CHAPTER 6
RECOMMENDATIONS FOR CONSTRUCTION, OPERATION AND REGULATION OF URINE-DIVERSION TOILETS

6.1 INTRODUCTION

6.1.1 What this research has shown

The standard of urine-diversion (UD) toilets in South Africa varies greatly. While there are many good examples of the technology, there are also many that have been ill-conceived and that are badly built and poorly operated. Project implementers are responsible for the quality of sanitation schemes and should be equipped with the necessary information to oversee the process. Of course, successful implementation also requires that sufficient funds are made available to allow good project supervision to take place. This is a crucial aspect and one that is often overlooked to the detriment of the project.

These guidelines are aimed at providing implementers with, firstly, the necessary technical information to build good quality urine-diversion toilets and, secondly, the basic operation and maintenance tasks that should be conveyed to the toilet owners. The guidelines are intended to be a stand-alone document and some repetition of information from earlier chapters is thus unavoidable.

6.1.2 Scope of guidelines

The technology of urine diversion is introduced, followed by basic design and construction guidelines, including drawings, for the superstructure and vault of a UD toilet. Both single- and double-vault toilets are discussed. A number of photographs are also provided, illustrating good and bad building practices. Further aspects discussed are requirements for urine pipes and ventilation.

Operation and maintenance of UD toilets are subsequently covered. Topics discussed are dehydration, odour, fly control, cleaning of the pedestal, disposal of anal cleansing material, urine collection and disposal, clearing of blockages in urine pipes, and faeces management.

The above guidelines are aimed at designers and toilet users. However, organisations responsible for administering public and environmental health, such as Departments of Health, Environmental Affairs, etc, as well as the local and regional authorities that actually implement the sanitation schemes, should become actively involved in regulating the operation of UD toilets, particularly the removal and disposal of faecal material. Some regulatory guidelines are therefore also included to assist these organisations to set uniform (high) standards in their respective jurisdictions.

6.2 DESIGN AND CONSTRUCTION GUIDELINES

6.2.1 Introduction

Urine-diversion (UD) toilets have been used successfully for many years in a number of developing countries, e.g. Vietnam, China, Mexico, El Salvador, Ecuador, Guatemala and Ethiopia, and recently also in Zimbabwe and South Africa. The technology is not restricted to developing countries, however; some highly developed countries, such as Sweden for example, have incorporated these sanitation systems into various housing estates in both single and multi-storey houses and apartment blocks. The most important difference between UD and composting toilets is the moisture content in the faeces receptacle. Urine is diverted at source by a specially designed pedestal and is not mixed with the faeces. A pit is not necessary as the entire structure may be constructed above ground; alternatively, only a shallow excavation (maximum 500mm) may be required. The toilet may even be inside the dwelling. Material such as ash, dry soil or sawdust is sprinkled over the faeces after using the toilet. These agents absorb the moisture and also control odours and flies. The dry conditions facilitate rapid desiccation of the faeces. The desiccated faeces make a good soil conditioner, while urine is an excellent source of fertiliser, being rich in nitrogen, phosphorus and potassium.

A schematic representation of a UD toilet is given in Figure 6.1, while Figure 6.2 depicts a typical UD pedestal. Figure 6.3 shows some examples of easy to build toilet structures.

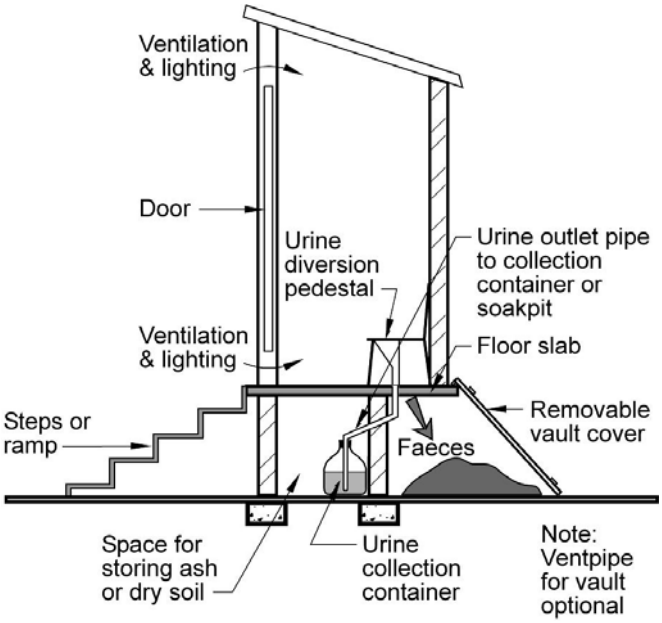


Figure 6.1
Schematic representation of a UD toilet.

Figure 6.2
Typical UD pedestal.
(Photograph: CSIR)

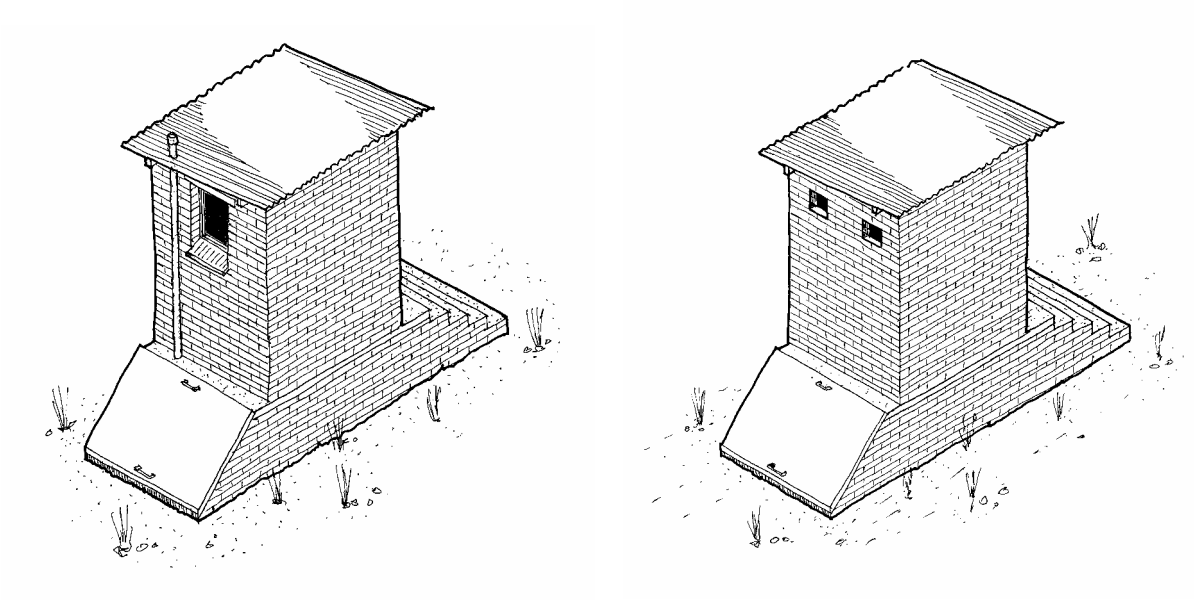


Figure 6.3: Typical examples of simple, easy to build UD toilet structures. As an alternative to conventionally built brick structures, some commercially available toilets are built with thin prefabricated concrete panels that are assembled on site (Drawing: MC Bolton).

