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MANUSCRIPT REPORT

The Latrine Project, Mozambique

Bjorn Brandberg

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IDRC-MR58e (Rev.)

THE LATRINE PROJECT, MOZAMBIQUE

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Ministry of Public Works and Housing

The National Directorate of Housing

Author: Bjorn Brandberg

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SUMMARY

A low-cost Housing Sanitation Project for the development of improved pit latrines has been carried out by the Mozambican government through the National Directorate of Housing, in cooperation with the National Directorates of Water and of Preventive Medicine, the International Development Research Centre (IDRC), Canada, and the United Nations (UNDP/HABITAT) Project MOZ/79/002.

Priority has been given to low-cost sanitation in unplanned urban areas. Currently employed methods for latrine building have been studied, and improved construction methods have been developed to meet basic requirements of hygiene and safety.

Five simple latrine types have been developed. Several designs were necessary because of varying soil, economic and social conditions.

The types of latrines proposed are as follows:

- S0 - the improved traditional pit
- S1 - the unlined pit with slab
- S2 - the lined pit with a slab
- S3 - the elevated pit
- S4 - the bore-hole pit

Special mention should be made of the elevated latrine (Type S3), which can be built in areas with high water tables and/or where flooding occurs. Until now, latrine building in these areas has been considered very difficult or impossible.

Three of the latrine types are constructed using a nonreinforced concrete slab that can be produced in local workshops at a rate of more than 1000 slabs per year.

The workshops also construct complete latrines. Project experience, however, shows that the people themselves have the greatest capacity to build the improved latrines if the appropriate building materials are available.

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FOREWORD

This paper is the product of a research project undertaken by the National Directorate of Housing (DNH), Mozambique, which was sponsored by the International Development Research Centre (IDRC), Canada, and the United Nations (UNDP-HABITAT) Project MOZ/79/002 "Assistance to Human Settlement Planning." The Swedish International Development Authority (SIDA) contributed substantially to the project through the United Nations by financing the project coordinator through their program for associated experts.

The purpose of the research was to develop simple but functional latrines for the population in the suburbs of the Mozambican cities, mainly Maputo and Beira. Although this project addresses peri-urban sanitation, the research team believes that the results are applicable to villages, schools, market places, and so on, and maybe also to rural sanitation in more developed Third World countries.

The outcome of this project was the development of a number of different latrine types and a method of making latrine slabs from nonreinforced concrete. These are presented in two appendices: "Latrine types and their prefabricated elements" and "Production of thin latrine slabs of nonreinforced concrete".

The research has been carried out at the National Directorate of Housing in close cooperation with the National Directorates of Preventive Medicine and of Water, through Mr. Noe Chongo, sanitary technician and Dr. Sandy Cairncross, sanitary engineer.

This report was prepared by Mr. Bjorn Brandberg, architect/building engineer, who was also the coordinator of the project.

On behalf of the Mozambican government, I want to express my gratitude to those who have contributed to the project.

José Forjaz
National Director of Housing
Maputo

FORWARD

Since the first edition of this report was prepared, the Latrines Project has become a National Programme for the implementation of the improved latrines presented in this project.

To date, 8,000 latrines have been built. Expansion is expected to include all Mozambican cities and a number of District towns, with a total of around half a million improved latrines.

For the rural areas, alternative technologies have to be evaluated, because of differences in access to building materials, transport and training possibilities.

This second edition contains one small but important amendment. The measurements of the hole mould on page 80 have been changed. Though this change might seem trivial, it is important for the correct fitting of the lid.

Jose Forjaz,

Secretary of State for Physical Planning

Maputo, January 1985.

1. INTRODUCTION AND BACKGROUND

This project originated from the experiences and problems related to the First National Latrine Building Campaign, which was launched on 27 January 1975.

The campaign was directed by the Ministry of Health and the Party FRELIMO, and was implemented mainly through the Dynamizing Groups. Although it made a significant impact on improving sanitary conditions, it also ran into certain difficulties, mainly of a technical nature. To solve these, an agreement was signed between the National Directorate of Housing (DNH), and the International Development Research Centre (IDRC) in May 1979.

In April 1979, another agreement was signed between the national directors of Water, of Preventive Medicine, and of Housing to carry out a latrine project, with the National Directorate of Housing as the coordinating body.

The agreement between the three directorates had no formal status in relation to IDRC, but formalized the division of responsibility between the Mozambican Government departments.

2. ORGANIZATION

2.1 Formal Organization

A Directing Committee was established composed of the national director of each directorate, with the National Director of Housing formally responsible for the project.

On a technical level, an Executive Committee was established, composed of three technicians, one from each directorate. The Executive Committee was responsible for the implementation of the project, according to the guidelines of the Directing Committee.

The representative from the National Housing Directorate (DNH) in the Executive Committee was charged with project coordination.

