urinal design (Source: United Nations 2003)

- At least one accessible urinal should be provided in public systems
- Urinals should have a clear space on both sides.
- A full-length urinal is the most accessible.
- Urinals with a protruding lip should be mounted at a height of 0.45 m from the finished floor level.

3) Grab bars (refer to sec 2.4.1.1.3)

- Grab bars should be installed in water-closets/toilet to assist disabled persons to use the facilities safely and easily. Figure 2-12 shows a typical section.
- Grab bars should have a diameter of 30 mm to 40 mm.
- Wall-mounted grab bars should extent between 35 mm and 45 mm from the wall.
- Grab bars should be firmly fixed with stand loads and should have non-slip surfaces; knurled surfaces usually prevent slipping.

4) Floors

Flooring materials should be skid-proof and easy to clean.

Summary

1) Children younger than 12 years benefit from specially designed children's facilities. The rest can comfortably use adult facilities.
2) When using toilets, children are affected most by the size of sitting pan/ squatting drop hole and the absence of support devices such as grab bars
3) Disability definition can be particularly confusing, as it has tended to be used in different ways. Similarly, estimates of prevalence of disability defer from country to country depending on the definition adopted.
4) WHO defines the following terms:
   → Impairment: A damage, illness to a person
   → A disability: A reduction in a person's capacity as a consequence of impairment.
   → A handicap: The limitation caused by impairment and disability to a person in daily life.
5) To design for easy access to facilities means to reduce the number of person's that are handicapped. Design for disabled persons is related to making facilities barrier free and the provision of support devices.
6) Design for a wheel chair user benefits all the disability groups.

CHAPTER THREE-METHODOLOGY

3.1 INTRODUCTION

The methods used to achieve the objectives of this project included field visits and observations, questionnaires and interviews, workshops and discussions, measurement of existing facilities and of wheel chairs. These methods and procedures are described in the next sections

3.1.1 FIELD VISITS AND OBSERVATIONS

Visits were made to the districts of Kabale and Kisoro where the use of Ecosan toilets is currently pronounced. This provided an opportunity of looking at the toilets and seeing them in use. In addition to the facilities in Kabale and Kisoro districts, some Ecosan units under construction in Kampala and Mukono districts by DWD and Kampala City Council (KCC) were visited. These visits acquainted the researcher with the toilets being studied.

3.1.2 INTERVIEWS AND QUESTIONNAIRES

Questionnaires were used to find out the problems faced by children and disabled persons while using the current toilets. The suggested solutions were also sought out. In Kabale and Kisoro districts, two questionnaires were used, one for household Ecosan units and the other for institutional units (mainly primary schools and public toilets). The two questionnaires are to a large extent similar in structure of questions, only modified to the user group. Heads of households or other responsible person filled out household questionnaires with assistance from the researcher. Teachers/matrons and caretakers filled those for primary schools and public toilet systems respectively. The latter received assistance from the researcher. These two questionnaires are both included in the Annex.

Because very few disabled persons were met in Kabale and Kisoro, a separate questionnaire was prepared for this group. Disabled persons at Makerere University filled these out. This questionnaire, being filled by persons with no prior use and experience of the Ecosan toilet was related to the common water closet thus making the students at the university suitable to answer it. A brief description of the system was included which was considered comprehensible to this group other than trying to explain the system to other groups. A copy of this questionnaire is included in the Annex.

Interviews/discussions were also carried out with staff of the Orthopaedic clinic in Mulago Referral Hospital, staff of the Department of Community and Disability studies (Kyambogo University), Crestanks and DWD.

3.1.3 CHECKLISTS

A copy of the filled in checklist is shown in the Annex. Every toilet that was visited had the detailed measurements taken. The results derived from this checklist are given in chapter four.

3.1.4 MEASUREMENTS AND ANALYSIS

Two types of wheel chairs were met. The imported ones are in a way different from those made from the Orthopaedic Workshop in Mulago hospital. Both their measurements were taken. A simple 3m measuring tape was used. Also, dimensions of prefabricated plastic squatting and sitting pedestals were obtained from Crestanks and by direct measurement by tape in Kisoro.

3.1.5 COST CALCULATION

Two costs have been calculated because different materials are used. The prototype was constructed out of wood whereas it is assumed that the real constructed structures for use will be in masonry. The costs are based on the design in chapter 5 and the drawings 1, 2 and 3 attached at Annex.

3.1.6 CONSTRUCTION OF PROTOTYPE

Based on the design, the prototype was constructed at the Faculty of Technology and later handed over to the sponsors (DWD). The materials used and costs of labour are summarized in chapter five.

CHAPTER FOUR – RESULTS AND DISCUSSION

4.1 INTRODUCTION

The two districts of Kabale and Kisoro were used as the research area. These two districts have a large Ecosan usage. Ecosan toilets are widely used both in institutions and in households. It was noted in the early stages that homes contributed little to the solution of this project either by lacking any of the subject members of this project, or by the availability of immediate help to children and disabled persons during the use of the toilet. Although several household toilets were also visited, the biggest focus has been on institutional toilets (mainly primary schools).

Similarly, organizations dealing with the provision of Ecosan toilets targeting households have not reported problems affecting children using Ecosan. The disabled have also rarely been met. For instance during the Water-aid conference on sharing Ecosan experiences (Fairway hotel, 14th May 2004), the main discussant reported no problems affecting children in the use of these toilets. Disabled persons were completely left out. This is opposed to the teachers in primary and nursery schools who concern themselves with a large population of children. The findings from primary schools and from questionnaires to disabled persons are discussed below.

4.2 RESULTS AND DISCUSSION

4.2.1 SUMMARY OF STUDY TOILETS

Table 4-1 summarizes the characteristics of the toilets and users in terms of users, type of toilet and location.