6.2.2 Constructing a UD toilet

(a) General

UD toilets require careful operation, but are inherently simple systems. For successful implementation, this feature should be maximised as far as possible, particularly in low-income communities. As proper operation and maintenance of the toilets are crucial factors in the success of any sanitation scheme, particular attention should be paid during the planning and design process to making these tasks as easy as possible. This will help to ensure sustainability.

UD toilets can be based on either the single vault or double vault principle. Many thousands of both types are found in South Africa and the world, and the decision on which type to implement in a particular project should be based on detail discussions between the implementing agent and the intended users.

UD sanitation systems have been developed and adapted over many years, and valuable lessons have been learned in the process. These guidelines are intended to illustrate what is generally regarded as “good practice”, incorporating the knowledge and experience acquired during evolvement of the technology. The guidelines should therefore not be regarded as the last word on the subject and the construction details shown here should be seen as suggestions, not mandatory requirements. The main criteria are that the basic principles governing UD sanitation, and good building practices, should be adhered to.

(b) Building materials and methods

Superstructure

Any suitable building materials may be used, as long as they meet the criteria of strength, durability and weather resistance, and have good thermal (i.e. poor heat-conducting) properties. Note that the latter requirement implies that galvanised corrugated iron should not be used for the walls. Most importantly, a toilet should be comfortable to use. User comfort will be enhanced by reducing heat gain in the superstructure.

In contrast to ventilated improved pit (VIP) toilets, which need to be partially darkened inside to assist fly control, UD toilets may be light and airy, as fly control is achieved by other means (covering faeces with ash, soil, etc). This enhances the attractiveness of the toilets. Provision should also be made for adequate ventilation of the superstructure.

Suitable roofing materials are galvanised corrugated iron, ferrocement, tiles, shingles, thatch or precast concrete. The main criteria are that the roof should be waterproof and adequately fastened to the walls of the superstructure. Ferrocement and precast concrete roofs have the advantage of not requiring timber beams or wire fixings, as they may simply be mortared in position. They are also the most durable and are not likely to require maintenance.

Figures 6.4 (a) to (e) show suggested dimensions for UD toilets that are built as separate rooms or structures. If retrofitting a new toilet into an existing dwelling or adding one to a new dwelling is being considered (Figure 6.7), the illustrations will also be useful in determining the feasibility and scope of the project. Dimensions have largely been determined by operation and maintenance requirements. Note that only basic, and not detailed, dimensions are shown, as different materials will require different thicknesses for the various elements, as well as different building techniques, etc.

Faeces vault

A faecal material accumulation factor of 70 litres per person per year is recommended for design purposes. This allows for the addition of covering material (ash, soil, etc) and soft toilet paper. If other types of anal cleansing material are used this will result in a substantial increase in the accumulation factor.

A minimum storage period of twelve months before use in the garden is recommended for faecal material. In the case of a single vault toilet, depending on the number of users and the size limitation of the vault, it may be necessary to remove the material from the vault periodically and store it in a sack or other suitable container for a further time so that a total period of twelve months elapses from the last addition to the pile until the material is used.

For a double vault system, each vault should allow for twelve months use in order for the resting period to be the same length of time before the material is removed from the vault. Because this resting period may be longer than what can be achieved in a single vault toilet, this system is superior to the single vault type from a safety point of view. The longer the material is able to be stored before handling takes place, the better.

It is essential to make provision for adequate stormwater drainage around the vault. Consequently, the floor should be a minimum of 75 mm (one brick height) above the natural ground. In addition, the ground should slope away from the access door of the

vault; however, if this is not possible, then a shallow ditch should be excavated around the vault to facilitate the diversion of stormwater away from the structure.

It is important for toilet owners to have easy access to the vault for emptying purposes (see Figure 6.5). Lids should be made of lightweight material (e.g. thin ferrocement sections or galvanized sheet iron (GSI)) and should not be grouted in place. They should, however, fit snugly in order to prevent flies and vermin from gaining entry, and to keep rainwater out (see Figure 6.4(b)). Figures 6.10 and 6.11 show some examples of poor practice that should be avoided. It is also preferable for the floor of the vault to be as close to ground level as possible. Where there is a slope to the natural ground this should be utilised to orient the toilet structure in such a way that the entrance to the toilet is on the higher side while the vault is on the lower side. In this way it is possible to minimise the number of steps at the entrance while ensuring that the vault is sunk into the ground to the minimum extent possible (Figures 6.6 and 6.8). Should it be necessary for the floor of the vault to be below ground level, a short ramp should be provided on the inside to facilitate the removal of faecal material by raking (Figures 6.4(c) and 6.5).

Urine pipes

Urine drainage pipes should preferably be not less than 38mm diameter and slopes should be at least 2% (1:50) in order to prevent struvite build-up caused by standing urine, which can eventually block the pipes. This minimum size reduces the likelihood of blockages occurring through accumulation of hair, etc. Standard 38mm diameter waste pipes with elbow inspection caps should be used, which enables blockages to be cleared easily. Metal pipes should be avoided, as fresh urine is corrosive.

Ventilation and fly control

UD toilets function on a different principle to VIP toilets, and their operating requirements are therefore not the same. Whereas VIP toilets require specific arrangements to be made for fly control as well as ventilation of the pit and superstructure, UD toilets are much less of a problem. Pit toilets produce odour due to mixing of faeces and urine, which causes the pit contents to be wet, or at least damp, more or less permanently. In a well-operated UD toilet, however, the faeces are covered with ash, dry soil or other moisture absorbing agent, urine is diverted and moisture kept out of the vault as far as possible. The faeces therefore dehydrate to some extent (this also depends on ambient temperature and humidity), flies are not attracted, and odours are virtually, and often completely, eliminated (efficiency of odour elimination depends to a large extent on proper use of the toilet). Therefore a different approach to building the toilet can be adopted.