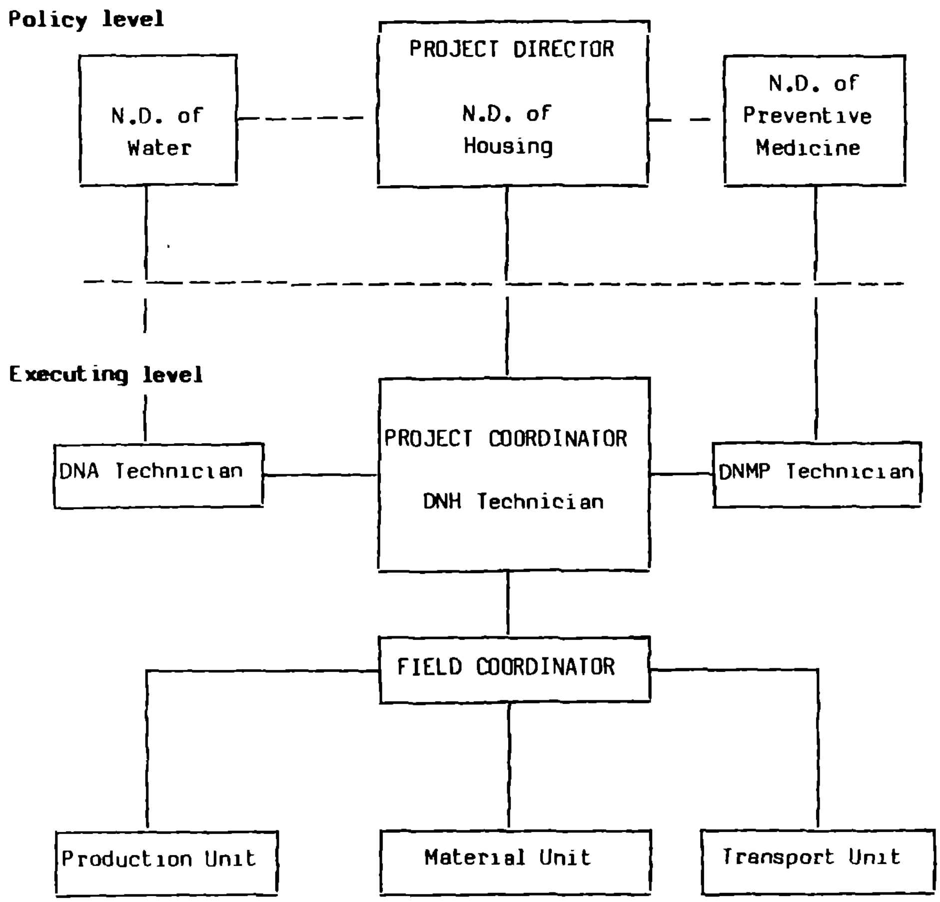


Fig. 1 The practical project organization

2.2 Practical Organization

While the project was in progress, an organization was developed to coordinate project activities. The field work was implemented by the Directorate of Housing and monitored by the directorates of Water and of Preventive Medicine.

2.3 Resources

The IDRC grant for this project totaled CA $45,550. This was divided into a DNH-administered part (CA $36,910) and an IDRC-administered part (CA $8,640).

DNH contributed skilled laborers, workers' foremen, lorry transportation, and a fully equipped workshop in a barrio (neighborhood) where the latrine slabs were constructed.

The United Nations Development Programme (UNDP) contributed the project coordinator and administrative assistance.

The most useful resource in the project was the inhabitants of the areas where the project was being conducted. They not only contributed their knowledge and opinions, but also helped financially by buying latrine slabs and complete latrines. As a consequence, the project workers received continuous feedback about the problems encountered.

2.4 Personnel

DNH (The National Directorate of Housing)

Formal authority for the project: José Forjaz, architect,
National Director of Housing, chairman of the Directing Committee.

Project coordinator: Bjorn Brandberg (UNDP), architect, building engineer.
DNH representative in the Executive Committee.

Field coordinator: Carlos Macave

Production authority: Alberto Cinquenta*

Material authority: Mario Jeremias Matsimbe*

Transport (driver): Zakarias João Chenebene (x)

Accountant: Maria Afonso (part time)

Typing: Maria Teresa (UNDP, part time)
Maria Efigenia de Sousa Fernandes (UNDP, part time)

10 workmen*

*Transferred to the city council of Maputo during the project 1/1/1981.

DNA (The National Directorate of Water)

DNA representative in the Directing Committee: Arnaldo Lopes Pereira, water engineer, National Director of Water.

DNA representative in the Executive Committee: Dr. Sandy Cairncross, sanitary engineer.

DNMP (The National Directorate of Preventive Medicine)

DNMP representative in the Directing Committee: Jorge Cabral, M.D., National Director of Preventive Medicine.

DNMP representative in the Executive Committee: Mr. Noe Chongo, sanitary technician (Mr. Chongo replaced Mr. Luis Pereira da Silva, sanitary engineer, who replaced Mr. Lim Ah Ken who was the original DNMP representative on the Executive Committee of the project).

3. THE PROJECT

3.1 Preproject Phase - Biological Toilets

In the preproject phase, before IDRC participation, Mr. Krisno Nimpuno (tech. lic. architect), proposed that composting latrines would be appropriate for a large-scale implementation of self-help sanitation. The idea has been more or less successfully introduced in other developing countries (e.g., Vietnam and Tanzania). A team was formed to study the proposal. Supervised by Mr. Lars Skamris, a number of experimental composting toilets were built and later evaluated.

However, the present research team came to the conclusion that the designs proposed in the preproject phase were too complicated to implement in large self-help schemes. Also, the cost was too high, as it exceeded the total cost of an average dwelling. The prototype also required building materials not readily available in Mozambique.