Table 4-1: Summary of characteristics of toilets and users

Toilet ID	Location	District	Users	No. of stances	Age (yrs)	Cost	Toilet type*
K_i2	Shalom P. S	Kisoro	Children	4	4	#	0
K_i3	Read Pre and Primary School	Kisoro	Children	4	1	200.000	0
K_i5	Kisoro New market	Kisoro	Public	4	4	35 million	2
K_i1	Aunt Phina kindergarten	Kisoro	Children	1	3	#	0
K_i4	Mosque	Kisoro	Public	1	2	#	0
K_i6	Kisoro town council	Kisoro	Public	6	4	14million	2
K_a1	Kikungiri primary school	Kabale	Children	10	2	7million	0
K_a2	Nyabikoni	Kabale	Household	1	1½	300.000	0
K_a4	Kigarama	Kabale	Household	1	1	#	0
K_a3	Kitumba	Kabale	Household	1	1	30.000 #	0
K_a5	St. Mary's Rushoroza S. S	Kabale	Disabled	1	New	#	1

*0 = 'squatting', 1 = 'sitting', 2 = 'squatting/sitting' #: toilet possibly subsidized

Four primary schools, three public facilities and three households were compiled. A toilet intended for disabled persons at St. Mary's Rushoroza was also visited. However, this toilet was not yet in use.

4.2.2 PROBLEMS FACED BY CHILDREN AND DISABLED PERSONS AND SOLUTIONS

Table 4-2 summarizes the responses obtained from the questionnaires used in Kabale and Kisoro with respect to problems faced by children and disabled and the suggested solutions. Included also are the observed operation and maintenance problems for the toilet.

Table 4-2: Summary of responses of interviewees in relation to children and disabled toilets

Toilet ID	Location	Users	Popn	No of disabled [π]	Problems of disabled	Problems of children	Suggested solutions		Comments on O & M and users
							Children	Disabled	
K_i2	Shalom P. S	Nursery P1- p4 P5 – p7	84 61 41	Nil	-	Fail to place ash Defecate in urine diversion			Clean, No smell, dry
K_i3	Read Pre and Primary School	Nursery P1-p4 P5-p7	65 60 25	Nil	-	i) Fail to place ash ii) Toilets are separated for classes			Most smelly toilet seen and with flies.
K_i5	New market	Public		-	Old people use sitting toilet, problem of steps	Defecate in urine diversion Sitting toilets are wide for children	-	Training users/sensitisation	Very clean, people fear to use toilet
K_i1	Aunt Phina kindergarten	Nursery P1-p4 P5-p7	40 60 30	1	Find it hard to climb to toilet as it is high	i) New pupils need training, defecate in wrong places	i) Reduce height of steps to toilet ii) Introduce separate facility for disabled	i) Need training ii) Use different squat holes sizes for different ages	Clean, No smell, No flies
K_i4	Kisoro town mosque	Public		-	-	-	-	-	Does not cater for washers. Out of use due to lack of emptying
K_a1	Kikungiri primary school	Nursery P1-p4 P5-p7	108 480 450	33	Unable to squat Unable to direct urine into diversion	i) Children p1-p4 use pit latrines. Only p5-p7 use Ecosan	i) Build special toilet for disabled children	i) Training children	Girls throw their pads into urine diversion

[π] Number of disabled persons may not be accurate as it depended on the perception of the interviewee about disability rather than definition adopted for evaluation. Responses of other toilets are not included.

The responses given in table 4-2 reinforce the problems cited in the literature. These are accessibility, and lack of support devices for disabled people. The problems that need technical solution for children include size of holes, height of stairs and provision of extra support. The other problem not mentioned in the literature relates to confusion by children as to which hole should be used. Thus in a few cases, children defecated in the urine diversion.

What causes this confusion? This trend was reported from certain toilets and not from others. The observation was that some urine diversions are deep and with larger holes (both defecation and urine diversion, photos 4-1 (K_a1) and 4-2 (K_i3)). It is possible that children get confused and interchange the functions of these holes. Meanwhile less deep diversions, photo 4-3 (K_i1)) seem not to have suffered this problem although new children unaccustomed to this kind of toilet could still get confused. This toilet $K_i1$was cleaner compared to the others, in spite of being used by nursery children.

Photo 4-1: Toilet Ka1

Photo 4-2: Toilet Ki3

Photo 4-3: Toilet Ki1

Photo 4-4: Toilet Ki5

Further, users of toilet in photo K_i1 had no complaint about large defecation hole. It is in fact users of toilets in K_a1, K_i3 who had this complaint. It should be clear that the defecation holes of toilets K_a1 and K_i3 are wider than for K_i1 (210mm diameter, 150mm). Another toilet that could solve the problem of large hole-size is one used in Kisoro New Market (photo 4-4) with rectangular rather than circular defecation holes and shallower urine diversion.

In the two extreme cases in photo 4-1 and 4-2, there was separation of toilet usage based on class of children in an attempt to abate such problems. In K_a1, the lower classes, nursery to P4 are forced to use pit latrines whereas the higher classes use Ecosan (photo 1-1). Whereas the Ecosan toilets were fairly clean, the pit latrines were wet, dirtier and generally unpleasant (photo 4-6).

Photo 4-5: Sitting Ecosan toilet in two-vault toilet. To the left is blocked stance (K_i6)

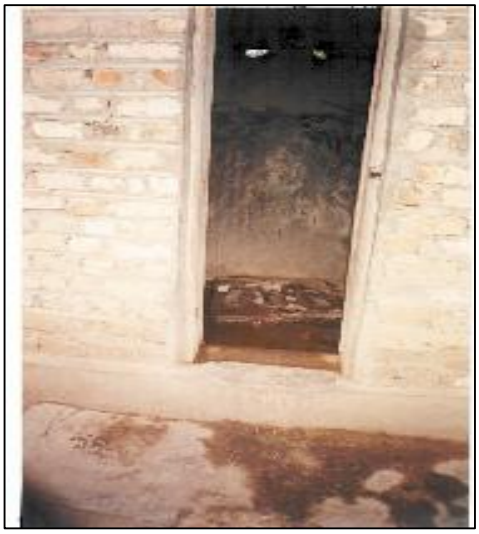


Photo 4-6: Internal scene of one room in the pit latrine in photo 1, chapter 1 (Ka1)

Coupled with maintenance problems, toilet K_i3 (photo 4-2) produced the smelliest Ecosan toilet seen, with swarms of flies, very much similar to an equally poorly maintained pit latrine.

The need for support suggests that very young children' toilets (Nursery to P4) had better be sitting type rather than squatting. But it is suggested that balancing while squatting be aided by raising the footrests backward in addition to the provision of hand supports. This may turn out to be difficult in construction but companies prefabricating these components can consider this option.

To maintain the performance requirements of the Ecosan toilet, some of the suggested solutions such as building chamber underground cannot be taken. Shorter steps, smaller squat holes and different sizing for different age groups will be adopted. The need for a separate facility for disabled persons is supported in the literature.