As discussed above, the inside of the superstructure should be light and airy, not partially darkened as for a VIP toilet. In a well-operated UD toilet the faeces are covered with ash or soil; therefore they do not produce odours, so flies are not attracted. Proper windows may thus be provided, if desired. Should this be too expensive, or not preferred, then sufficient small openings should be left in the walls to provide for light and ventilation.

A ventpipe may be provided, if desired, in order to encourage ventilation of the vault. Although flies should not normally be a problem, a flyscreen should be fitted to the top of the ventpipe, and both the pipe and screen should be made of corrosion-resistant materials. Ventpipes should be 100 mm in diameter and extend to at least 500mm above the highest point of the roof. If possible, the ventpipe should be painted black and positioned to make maximum use of sunlight, although this is not a critical requirement. Ventilation occurs mostly due to movement of air across the top of the ventpipe, which

induces suction in the system. It is only on windless days that thermal convection caused by sunlight will be responsible for air movement in the pipe. Note that provision should be made to prevent rainwater entering the ventpipe, and thus the faeces vault, as shown in Figure 6.12.

The ventpipe should be rigidly fixed to the superstructure with galvanised wire ties, and the hole through the cover slab well sealed.

Practical experience in hot and temperate climates has shown that, as long as the toilet is operated correctly (see section 6.3 “Operation and maintenance aspects”) there will be no odours or flies. Under these conditions, a ventpipe is not strictly necessary and may be dispensed with. Its use is encouraged, however, as good operation of the toilet cannot be guaranteed.

Upgrading VIP and bucket toilets

From the drawings in Figure 6.4 it can be seen that pit and bucket toilets can be upgraded to UD toilets at minimal cost. All that is required is that the old pedestal be removed and replaced with a new UD type according to the user’s preference (plastic, concrete, etc) a urinal added, and urine drainage pipes fitted.

(c) Costs:

The current (July 2007) cost of building a double vault UD toilet similar to that shown in Figures 6.4(c) and (d) is about R4 500 to R5 000 (US$643 – 714). However, this is only applicable in areas that are easily accessible. In areas with poor access, or where the terrain is rough or steep, this cost can increase to R6 500 (US$929) (W. Pfaff, eThekwini Water Services, personal communication).

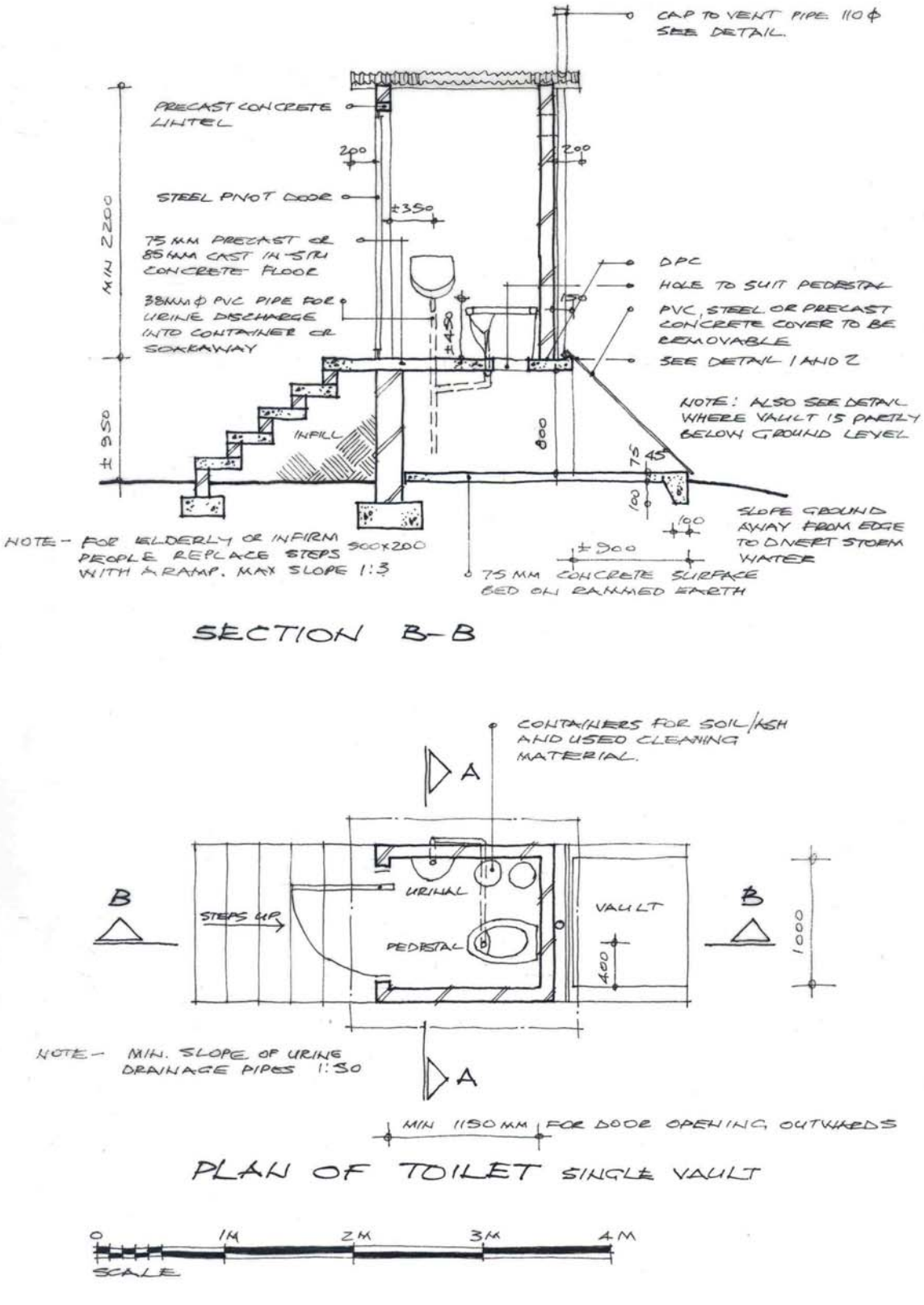


Figure 6.4(a): Details of a single vault UD toilet. The number of steps at the entrance can be reduced by constructing the floor of the vault below ground level (see Figure 6.4(c)).
(Drawing: MC Bolton)