3.2 New Hypothesis - Improved Pit Latrines

The main objective for the sanitation project was to develop a technical solution that could be implemented easily on a national level in the peri-urban areas of the cities, where the need was most urgent.

The solution had to be acceptable to the population and accessible in terms of the purchasing power of the residents. It would, therefore, have to meet their felt needs and so constitute an improvement on their existing methods of excreta disposal.

However satisfactory it might be from a technical or sanitary point of view, a technology that could not be implemented on a wide scale would be of little use and would certainly have no chance of contributing to an improvement of health in the cities.

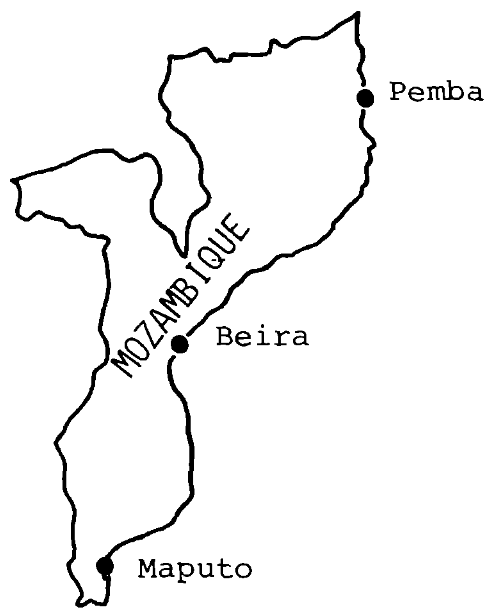
The most common existing solution was the pit latrine, and the felt need most commonly voiced by the residents was for materials to build it in a safe, sanitary, and durable way.

4. SANITATION - THE EXISTING SITUATION

As mentioned in the introduction, a reasonably high level of sanitation had been achieved through the national latrine-building campaign and the work carried out by the Dynamizing Groups.

Although latrine designs varied widely, as many as 80-90% of families in urban areas and more organized rural areas have access to latrines. Each family normally posesses a latrine and communal ones are also found at markets, bus stops, etc. However, the latrines are often in bad condition and if they are not available, it is usually due to technical reasons.

As the project's aim was to improve urban sanitation, sites were chosen from three representative cities: Maputo, Beira, and Pemba.



4.1 Maputo

It was observed that approximately 90% of the families in the peri-urban areas in Maputo have their own latrines, or share one with a neighbor. This is a result of the work carried out by the Dynamizing Groups and the Ministry of Health.

Since 1975, when the first cholera epidemic occurred, the city council of Maputo had been providing latrines free of charge to the inhabitants in some selected areas of the city. The same type of latrine had also been constructed for markets, bus stops, and other communal places. So far, 7200 such latrines have been built. However, most of these have fallen into disrepair as their average lifespan is only 3 years.

The system of providing latrines free of charge to the population is being questioned as it does not encourage the rest of the inhabitants to build their own. Construction of latrines then becomes the task of the city council thereby inhibiting the individuals from assuming the responsibility.

Most existing latrines are built with nonpermanent material, but there are also large professionally constructed pit latrines made with cement blocks and reinforced concrete.

Many people feel that latrines constitute a nuisance. They mention the flies, the smell, and the risks. Latrines are not only risky to build; but also, when they get old, risky to use as they might cave in. The biggest difficulty is, however, in finding the necessary building materials. Often, the soil is unstable and planks are needed to prevent the pit from caving in. However, the wood is subject to attack by rot and termites.

The existing latrines are unhealthy because they are impossible to keep clean and it is impossible to keep the flies away. The covers get fouled with excreta, and thus are ideal sources of hook-worm infection. The safety problem was especially serious because children often hesitated to use the latrines as they are afraid the structure would collapse and they would fall in.

The problem of high water tables and unstable soil required a special study.

4.2 Beira

Beira is known for having a location that makes sanitation difficult. The flat and swampy ground has made it difficult not only to arrange a proper sewage system, but also to build good latrines. The soil in most of the area is heavy clay and the water table is fairly high. Sand has been used as landfill over large areas to provide land more suitable for housing. However, the sand used is very unstable and tends to cave in easily. Areas not filled are frequently flooded during the rainy season causing latrines to overflow. This has not helped the reputation of the latrine program.

During the first period of the National Latrine Building Campaign, there was very little rain. Thousands of latrines were constructed in Beira, mostly in areas in which there had been no landfill. The water table was low, and the clay was dry and hard. When the heavy rains came, the latrines overflowed and the entire area was flooded with fecally contaminated water. According to the Provincial Director of Health, it is now very difficult to generate enthusiasm for a latrine-building program in Beira.

4.3 Pemba (and other cities)

To illustrate the special circumstances that can exist, Pemba was chosen as an example.

Pemba is the capital of the most northern coastal province of Mozambique, and it is situated mainly on a peninsula with rocks, loose sand, and a high water table. Most of the citizens have ready access to the beaches. The majority of the population of Pemba is Muslim, and therefore use water for anal cleaning following defecation. Consequently, large numbers of the population use the beaches as a defecation site.

This practice has created a serious pollution problem due to the increase in the urban population. As a result, the use of the beach for defecating is now forbidden. People are asked to build latrines. To guarantee that restrictions are followed, guards are posted at the beach. However, the restrictions are not respected as soil conditions are not suitable for latrines.