The other problems are isolated and non-technical in nature. These include; failure of children to place ash (an ash flushing system is a subject of a parallel research project), girls throwing pads into urine diversion etc is an operation and maintenance problem (also subjects of a parallel research project). However, the operators of these toilets have already expressed the solution in their insistence on training and sensitisation of users.

4.2.3 DISABLED PERSONS RESPONSES FROM QUESTIONNAIRE AND DISCUSSION

Table 4-3 gives the responses in relation to the questions: 1.what difficulties do you meet when using the toilet (Water closet)? And 2. Please suggest modifications you think will be necessary to minimize the difficulties you have listed above. The first question aims to determine whether or not the disability constitutes an activity limitation (Table 2-4).

All the disabled persons suggest a special facility, built for disabled persons. In addition, most of the problems mentioned here are already covered in the literature. The problem of slippery surfaces (due to water on smooth floor finish) will not be considered of significance in Ecosan toilets (dry type) because the floor will always be maintained dry due to non-tolerance of water in the toilet. The mention of this problem arose because the questionnaire compared Ecosan to the sitting Water Closet (WC).

Another previously un-recognized problem relates to the height of the toilet above ground. For wheelchair users who have complete lack of control over the lower half of the body, dragging the body up the toilet is a feat. They think that if the toilet were flush on the ground (similar to the squatting toilet), it would save them effort. This would create more serious problems for other groups who would find it difficult to rise from that position, for instance one using crutches. The suggested solution is to include a dropdown rail on the side of the toilet to provide support at hand or armpit level. Wall-mounted handrails provide additional support. Further, the sitting Ecosan chair can be constructed to suit any given height.

Disease transmission by way of the sitting toilet is a possibility whose solution is outside the competence of this project. This issue may require expert advice. However, it relates to hygiene and cleanliness.

In conclusion, the suggestions reinforce the problems already discussed in the literature and whose solutions are provided in the design codes for direction.

Table 4-3: Summary of responses of disabled persons and suggested solutions

Age, M/F	Disability	Occupation	Time with disability (yrs)	Type of toilet used	Difficulties using toilet	Suggested solutions
23 M	Wheelchair	Student	14	Sitting	• Toilet is high • People climb on toilet seat making it dirty.	• Toilet should be lower • Disabled persons should have separate toilet
21 M	Crutches	Student	20	Squatting	• Floor is slanting and uncomfortable. • It is also slippery	• Minimize gradient. It should be flat • Moderately rough floor will minimize slipping surface and increase comfort
24 M	Crutches	Student	22	Sitting	• Seats are high • Ground is slippery • Flooding of ground	• Toilet seats should be at ground level • Floor should be dry at all times • Toilets for disabled should be special, separate from the rest and near the users
21 F	Calliper	Student	20	Sitting	People step on toilet seats rather than sitting on them	Get special toilets for disabled people
23 F	Crutches	Student	23	Sitting	• Toilets are dirty because some people step on them • Someone always to help when there are stairs which is uncomfortable	• Separation of toilets of disabled persons from abled • Toilets with no stairs • Toilets should be dry to avoid slipping
23 F	Wheelchair	Student	18	Sitting	• Wheelchair can't fit in the toilet room. The room is so small, the door can't close • Toilets are dirty and sometimes flooded • There are problems of contracting diseases like candida from toilets	Make sure there are no stairs on disabled persons toilets To consider wheelchair users when constructing toilets and special toilets for PWDs
23 F	Crutches	Student	18	Sitting	• Public toilets are always dirty, not suitable for sitting • Some public toilets are not accessible	• Ramps should be put on toilets for wheelchair users • Toilets for disabled persons should be separate from those of persons not disabled. • Rails should be put on the sides of the toilet seat to support PWDs while sitting on the toilet seat. • Doors should be wide enough to enable wheelchair users to enter with their wheel chairs instead of crawling down
22 M	Wheelchair	Student	20	Sitting	• Sitting/squatting latrines are so tiresome especially in transferring from and to the wheelchair • Poor hygiene conditions	• Get special toilet designed to suit disability • Getting person to ensure daily cleaning • Special toilets separate from others for disabled persons
22 M	Wheelchair	Student	20	Sitting	• Sitting/squatting latrines are so tiresome especially in transferring from and to the wheelchair • Poor hygiene conditions	• Get special toilet designed to suit disability • Getting person to ensure daily cleaning • Special toilets separate from others for disabled persons

4.2.4 MEASUREMENTS OF TOILETS FROM CHECKLIST

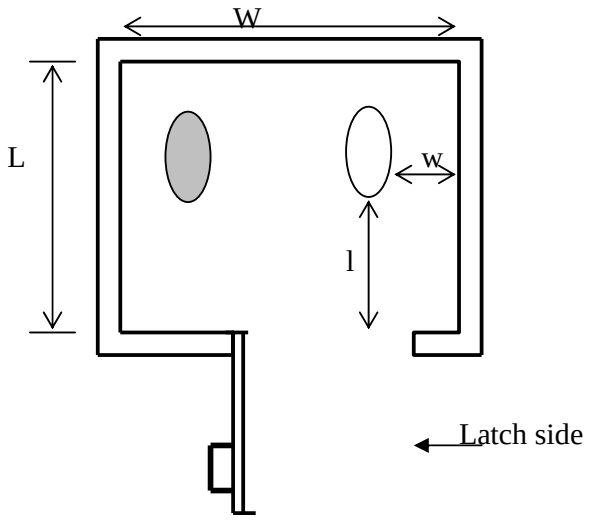


Figure 4-1: internal toilet space

The toilets listed were not constructed to be accessible but have been used as a basis of study. It can be seen from the given dimensions that there isn't any attempt at standardization. These seem to be random. The toilets are not easily accessible because of steep steps or high pitch ramp (St. Mary's Rushoroza), small door widths, small internal space, inadequate doors or inappropriate toilet (squatting rather than sitting) as illustrated in section 4.2.7