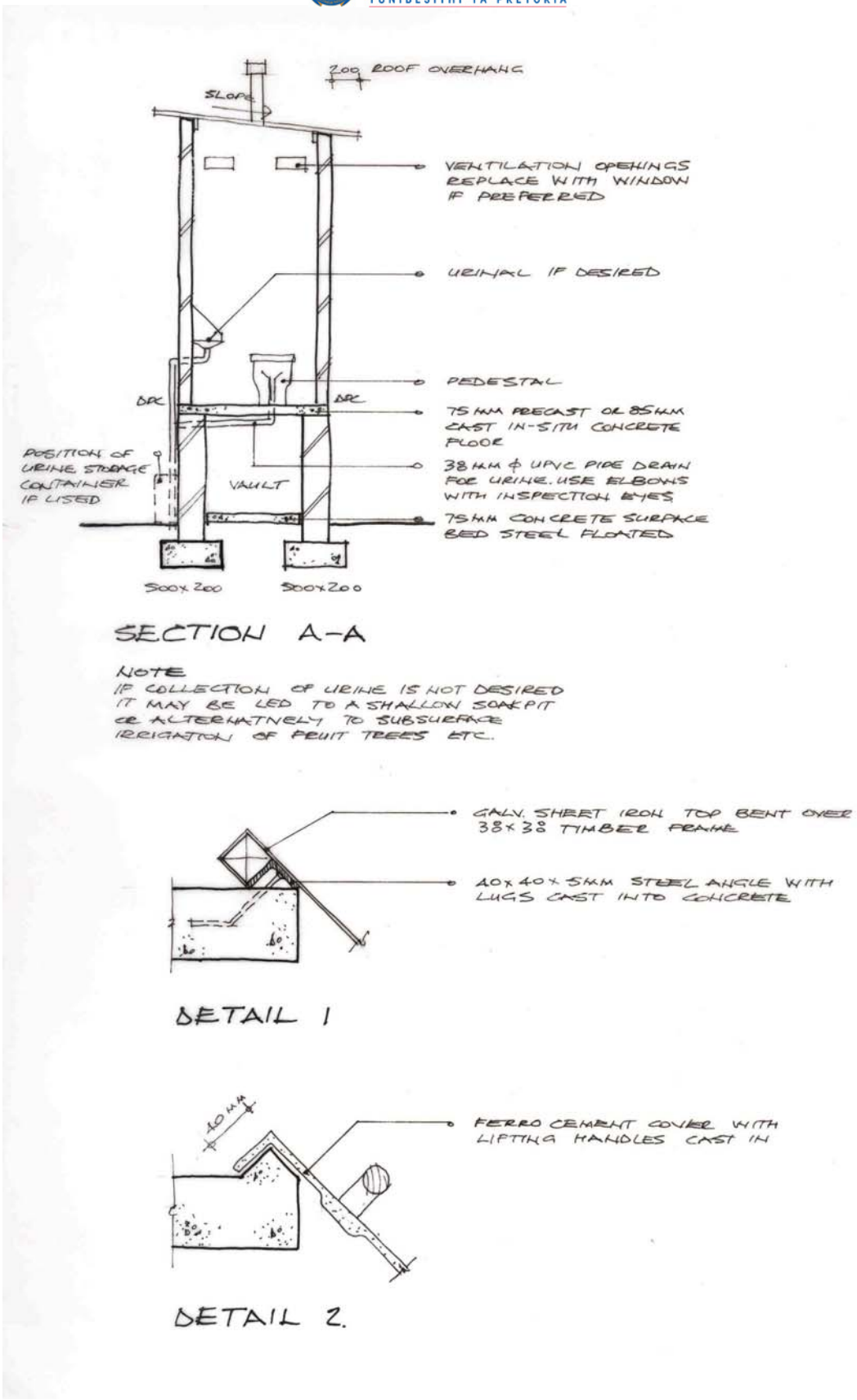


Figure 6.4(b): Details of a single vault UD toilet (continued)
(Drawing: MC Bolton)