This is partly true in Pemba; the ground is very rocky in some places and the water table is high in others. Only in a few places are conditions favorable for latrine construction.

The problems involved in construction of latrines in Pemba are not only technical; social habits must be changed as well.

In other cities, situations are generally less dramatic. Some cities are better organized than others, but everywhere there are technical problems, and the latrines are often without lids and difficult to keep clean.

4.4 Conclusion

Although geographical and cultural differences exist, no serious obstacles to the use of pit latrines have been found.

However, covering of the pit is a problem, as rot and termites usually attack any wooden structure. Hygienic problems are general where earth forms the floor close to the drop hole of the pit. Flies are often a problem.

The practice of using water for anal cleaning, or bathing in the latrine building, can cause sandy soil to become unstable and thus requiring the pits to be lined.

It seems practical to propose a limited number of standard latrine designs suitable for different conditions. However, wall materials and roofing can be selected according to personal preferences and materials available.

5. SURVEY OF EXISTING LATRINES

Existing latrines have been continually surveyed during the whole project. These consist of a pit, slab, and superstructure (walls, etc.) plus complementary elements, such as a place to urinate, a bucket for toilet paper, and sometimes a corner for washing.

5.1 The Pit

The pit is normally a simple hole in the ground. Dimensions vary considerably with the smallest having a diameter of 60 cm. It takes two people to dig a small diameter pit as the person in the pit must pass the dirt-laden shovel to an assistant at ground level to empty it.

The next most frequent diameter is 1.1 m. This is about the length of a spade, so thus one man can swing the spade while in the pit. The wider diameter means the pit can be used for a longer period but it is more difficult to cover and may present a safety hazard.

In areas with unstable, soil planks are often used to secure the sides of the pit, which is normally square.

Old oil drums, which earlier might have served as water tanks, are frequently used to prevent the pit from caving in. This is especially common in areas with high water tables, where the drum is often only partially buried in the ground. The diameter of these drums is about 50 cm and the volume about 200 litres.

5.2 The Cover

The simple pits are usually covered with poles, sheets of scrap material, and sand. Often a kind of box is placed over the hole.

In areas with good access to wood, the number and dimension of poles are increased.

In rural areas, where scrap material (such as corrugated iron or asbestos sheet) is less easily available, the whole pit is covered with poles in two directions and then covered with grass and soil.

5.3 The Lid

Most latrines tend to have lids to cover the holes and these are often used. Poor fitting covers, however, allow flies to find their way in and out of the pit.

Fig. 2 Wooden latrine. Note the bin for used anal cleansing paper, which is subsequently burned. The residents claim that this reduces the prevalence of cockroaches in the pit.

Fig. 3 Latrine made by a mason. There is a wooden cover but this has been left open. The aspiration for a raised seat is widespread but the seat adds greatly to the cost.

Fig. 4 The pit is normally in a corner fenced off from the rest of the plot; this provides privacy, not only for defecating, but often for taking a shower.

Fig. 5 The Maputo City Council constructed 7200 latrines with a pit diameter of 60 cm and a depth of 2.5 to 3.5 m.

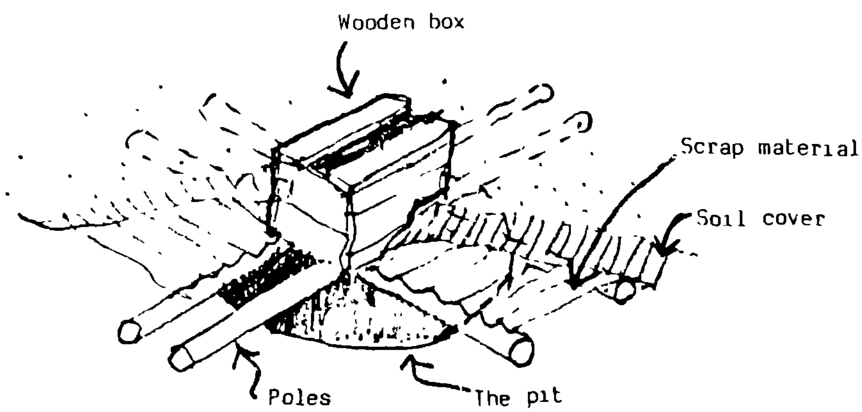


Fig. 6 The common way to cover the pit.