Table 4-4: Checklist of toilet rooms

No.	Toilet ID / Parameter	K_a1	K_i1	K_i2	K_i3	K_a2	K_a3	K_a4	K_i4	K_i5	K_i6	Codes
1	Users	Child	Child	Child	Child	H/hold	H/hold	H/hold	Public	Child	Public	
1	Internal space (W, L m)	1.5x0.85	1.1x0.9	1.5x1.15	0.8x1.1	1.6x1.4	1.5x1.5	1.2x1.4	1.4x1.2	1.5x1.5	1.4x1.4	Min 1.5x1.5
2	Toilet location, w	0.25	0.15	0.3	0.2	0.25	0.2	0.35	0.3	0.2	0.2	0.3
4	Distance, l	0.3	0.4	0.9	0.7	0.7	0.9	0.8	0.6	0.9	0.4	1.5
5	Rise of stair	0.8	0.5	0.96	0.7	0.9	0.86	None	1.0	0.6	1.1	Ref §4.2.7
6	Nature of floor (R, S)	R	R	R	R	R	R	R	R	R	R	R
7	Min. width of door	0.76	0.65	0.8	0.6	0.8	0.78	0.74	0.8	0.78	0.8	0.9
8	Min width of corridor	0.87	-	0.95	-	-	-	-	-	-	1.9	1.5min, 0.9child
9	Ht. Of door hardware	1.1	1.0	-	1.1	1.2	1.2	1.1	1.1	None	1.1	0.9-1.0
11	Nature of toilet	0	0	0	0	0	0	0	0	0	2	-
12	Size of squatting hole	0	0	0	0	0	0	0	0	0	2	Ref §4.2.6

R = rough S = smooth, 0 = squatting 1 = sitting 2 = both

4.2.5 WHEELCHAIR MEASUREMENTS

The wheel chairs used by disabled persons were found to be of two makes. There are those imported, which are relatively more expensive. Those seen and measured vary in width between 550mm and 700mm wide with a constant length of 1100mm. The second types are made/assembled at the Orthopaedic workshop in Mulago hospital. These have characteristic dimensions similar to those of the imported chairs and are only modified to suit the local conditions. They are said to be more suitable to the conditions in Uganda in addition to being relatively cheaper.

These wheel chair measurements agree with the design sizes used by the design codes cited (see Reuterswaard, 1995). In Uganda, there are also tri-cycles used by disabled persons who can manually pedal by hand. These are greater than 800mm wide and greater than 1700mm long.

Basing on these dimensions, the space requirements for the tricycles would be large and it would be uneconomical to provide. Rather such tricycles may be packed outside the toilet. Disabled persons who can peddle on tricycles are strong enough to crawl a short distance on the ground and are usually well equipped with moving aids for this.

4.2.6 TYPICAL SQUATTING PLATES

The following squatting plates (Figure 4-2, 4-3, 4-4) were identified. The darker shade is the defecation hole whereas the light shade is the urine diversion. The plan of each type is over its section.

The plate in Figure 4-2 had not generated complaints. The toilet was not fully utilized as people feared to use it for any reasons. The plate in Figure 4-3 had complaints of large-hole size and of children getting confused about which hole to use, because of the deeper urine diversion. The plate in Figure 4-4 was used by nursery children and was well maintained. It generated fewer complaints.

Note from the photo 4-3 that the urine diversion is distinct from the defecation hole. The defecation hole is most noticeable (compare with photos 4-1, 4-2). This kind of design should be encouraged as opposed to the deeper urine diversions (more so for children). A gentle slope is enough to convey the urine to the hole rather than a very deep one. It is common in ordinary latrines for the front part to be lowered than the sides to gather urine. In that case the urine flows back to the defecation hole. In this case the urine flows away to the urine transport and a small lowering can as well do the trick.

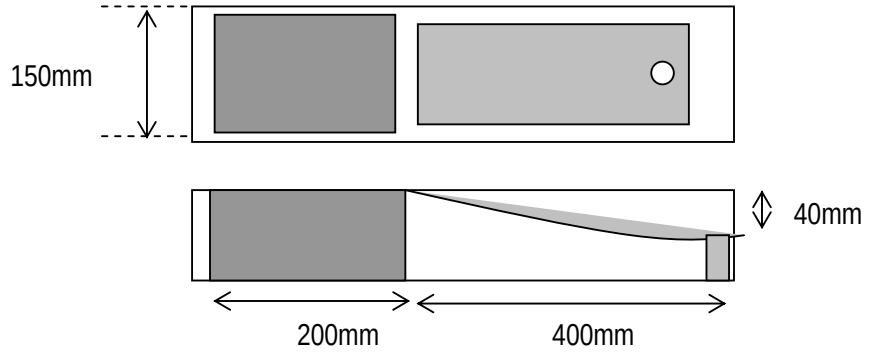


Figure 4-2: Rectangular shaped plate as used in Kisoro New Market (photo 4-4)

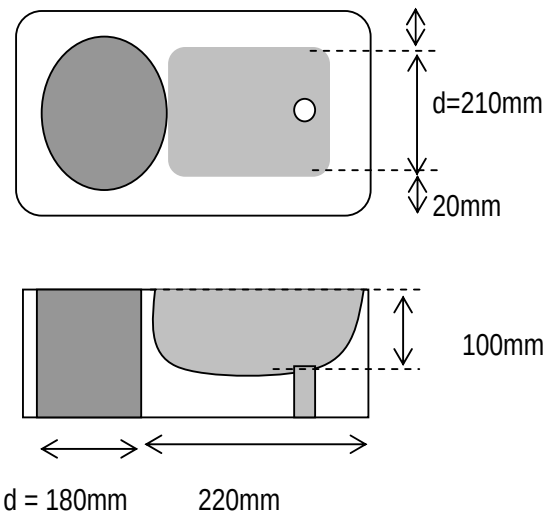


Figure 4-3: Typical squat plate made by Crestanks Ltd (photo 4-2)