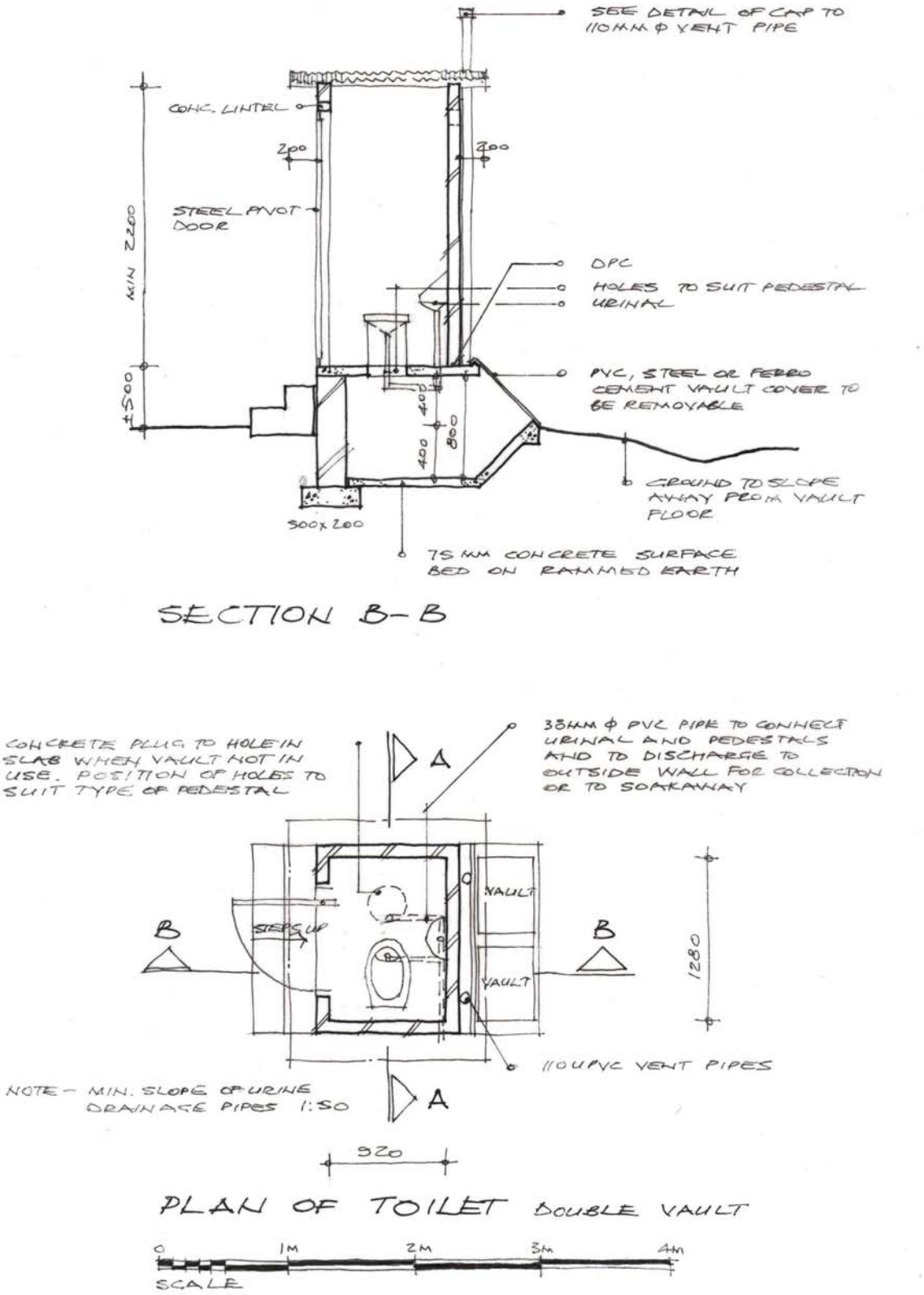


Figure 6.4(c): Details of a double vault UD toilet. Note reduction of steps by constructing the floor of the vault below ground level.
(Drawing: MC Bolton)

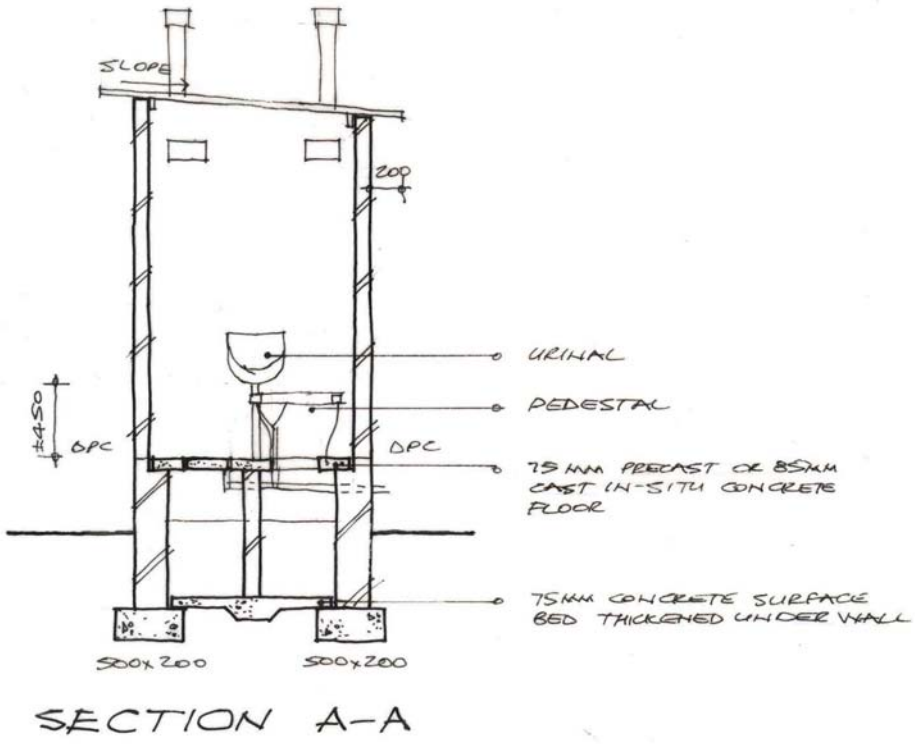


Figure 6.4(d): Details of a double vault UD toilet (continued)
(Drawing: MC Bolton)

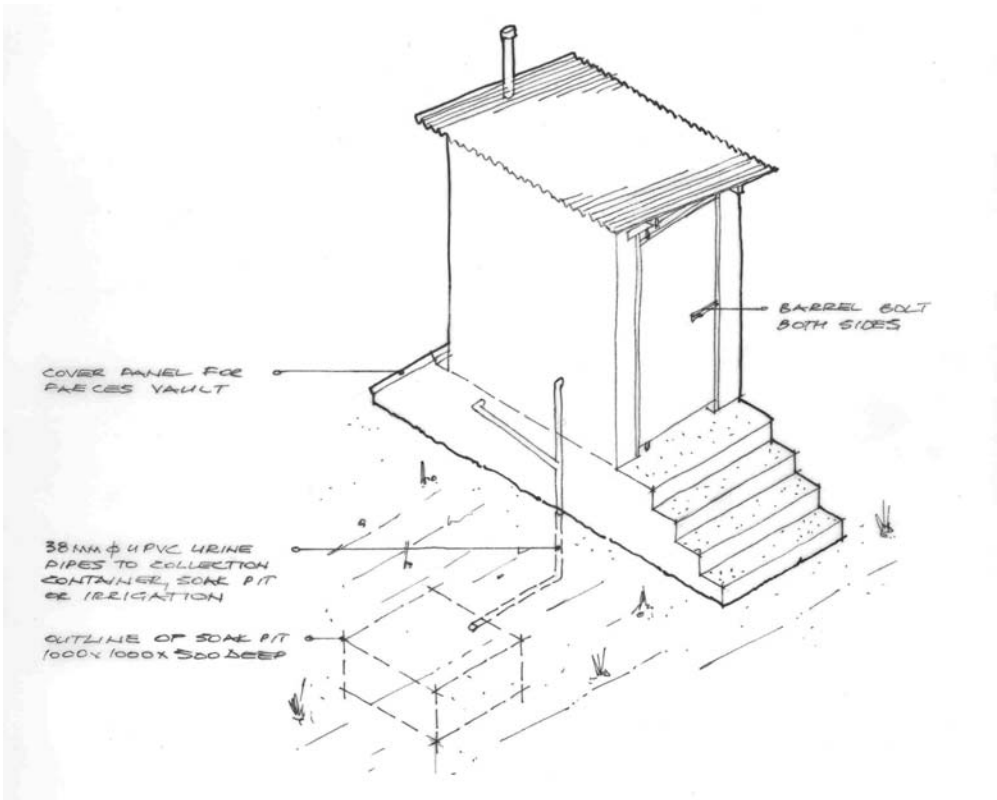


Figure 6.4(e): General layout of a UD toilet
(Drawing: MC Bolton)