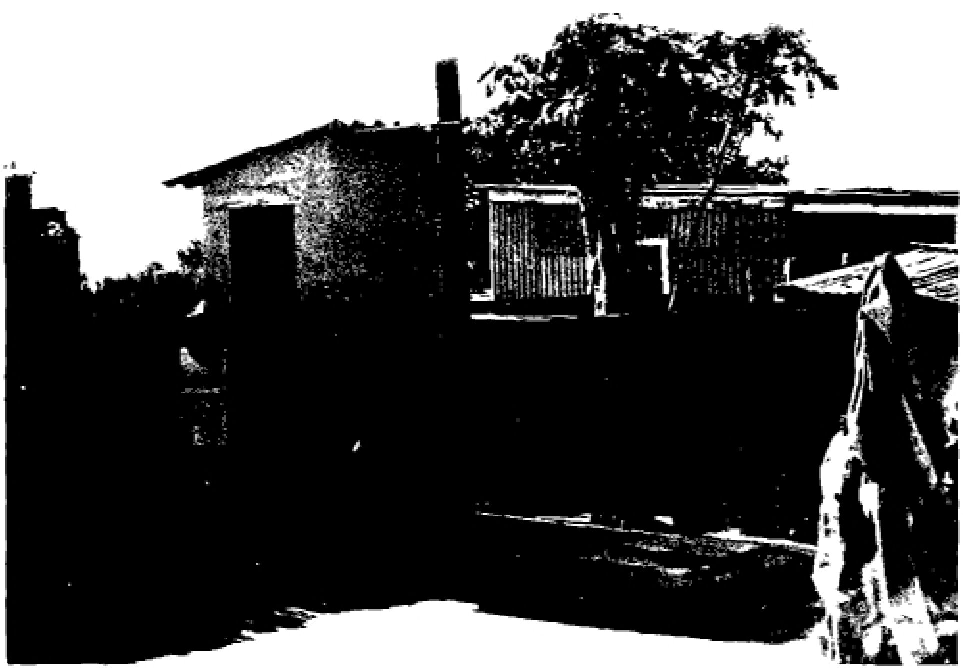


Fig. 7 A continuous moldering toilet built during the preproject phase.

5.4 The Walls

The pit is always surrounded by walls to give privacy. The wall material is often the same as the house and of inferior quality (generally reed).

When the dwelling is constructed in more permanent material such as concrete blocks or corrugated sheet metal, scrap materials are often used.

5.5 The Roof

Roofs are very seldom found on latrines. They exist on the latrines constructed by the city council and in a few other cases, then often in combination with a flush toilet or a pit latrine with a riser for sitting instead of a simple slab.

5.6 The Ventpipe

The only latrines with ventpipes were those built during the preproject phase. Screened ventpipes were very effective in preventing fly breeding and in most cases not even larvae were found.

6. BUILDING MATERIALS

Latrines are usually built of natural materials with the exception of the scrap material often used to prevent the soil from falling into the pit.

Access to more durable building materials is restricted because of frequent shortages, the foreign exchange situation, and political priorities. As laid down in the Central State Plan, permanent building materials are directed in the first instance to development programs that are economically important to the nation.

Cement, for example, is one of the most important materials for building industries and planned urban areas. In the unplanned areas, cement houses are discouraged as their permanence hinders future upgrading.

To guarantee the proper use of industrial building materials, they are distributed according to the Central State Plan. Building of latrines in planned and unplanned areas were included in the proposal for the Central State Plan for 1982 and the prospective indicative plan for the decade 1981-90.

6.1 Wood

Wood available as timber ranges in quality from very soft and susceptible to weathering, to very hard.

We expect that, in the next few years, hardwood will be in short supply, but an industry is being developed to supply softwood for use within the country. Hardwood is sawn for the export market and for planned urbanization.

Wooden poles are available in the rural areas free of charge. However, they are expensive to buy in the major cities.

6.2 Reed and Thatch

"Canico" is a kind of reed commonly used as building material in southern Mozambique. It is usually used for walls together with unbarked poles. In some rural areas, it is also used as roof material. In certain swamps, it can be cut in huge quantities, whereas in the cities it is expensive to buy.

Grass, coconut palm leaves, etc. for roofing material (thatch) are not used very frequently in the urban areas of Maputo and Beira. They are more common in the smaller cities and the countryside. A market exists, but one rarely finds thatch material for sale in peri-urban Maputo.

6.3 Sand and Stone

Fine sand is common in southern Mozambique. The sand is, however, not very useful for concrete, as the grain size is too small.

River sand, suitable for concrete, is available in all cities but transport is a major problem. Often a four-wheel-drive truck is needed to transport it from the sand-pit.

Beach sand is available along the coast. In Beira, it has been used as landfill for urban housing. However, beach sand is often too fine to be used in concrete.

Crushed stone for concrete is available. Natural stone is generally not available in southern Mozambique, whereas it is more common in the north. Again, transport is a problem.

6.4 Clay and Clay Products

While clay is not readily available in Maputo, it is the natural soil in Beira. Red hollow bricks are a common, economical building material. Demand is, however, often greater than supply. One problem mentioned is the large amount of energy needed for firing the bricks. Alternative fuels are being studied. Clay is also used for sewage pipes.

6.5 Cement and Cement Products

Mozambique has Africa's cheapest cement. It is produced in Maputo, Beira, and Nacala, and is considered a strategic material in the development of the country. Its export is also important for economic and political reasons.

Lime can partially replace cement for building purposes. However, lime production is still very low and its use is not common.

Cement is used for making blocks, which are frequently used in suburban housing.

6.6 Asbestos Cement

Cement is one of the ingredients in various asbestos-cement products produced in Maputo and Beira. The asbestos cement is mainly used for roofing material. In Beira, asbestos cement sewer pipes are produced.

6.7 Steel and Steel Products

A small amount of steel is produced in Mozambique from scrap metal, but as quantities are not enough to meet the nation's needs, it is also imported.

Reinforcing steel is rolled in Mozambique. It is generally not available on the open market.

Corrugated sheet metal is the usual roofing material used in the peri-urban areas. However, because its sale is limited, it is being replaced by asbestos cement.

7. EXPERIMENTS AND RESULTS

The objective of our experiments was to develop latrines appropriate to various circumstances, and production methods.