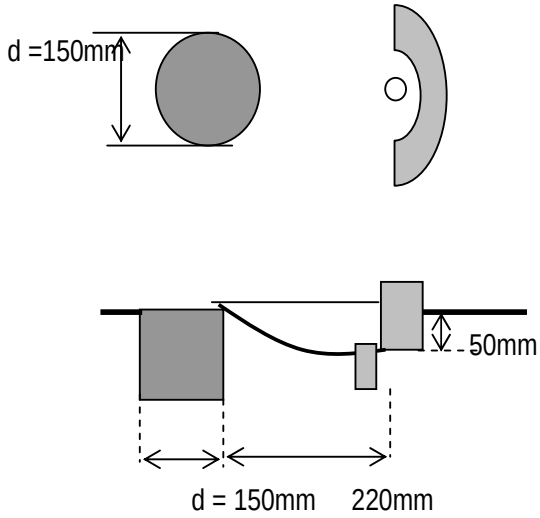
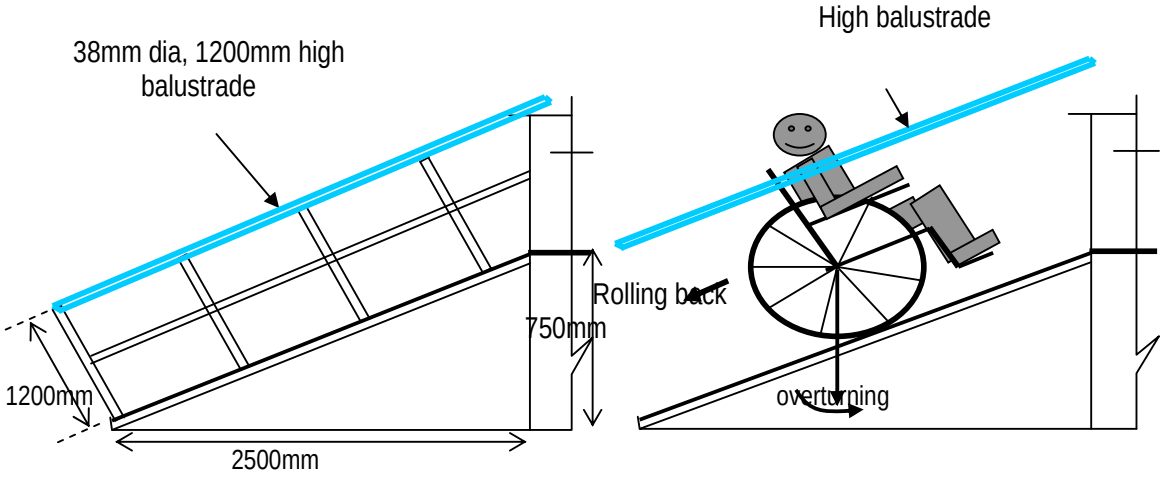


Figure 4-4: Cast in place as in Aunt Phina kindergarten Kisoro (photo 4-3)

4.2.7 INAPPROPRIATE DESIGN IN SOUTHWESTERN TOWNS ECOSAN DESIGN MANUAL.

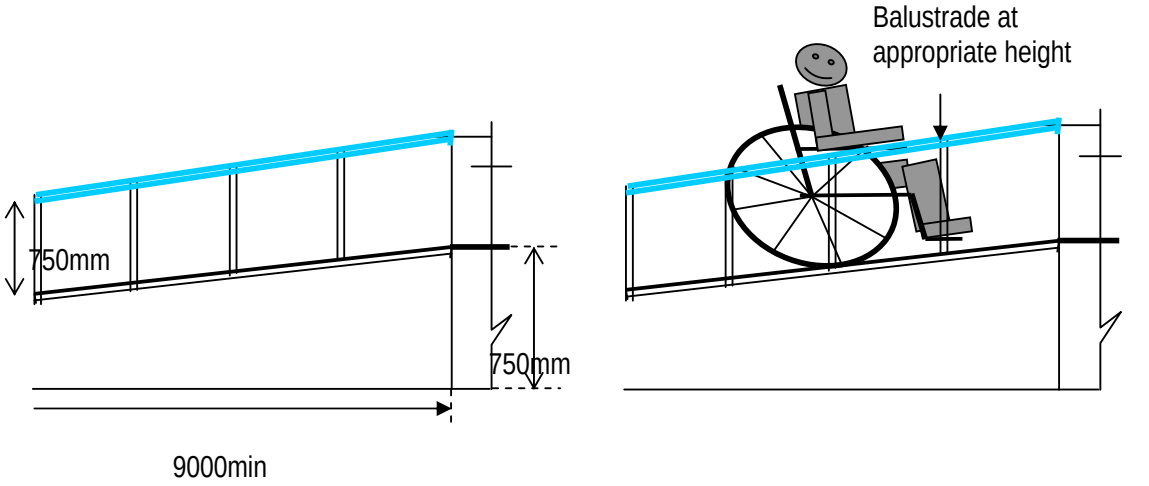
A number of hitches have been identified in the design manual. The next subsections illustrate these situations. The design manual is compared with acceptable values from design codes quoted earlier.

4.2.7.1 Steep ramp



(a) Manual specification (slope 33%) (b) Possible effects of steep ramp

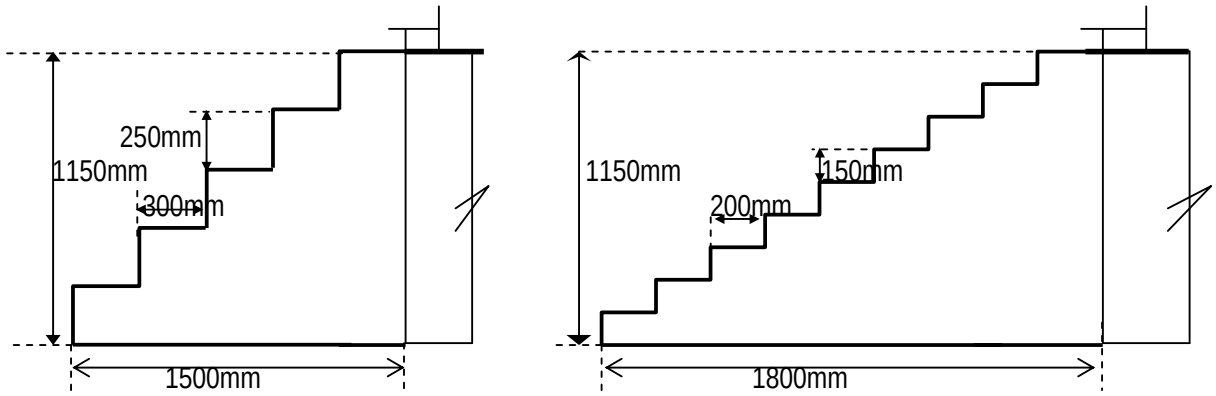
Figure 4-5: Inappropriate ramp design (Not to scale)



(a) Gentle slope (8.5%) (b) Comfort of wheelchair on gentle slope

Figure 4-6: Appropriate ramp design (Not to scale)

4.2.7.2 Long rise of steps for children's toilets



(a) Steeper risers in steps (b) shorter, suitable steps

Figure 4-7: Illustration of steep steps (manual) against gentle steps for children

CHAPTER FIVE – DESIGN SUMMARY

5.1 DESIGN PARAMETERS

5.1.1 INTERNAL SPACE

Minimum 2200 X 1525mm for disabled persons toilet, 1525 X 1525 for children's toilets when toilet is at corner of room. If the toilet is in the middle of room, space should increase beyond 2200x1525mm. The former case is suitable for two-vault Ecosan toilet.