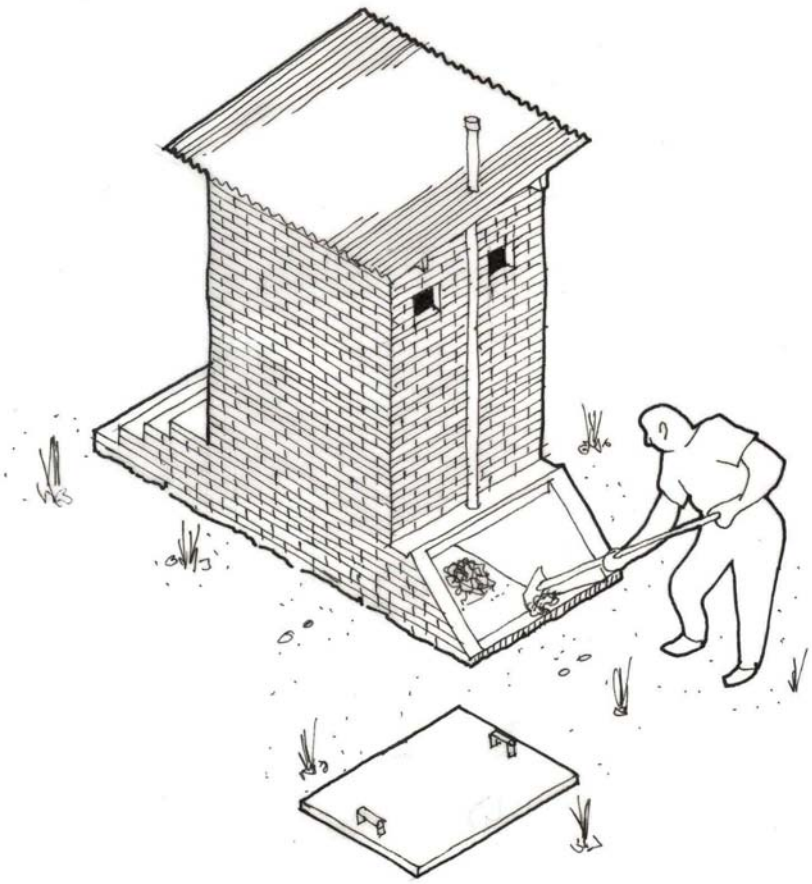


Figure 6.5: This vault is easy to empty
(Drawing: MC Bolton)

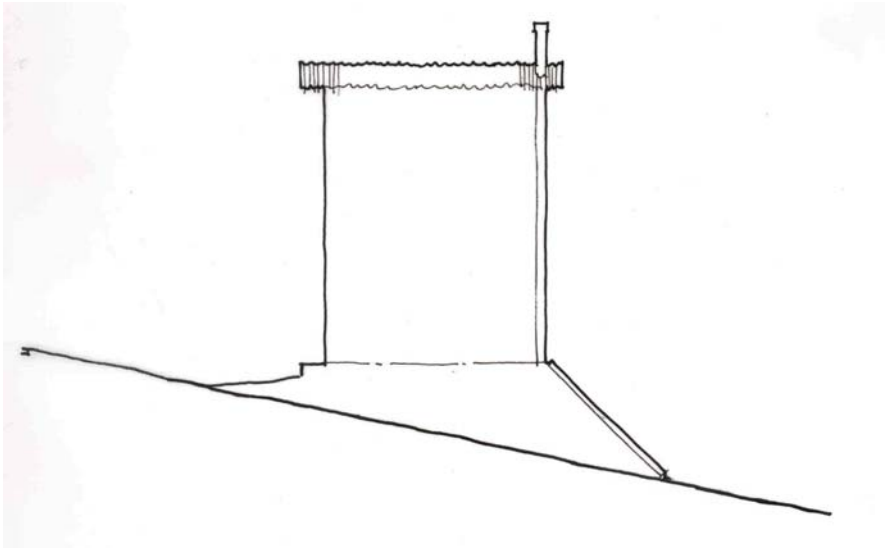
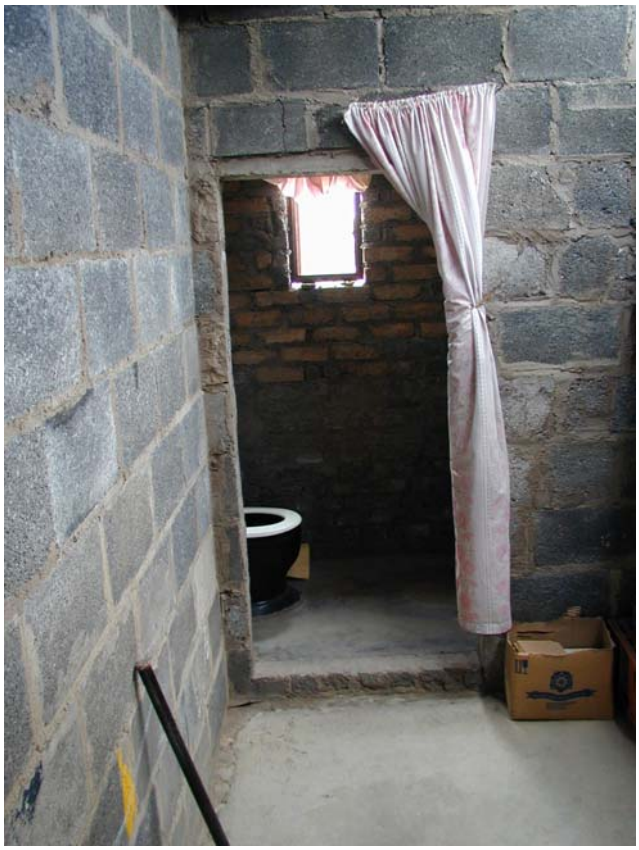


Figure 6.6: Using the natural ground slope to minimise steps at the entrance and depth of vault below ground level (1)
(Drawing: MC Bolton)

(a)



(b)

Figure 6.7: Double vault UD toilet being added onto a house.
(a) Exterior view; (b) interior view
(Photographs: R. Holden)

Figure 6.8: Using the natural ground slope to minimise steps at the entrance and depth of vault below ground level (2)
(Photographs: F. Stevens, eThekwini Water Services)

Figure 6.9: Well-fitting vault lids at a school toilet block
(Photograph: CSIR)

Figure 6.10: Examples of poor practice (1): It is extremely difficult to gain access to these vaults for emptying purposes
(Photographs: CSIR)