Experiments were carried out on designs, construction techniques, management schemes, etc. These are categorized as follows:

- The latrine slab
- Improved pit latrines
- Compost latrines
- Bore-holes
- Workshops
- Training
- Marketing

Fig. 8 Experiments were made with ventilated latrines. Here, a slab did not pass the security test.

7.1 The Latrine Slab

Research at an early stage of the project showed the need for a prefabricated element (slab) to cover the pit. The slab should have the following properties, if possible:

- Resistance to rot and termites
- Smooth surface
- Easy to keep clean
- Not too expensive
- Easy to transport

The following materials were considered:

- Concrete
- Asbestos cement
- Wood

Wood was excluded due to hygienic reasons as it is difficult to keep clean and hoodworm larvae are liable to hatch in the joints. Also, availability in the major cities was an important obstacle.

Development work on the asbestos cement slabs never worked out, due to administrative difficulties. This does not mean, however, that they will not be tried in the future. Nevertheless, they require centralized production, which depends on reliable transport for distribution of the slabs.

Pit designs

The size and shape (design) of the pit are influenced by the following objectives.

1) Long lifetime, requiring a large volume.
2) Easy to cover, requiring a small diameter.
3) Easy and safe to excavate, requiring a shallow depth.

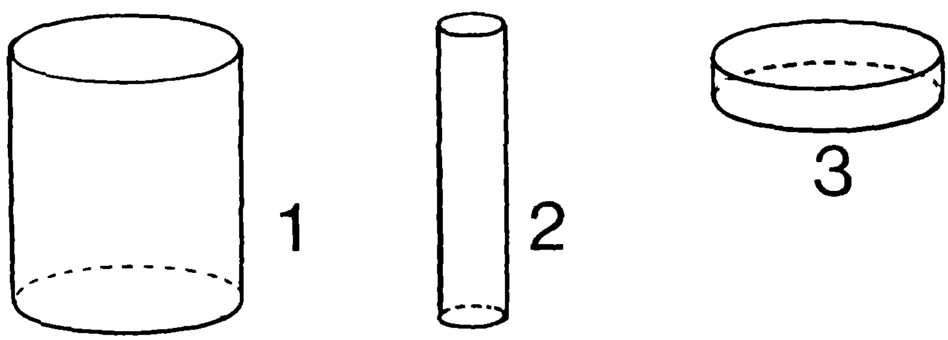


Fig. 9 Pit designs.

Objective 1 conflicts with objectives 2 and 3. Although the volume increases rapidly with increasing diameter and a larger diameter pit is safer to excavate in cases where a cave in is possible, it is more difficult to cover. Therefore, we compromised with the widest diameter that we could cover.

In the literature, both round and rectangular slabs are suggested. We chose round ones because they can be easily moved by rolling. As well, a round pit is more stable than a square one.

Later, we discovered that the round slab could be used without reinforcement bars. This not only reduced the weight of the slab but also cost and production problems.

Taking into consideration the digging technique, it was found that the optimum pit diameter is 1.10 m - the length of a spade. We estimated that 20 cm of support would be needed at the edges for unlined pits. Consequently, the diameter of the slab should be 1.50 m. For a lined pit having the same volume, only 5 cm of support is required so that a maximum diameter of 1.20 m. is adequate.

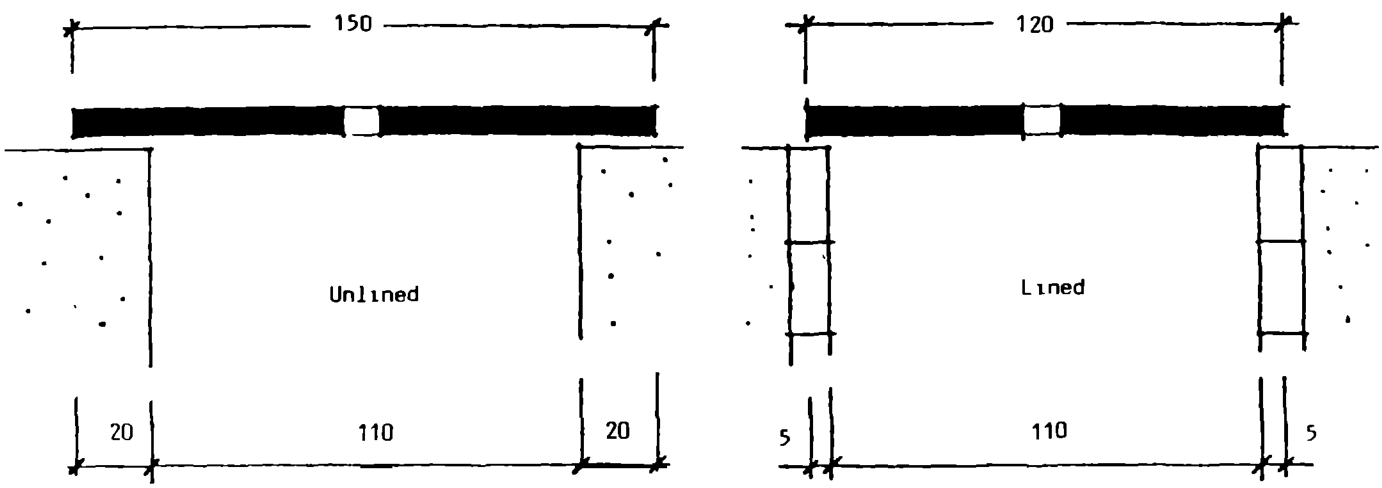


Fig. 10 Slab diameters for lined and unlined pits of 1.10 m diameter (dimensions in centimetres)

Construction

Our first slabs were made with conventional steel-reinforced concrete at a factory for precast concrete products.