5.1.2 DOORS

- 900mm opening outward unless internal space is much lager than given here
- Pull handle at 900 - 1000mm above floor for disabled persons, 465-730mm for children. Younger children's toilets having the lower values.
- Thresholds omitted completely
- Should have appropriate informatory/ directional signage

5.1.3 CORRIDORS

- Width of corridors 1.5m minimum for public toilets
- Maybe 0.9m for children's toilets

5.1.4 RAMPS AND STAIRS

RAMPS

- Gradient: 1:20 - 1:12. If gradient is steeper than 1:12, provide alternative stepped access. For children, gradient is 1:16
- Vertical rise of ramp before landing < 0.5m
- Width of ramp 900 - 1000mm
- Length of landing 1.3 - 1.8m
- Provide handrails 32 - 38 mm diameter, 25mm for Nursery children, on each side of ramp steeper than 1:12 at height 900mm and 700-750mm and should continue 300mm beyond beginning and end of ramp.
- For children's toilets, provide handrails at 0.6m height
- For ramp not steeper than 1:12, provide kerb 75mm high. If handrails are provided, kerb is 50mm high

STAIRS

- Normal adult stairs for ambulatory disabled persons
- For children, rise of step is 135-175mm, width of tread 300mm

5.1.5 URINALS

Provide full-length urinals without any obstacles and include support grab bars at ends

5.1.6 HAND WASHING

Provide for hand washing outside toilet with taps at 600mm above ground.

5.1.7 SUPPORT DEVICES

- Support rail in sitting children's toilets at height 455 – 685mm above floor according to ages in table 2-2 or 2-3. Rails for nursery school children are 25mm diameter. In squatting children's toilets support rails are at height 355-585mm above floor according to table 5-1 or 5-2
- In adult toilets, at height 850 – 950mm above floor and 32mm to 38 mm diameter grab bars
- Include dropdown rail at 480mm – 680mm as shown in adult disabled toilets (Annex-drawing 1)

5.1.8 LOWERING OF SUPPORT DEVICE HEIGHTS FOR SQUATTING CHILDREN

This can be determined within the reach ranges of children detailed in table 2-2 or 2-3. An arbitrary value is chosen here for the lowering of shoulder of child when squatting compared to when seated on the toilet. This assumption is valid because the high reach of the child is longer than the lowering. Inaccuracy will be compensated by the ability of the child to reach higher. What results may be some discomfort when holding the grab rail. This is not expected to be extreme as to be stressful.

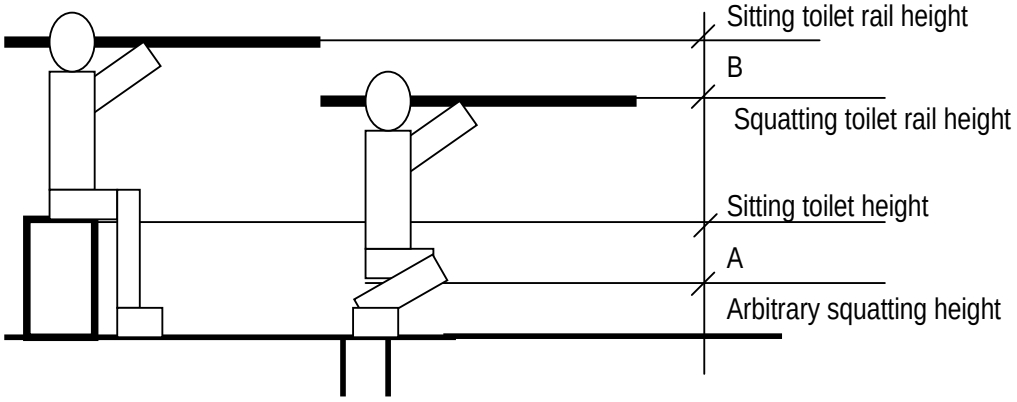


Figure 5-1: Illustration of lowering of support rail in children's toilet assumption

Computation

Consider the heights given in Figure 5-1 above as follows:

Height from floor level to Arbitrary squatting level = 100mm (assumed)

Height of sitting toilet and sitting toilet rail are given in table 2-2 or 2-3

Sitting toilet rail ht – squatting toilet rail ht (B) = sitting toilet ht – Arbitrary squatting ht (A)

Therefore, lowering of rail is equal to the height from floor level to arbitrary squatting level (100mm).

Table 5-1 and 5-2 below includes computed values based on this assumption. These tables are modifications to table 2-2 and 2-3. The dispenser heights are however left out.

Table 5-1: Grab bar height in children's squatting toilets

Age group (yr.)	Toilet seat height (mm)	Grab bar height sitting (mm)	Grab bar height squatting (mm)	Dispenser height (mm)
2 – 4 (Nursery)	280-305	455-510	355-410	355
5 – 8 (P1 – P4)	305-380	510-635	410-535	355-430
9 – 12 (P5 – P7)	380-430	635-685	535-585	430-485

Table 5-2: Modification according to age groups in table 2-3

Age group (yrs)	Toilet seat height (mm)	Grab bar height sitting (mm)	Grab bar height squatting (mm)	Dispenser height (mm)
2 – 8	305	510	410	355
5 – 12	380	635	535	430