Figure 6.11: Examples of poor practice (2): These vaults are not sealed against ingress of flies, rodents, snakes, rainwater, etc
(Photographs: CSIR)

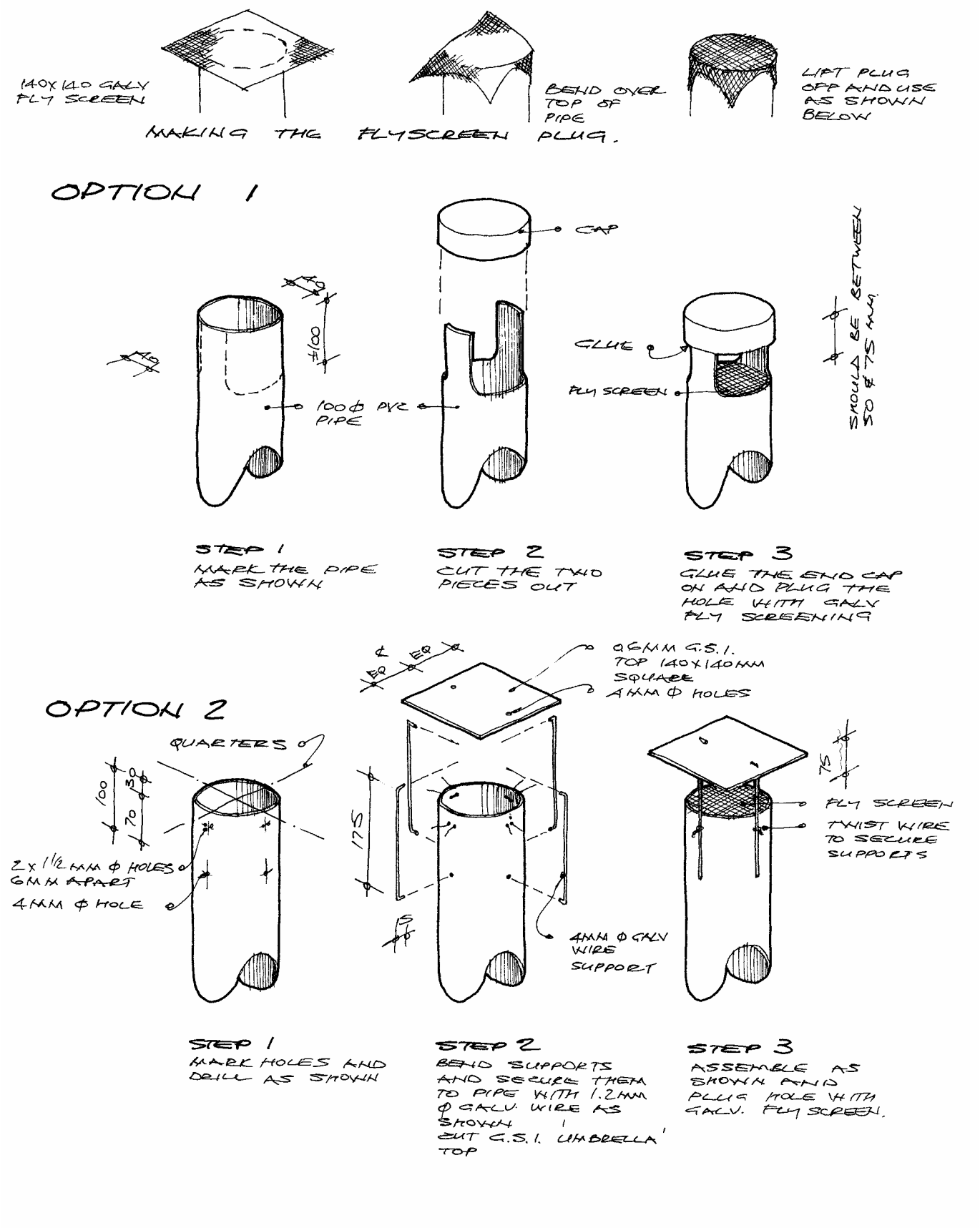


Figure 6.12: "Umbrella" for ventpipe
(Drawing: MC Bolton)

6.3 OPERATION AND MAINTENANCE ASPECTS

6.3.1 General

UD toilets require a higher level of commitment from users than do other forms of dry sanitation, such as VIP toilets. The reason is that they are more sensitive to, and consequently less tolerant of, abuse. In many of the poorer and under-serviced communities in South Africa, pit toilets are often used as rubbish depositories as well. The use of anal cleansing materials other than tissue paper, such as rags, plastic bags, newsprint, maize cobs, etc, is also common, and these objects then end up in the pits. Furthermore, wastewater may occasionally be poured into the pits. If one considers the nature of a UD toilet, it becomes obvious that abuse of this nature can only lead to failure of the system.

6.3.2 Dehydration, odour and fly control

The key operational factor for a successful UD toilet is minimal moisture. A supply of ash, dry soil, or other absorbent material, should always be available in a suitable container, and this should be sprinkled over the faeces after defecation. A cupful (approximately 200mℓ) should normally be sufficient, but users will quickly learn how much is required for their individual needs. This material will absorb the inherent moisture in the faeces, thus aiding the dehydration process. Flies and odours are also controlled in this manner. Furthermore, ash, particularly wood ash, has a relatively high pH (approximately 10), which is useful in reducing pathogenic organisms in the faeces.

6.3.3 Cleaning the pedestal

As with any toilet, cleanliness is essential for good hygiene. If the inside of the pedestal or squat plate becomes soiled, it may be cleaned with a damp toilet brush or cloth, as small amounts of water that enter the vault in this case will evaporate quickly. If disinfectant is used, care should be taken that only small amounts come into contact with the faecal material. The urine bowl, however, should be periodically rinsed with a little disinfectant diluted in water in order to eliminate odour. Only a small quantity of water (about 200 mℓ or a cupful) is required for this operation.

6.3.4 Disposal of anal cleansing material

Various methods are used for the disposal of anal cleansing material. It is usually recommended that this material not be put into the vault, as the lack of moisture prevents its breakdown. A special container should be kept next to the toilet for storing used cleansing material, which may then be periodically disposed of by burning or burial. Alternatively, where a well-operated solid waste removal service exists, the used materials can simply be enclosed in a suitable bag and disposed of in the rubbish container.

Where faecal material is used in the garden or co-composted with other organic material, the toilet paper can be deposited into the vault, as the paper decomposes when wetted afterwards. It should be noted that only soft tissue paper can be used in this case, and the quantity may need to be restricted, depending on the size of garden and extent of use.