Although the slabs were well constructed and passed safety tests, problems were encountered during transport to the dwelling area. The slabs were dangerous to take down from the truck as they weighed about 300 kg. The workers, therefore, dropped them from the truck, which caused many of them to crack in spite of all their reinforcement.

Also, in Mozambique, transporting the large number of slabs required is very expensive and difficult.

The Conical Form

As reinforcement bars are imported and expensive, we attempted to find a way to reduce the amount of reinforcement. By making the slabs conical, we could obtain ring tensions in the periphery and compression in the centre. The ring-reinforced slab proved to be very strong; it did not break even when loaded with 600 kg. After this experience, it was decided to try to produce a slab without any reinforcement, which would require less quality control during manufacturing.

No Reinforcement

The first experiments with nonreinforced slabs were successful. Test-loading showed that nonreinforced slabs made from a mixture of 1 : 2 : 1½ (volumes of cement, sand, and 0.5-inch stone, respectively), and with a rise of 10 cm to the centre, sustained the weight of about nine persons.

The question now was whether to introduce mass production. The project team was aware that a number of factors would influence the strength of the concrete. A nonreinforced slab behaves more predictably than a reinforced one. Once checked, it can only become stronger as the concrete cures. Reinforced concrete sometimes loses its strength.

For example, the atmosphere within a pit rapidly corrodes iron if the iron is not properly covered with compacted concrete. This means that, although a reinforced slab may pass strength tests after manufacture, after some years the iron rods may corrode and result in the slab collapsing. The team therefore concluded that it would be safer to produce nonreinforced slabs as long as each was test-loaded.

Test Loading

The method devised to test-load a slab was to have several people stand on top of it. Normally, a latrine is used by only one person at a time. However, up to three persons may stand on the slab at one time in exceptional cases - for example, when two people assist an old or sick person. Choosing a safety factor of two for this exceptional case, it was concluded that test-loading with six persons should provide an adequate margin of safety.

To simulate adverse conditions of support, the slab is placed on four wooden wedges equally spaced around the perimeter.

Clearly, failure of a slab in use would have serious consequences. Thus, every slab must be test-loaded in this way with six persons. Moreover, six persons is the minimum staff required for a slab-production workshop.

Because the slabs are normally tested 1 week after casting, a further safety factor is added when the concrete reaches its full strength after 4 weeks. To assure that each slab really gets test-loaded, they were not stored vertically until tested. It has been easy to maintain this routine.

Fig. 11 The correct position for test-loading according to the accepted practice in the project. Each slab is tested with a load of six persons.

Alternative Reinforcement

Due to doubts about the nonreinforced slab, ferrocement was used as an alternative. None of the chicken wire-reinforced slabs, however, passed the loading test, probably because the chicken wire did not allow the concrete to be fully compacted.

Chicken wire also turned out to be time-consuming to cut and to fit into the conical form. Also it was expensive and often difficult to obtain.

Because the experiments with nonreinforced concrete were successful, further experimentation with alternative reinforcement was abandoned.

Corrosion of the Slab

A serious problem with sewers made of concrete is sulphide attack, decomposition of the concrete caused by hydrogen sulphide (H_2S) and sulphuric acid (H_2SO_4). Humid latrines might present similiar conditions. The risk of attack weakening our latrine slabs was the subject of a special study.

In a sewer, sulphide attack normally appears in the top ("crown") and at the waterline. In the case of a latrine, waterline corrosion does not exist. The crown corrosion could theoretically appear. A common method to prevent this type of corrosion in smaller sewers is the introduction of vent holes at every 200 m. The normal latrine should give a corresponding degree of ventilation.

To get an idea of the rate of sulphide attack, the lids of septic tanks have been examined. Very old lids (30 - 50 years) showed a corrosion depth of about 1 cm. It is, however, suspected that these lids were made from cement of lower quality than that now available.

Lids of modern septic tanks with an age of about 10 years showed corrosion to a depth of between 0 and 1 mm. Because these lids were cast using a similar technique to that for the slabs, it was concluded that there is little risk of our slabs weakening due to sulphide attack.

The Final Design

Slabs are produced in two diameters: 1.5 and 1.2 m. Both have a slight conical form and are made of nonreinforced concrete. The vertical distance from the center of the slab to the base is 10 cm for large slabs and 5 cm for the smaller ones. The slabs are between 4 and 5 cm thick.