5.1.9 ECOSAN TOILET CONCEPT AND BASIS OF DESIGN OF SITTING CHAIR FOR DISABLED PERSONS

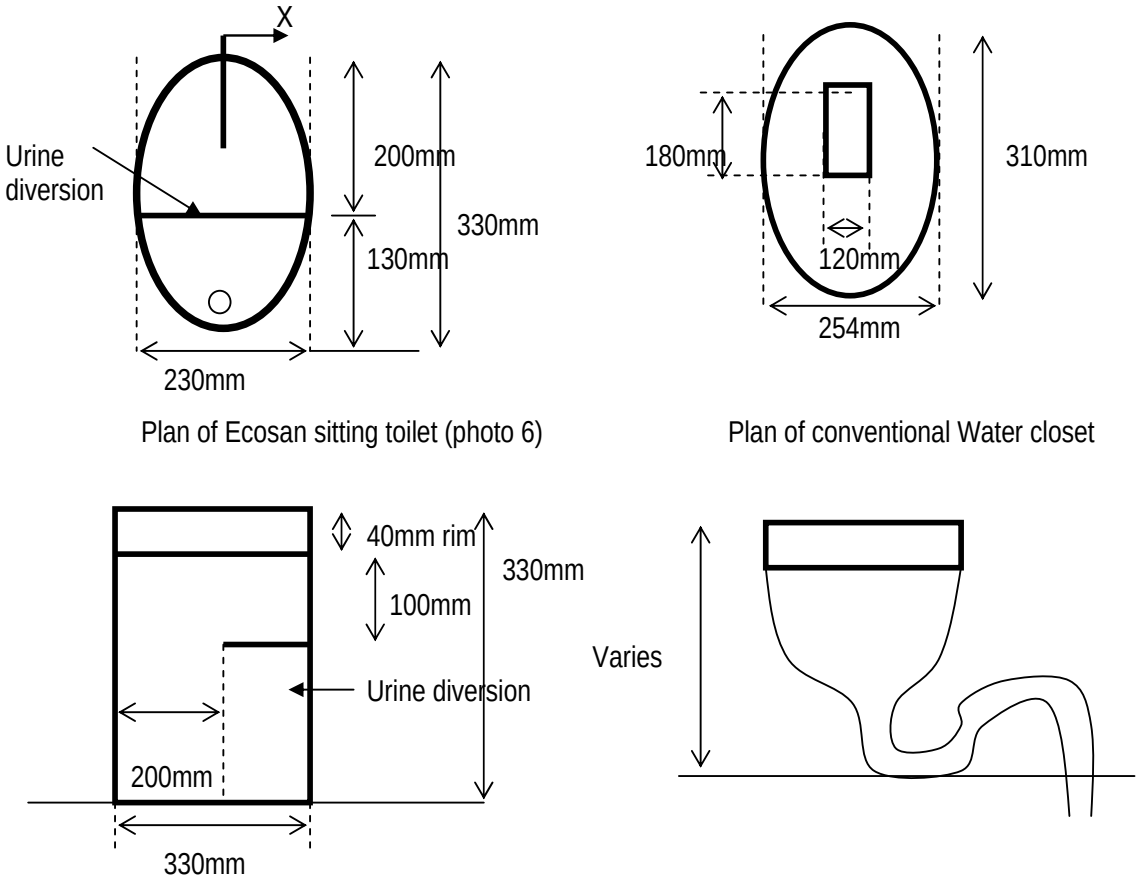
The internal dimensions of a typical sitting Ecosan toilet used in toilets K$_i$5 (New market Kisoro), and a conventional Water Closet are approximately as given in Fig 5-2 below.

The diagram of the Ecosan toilet shows that the defecation orifice is oval, similar to the water closet with dimensions 200mmx230mm; the urine diversion is 130mm wide. The height of the toilet seat above ground will be allowed to vary according to the heights of Table 2-2 or 2-3 or Table 5-1 or 5-2 for children or, for adult disabled persons, as mentioned in section 5.1.7.

The Water closet has been produced here to emphasize that the design of the sitting Ecosan toilet is based on the water closet. The increase in the longer dimension of the Ecosan is due to the urine diversion. However, the shape of the water closet is according to the way it functions. Here, both the urine and faecal matter enter into the same hole (they can both fall anywhere within). However, for the

Ecosan, with the additional functional requirement of separation, the argument is whether or not it should maintain the water closet architecture.

Drawing 3 (Annex) illustrates an individual concept of an Ecosan toilet. At the junction between the two functional holes, there is a constriction of about 150mm. The solids hole can be allowed to vary across between 150-230mm, whereas the urine diversion is oval (and bowl shaped) with suggested length between 150-200mm. The lower values preferably tested to young children. At the constriction, the separating strip is at least 100mm below so that there is little chance of contact of organs with the solid surfaces of the seat. This is assumed to be an appropriate precaution to transmission of disease. This suggestion is made mainly in respect of children so that while sitting astride, the seat can suit their small bodies. The edges of the urine diversion are thinner to emphasize that this is not a sitting surface. This is in contrast to the edges of the defecation part, which are wider – suitable for sitting.



Plan of Ecosan sitting toilet (photo 6)

Plan of conventional Water closet

Section of Ecosan sitting toilet

Section of water closet

Figure 5-2: comparison of sitting Ecosan toilet and the sitting water closet dimensions

For squatting toilets, the defecation holes range between 150mm and 210mm diameter. For younger children, the 150mm-diameter hole is the more suitable. In order that a person sitting on the Ecosan chair using the squatting hole, the dimensions of the chair should be such that there is little chance of faecal matter dropping on the sides of the hole and the urine should conveniently drop into the urine diversion. With a hole used on the chair of diameter 200-220mm, the distance left between the chair hole and toilet hole (pit hole) at the edges is maximum 35mm using the 150mm-diameter hole, when the chair is well centred (Figure 5-3). This can work as well as the sitting toilet. The urine diversion is offset to pour at least 100mm beyond the end of the defecation hole. The chair is shown in drawing 3 (Annex) and its prototype is also modelled.

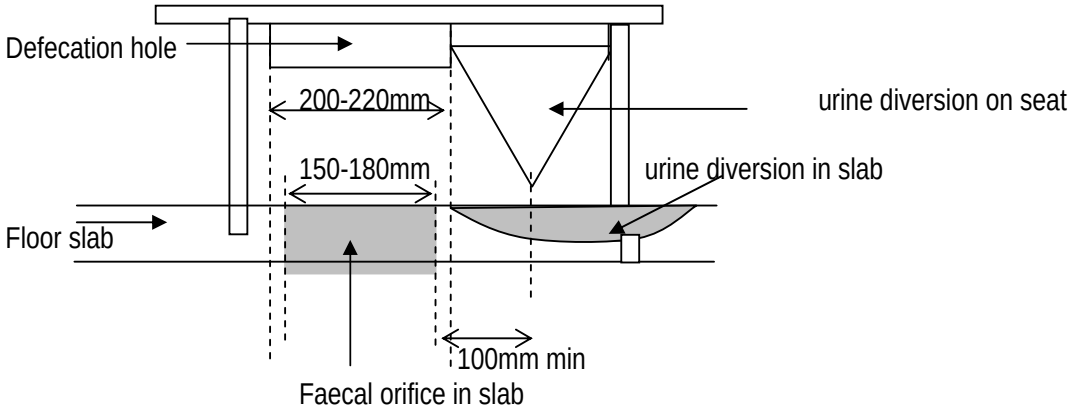


Figure 5-3: Diagrammatic illustration of placement of Ecosan toilet chair over defecation hole.