In hot and dry climates, where faeces dehydrate rapidly, all cleaning paper may be deposited in the vaults and periodically burned – paper as well as dehydrated faeces. Where use of the faecal products is not desired, this is a relatively easy way to dispose of the contents of the vault.

6.3.5 Urine collection and disposal

Where it is intended to use urine for fertilising crops, it should be collected in a sealed container. If the container is not sealed, some nitrogen is lost in the form of ammonia and the urine thus loses part of its fertilising value. The soil should be loosened and the urine worked in quickly, in order to minimise nitrogen loss. This should be followed by ordinary watering.

For persons who do not wish to handle or use the urine, it may be led into a shallow soakpit adjacent to the toilet. The volumes produced by the average family are small and, except for very clayey soils, will not present a disposal problem.

6.3.6 Clearing blockages in the urine pipes

Occasional blockages of the urine pipes may occur due to precipitation of struvite (magnesium ammonium phosphate $MgNH_4PO_4.6H_2O$) forming on hairs or fibres. These may be cleared with conventional caustic soda drain cleaner.

6.3.7 Faeces management

Proper management of the excreted faeces is crucial for sustainable operation of a UD toilet. Various factors play a role in the dehydration process, and thus also in the reduction or elimination of pathogenic organisms. Because part of the management procedure consists of handling the faecal material, health and safety aspects are important.

The faecal material needs to be collected in a way that facilitates storage and easy removal from the vault. In a single vault toilet it can be collected and stored in either of two ways - in a suitable container or in a heap on the floor of the vault. For the former method, two separate containers are required. When the first container is full, it is moved to one side and the second one moved into place beneath the pedestal. By the time the second container is full (usually a few months, depending on the size of container and number of users) all the material in the first one should be sufficiently dehydrated to resemble a crumbly type of soil with a slight musty, not unpleasant, odour. If there is insufficient room in the vault it should be removed from the container and stored in a sack for a further period, as there may still be vast numbers of viable pathogens present. A minimum total storage period of twelve months, from the time when the container is full to eventual use in the garden, is recommended.

The second method of collection and storage, in a heap on the floor of the vault, involves a little extra attention. When the heap reaches a certain size, it should be raked to the side of the vault where it can dehydrate for a further period, until the space is needed to store more material. Further storage in a sack for a total storage period of twelve months is also recommended in this case.

With a double vault toilet the two sides are used alternately, thus allowing faecal material to be stored in a full vault for at least twelve months before it needs to be removed. This is better from the safety point of view.

Even if a community is not particularly inclined towards use of the desiccated faeces, experience in the field has shown that their disposal does not pose a problem, as they may simply be buried.

6.4 REGULATORY GUIDELINES

6.4.1 General

It is important to note that UD sanitation technology should not be regarded as being only applicable to poor and rural people, but rather to communities representing all income groups. However, these particular guidelines focus on the implementation of UD sanitation projects in mainly lower income areas, because special and specific interventions are necessary to ensure the success and sustainability of the technology in these cases (Austin and Duncker 2002).

Sanitation is not just about building toilets – for successful project implementation it is essential that the responsible local authority takes an active part in the process, from the initial conceptualisation right through to construction, handover and post-project monitoring. The local authority should also be aware of its responsibilities with regard to public and environmental health, and the various pieces of legislation governing these aspects. Further, the requirements concerning hygiene awareness in the communities receiving the toilets are an integral part of the sanitation process.

Implementing authorities (through their appointed agents if this is the case) need to ensure that good quality planning, design and construction processes are put in place. Design and construction of UD toilets should follow the guidelines given in the previous section. Note that the planning process includes the required community liaison activities. For a full exposition of the latter, refer to chapter 5 of the publication "*Urine-diversion ecological sanitation systems in South Africa*" (Austin and Duncker 2002).

6.4.2 Disposal/collection mechanisms for faecal material from UD toilets

Disposal of faecal material from UD toilets requires particular attention, as community and environmental health may be negatively affected by poor practices. Where there are no formal collection activities in a particular village or settlement, householders will normally need to empty the vaults themselves and either bury the contents or, should they wish, use it as a soil conditioner in their gardens. Where it is simply buried, householders should be encouraged to plant a tree on the spot – apart from beautifying the area this also serves to mark the place where the faecal material has been buried.

The practice of emptying the vaults should be monitored to ensure that, as far as possible, only faecal material that has been stored for at least 12 months is removed from the vault. This may not always be possible in the case of single vault toilets, however. In the latter case it should be ensured that no fresh faecal material is removed from the vaults and that any material that has been stored for less than 12 months is not used in a vegetable garden, but either stored in a sack or other suitable container until the 12 month period

has expired, or buried. Householders should also be encouraged to wear gloves during the emptying process, not to smoke while doing so and to observe good personal hygiene.

Where a community is not disposed towards using faecal material in their gardens, the local authority should support the establishment of a formal collection system. Such a system may be set up by a local entrepreneur using simple equipment such as hand tools and a horse-or donkey-drawn cart, or, where the disposal site is nearby, even an ordinary wheelbarrow. The fee for emptying a toilet vault is usually negotiated or may be a fixed fee. Disposal of the material should be at a site approved by the local authority, which should be protected. Alternatively, the municipality could support a co-composting venture, where the faecal material is composted together with waste from the local parks department, e.g. leaves, grass cuttings, etc.

6.4.3 Use of faecal material

Local authorities should monitor the use of faecal material in agriculture, particularly in food gardens. Education is of vital importance. The primary hazard is related to exposure of untreated or insufficiently treated faeces containing pathogens. The faeces may contaminate food or water. Contact may occur before treatment, during treatment (including handling or transport) or when the material is applied to the soil (WHO 2006b). Field trials have shown that the edible portions of certain crops can be contaminated by pathogens from inadequately treated faecal material (Mnkeni et al 2006). Treatment of the material (e.g. by storage) should aim to fully or substantially reduce the pathogenic content before application to the soil. For this reason it is important that the recommended minimum storage period of 12 months be adhered to and that the required bulking agents are added to the faeces, e.g. ash, lime or dry soil. The wearing of gloves, washing of hands, etc should also be encouraged. On-site treatment will always be beneficial from a health point of view, since this gives the initial pathogen die-off, which can be further corrected with off-site treatment (e.g. co-composting) if necessary (WHO 2006b).

Monitoring agents should refer to the WHO publication "*Guidelines for the safe use of wastewater, excreta and greywater, Volume 4: Excreta and greywater use in agriculture*" (WHO 2006b).