The advantage of having the chair is that the height can be conveniently made to suit the requirements of a disabled person as seen from the questionnaires. Such a chair could form a basis for experimentation for the size of toilet for children. A smaller defecation-hole, say 180mm diameter can be tried. Further, it is expected that the cost of the chair (say in wood) will be cheaper than a commercially made sitting Ecosan pan.

5.1.10 Design Population Per Stance

The following flow diagram (Government of India, 2003) suggests how to determine the number of toilet stances to be built for a given population of a school. Note that only consideration of users per toilet is the main concern here. Also, according to this flow chart, separate urinals will be provided for boys hence the number of units for boys will be equal to half those calculated here. Number of users per toilet stance = 20.

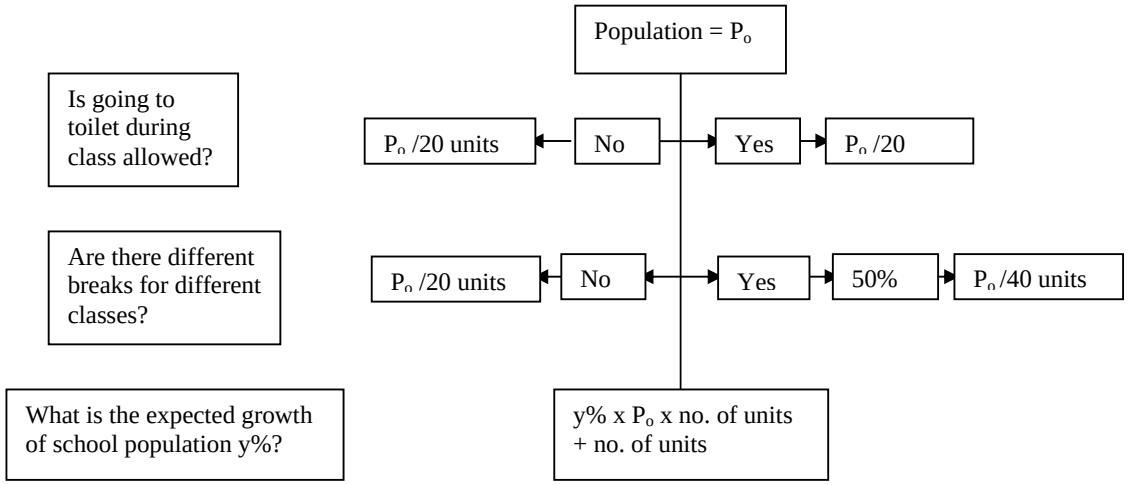


Figure 5-4: Flow diagram showing computation of number of units of toilets for a given population of school children

CHAPTER SIX – CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

This project has investigated the problems restricting disabled persons and children from using the available dry sanitation systems with emphasis on Ecosan toilets. These problems have been cited as inaccessibility (including small toilet rooms), lack of needed support, and large size of squatting plates, deeper urine diversions and generally an unfamiliar technology.

The causes of these problems have in many cases been found to be inherent in the Architectural construction. The architecture being used does not create an accessible environment to disabled persons. Further, no consideration has been put to creating a friendly toilet environment for children. For instance the prefabricated squatting plates are made to suit adult users yet are used for children.

The project has combined judgment and directions in the design codes quoted in this report to produce an adequate modification involving creating more space in toilet rooms, including gentle access ramps for wheelchair users and suitable stairs for ambulatory disabled persons, shorter steps for children's stairs and in all cases providing suitable support rails.

A model of the disabled person's toilet system has been constructed. In addition, an Ecosan-chair (Eco-chair) prototype for use by disabled persons has been designed. The cost of model is summarized. Therefore, the objective of this project has been reasonably achieved.

As a final caution, various circumstances have been cited in this report. The drawings provided are a mere guide. It is unlikely that any field construction will follow these idealised forms. Every building is unique. The final appearance will depend on the input of the engineer executing it. The lengths of ramps for instance may vary with the site topography. Therefore, the limitations of these drawings must be borne in mind.

6.2 RECOMMENDATIONS

In addition to the suggestions made in this report, the following considerations should be made

6.2.1 NEED FOR SAFETY

Children's toilets need to be located such that they feel safe from animals such as snakes. Access routes must be open and clear from long grass or bushes. Toilets should be at hearing distance (30m) for assistance to children if attacked. Girls must particularly be offered privacy.

6.2.2 NEED FOR SPACE

Toilet entrances, corridors and rooms should be wide enough to give a sense of security. According to Ernst and Peter Neufert (2000), narrower rooms promote a feeling of restriction whereas wider rooms promote a feeling of freedom. Applying suitable colour can also create an impression of size. A typical design that may be unsafe is shown in Annex. The photograph shows an internal corridor for an Ecosan toilet constructed by DWD in Mukono. Even to normal mature adults (without disability), this corridor is restrictive and unsafe.

6.2.3 CONTINUED SENSITIZATION

With sanitation facilities in place sensitisation of users is still necessary. Engineering design may only serve to minimize the need for sensitisation by eliminating complexity and by being intuitive (Bettye et al, 1997). Children easily learn and take advice and also influence the sanitation practices of their communities. This means that future generations are likely to follow sanitary procedures and hence be healthier.

6.2.4 DESIGN CODES

Several provisions in the design codes deal with various possible designs to suit different situations. The amount of information included in this report is limited. It is therefore necessary to look at the codes and put the recommendations in to practice. These codes are; BS 8300:2001, ADAAG 2003, United Nations Design Manual for a Barrier Free Environment, and Architectural Access Board.

6.2.5 TOPICS FOR FURTHER RESEARCH

1. Suitable modification of water closet architecture to suit sitting separation Ecosan toilet
2. 'Anthropometrics and Ergonomics' to design appropriate sitting separation Ecosan for children

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