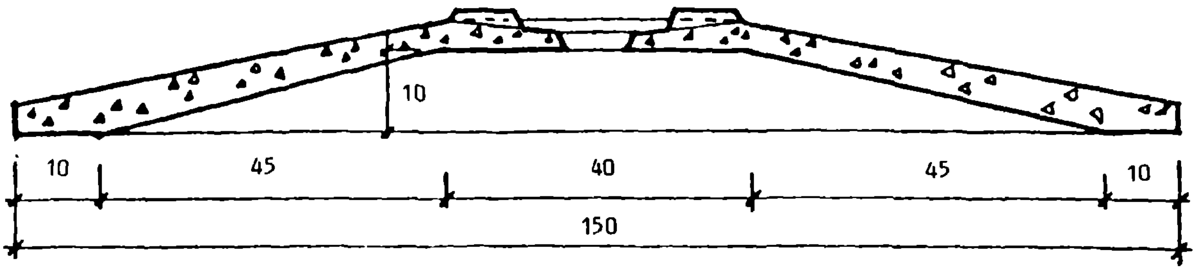


Fig. 12 Overall form of 1.5 m slab showing conical form (dimensions in centimetres)

Around the hole, an area 10 cm wide is sloped inwards to assure that faeces are washed into the latrine, whereas the rest of the slab slopes outwards. The sloping surfaces dry quickly and dirt normally does not stay on the slab. The outward slope of the slab keeps the pit from filling up with rain and with earth carried by wind or rain, or from sweeping the ground. Footrests are also incorporated into the design to position the user correctly in relation to the hole.

To reduce fly breeding and odours, each slab has a tight-fitting lid that covers the hole. The lid has a handle made of 6-mm diameter reinforcing steel.

Materials

For production of slabs, the following materials are needed:

- 32 kg cement
- 65 kg river sand
- 50 kg 13-mm crushed stone
- 60 cm 6-mm diameter reinforcing iron

These quantities are an average for small and large slabs not including wastage, which is estimated at 10%.

Fine sand, paper, and string are also required for making the moulds.

The fine sand can often (in Maputo) be taken from the site. Beach sand would do if kept humid. When this is not possible, fine plaster sand is perfect. Used plaster sand can be recycled, if sifted; or it can be used for blockmaking.

Cost

Recommended manpower requirements are as follows:

- 3 men can make eight slabs per day;
- 2 men can make lids and footrests;
- 1 man helps with transport of slabs; and
- 1 man guards the work place during the night

They work 8 hours/day and 5 days/week (Saturdays are for cleaning up).

Production: 8 x 5 = 40 slabs/week or 160 slabs/month and, assuming 11 working months/year, 160 x 11 = 1760 slabs/year

Salaries: Foremen: 5000 MT/month*
Workmen and guard: 2250 MT/month

12 [5000 + (6 x 2250)] = 222,000 MT/year

Cost manpower/slab: 222,000/1760 = 126 MT/slab

Cost of materials:

2 slabs can be produced per sack of cement
100 MT/sack (including transport, estimated) = 50 MT/slab
Sand 50 MT (including transport, estimated) = 50 MT/slab
Total material cost: 100 MT/slab

"Total" average cost per slab:

Manpower	126 MT
Materials	100 MT
Total	226 MT

Slabs are sold for 500 MT for the 1.50-m-diameter size and 350 MT for the 1.20-m-diameter size.

* One Canadian dollar is 30 meticals (MT)

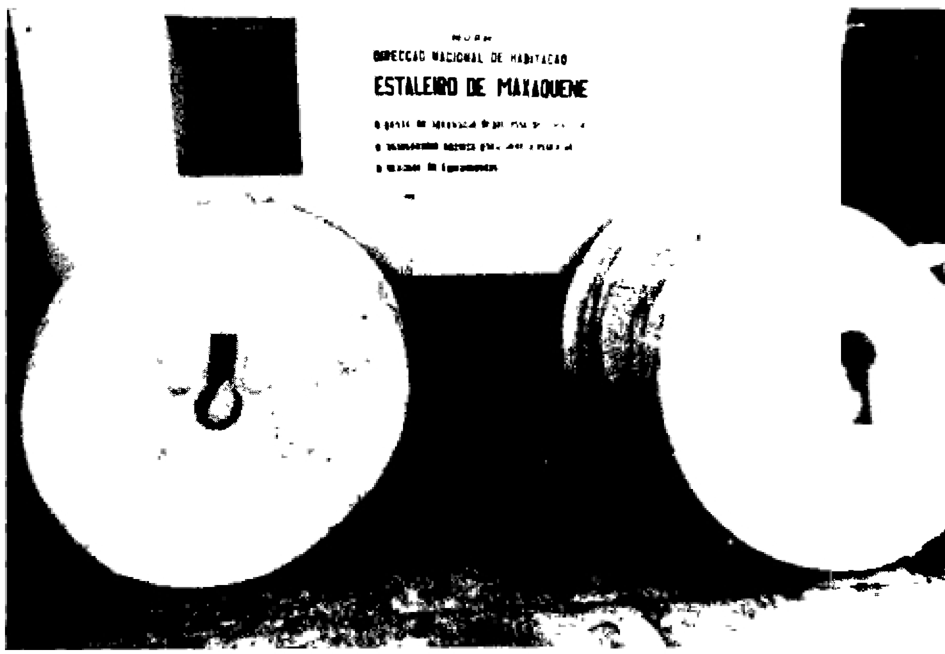


Fig. 13 Slabs for sale at the workshop. At the time of writing (October 1982), over 1500 slabs have been sold, and sales continue to improve.

7.2 Improved Pit Latrines

The survey of sanitation in Mozambique and the technical survey of existing latrines, convinced the research team that improving the pit latrines is both possible and necessary if sanitation is to improve in peri-urban areas, especially in the two major cities of Maputo and Beira.

The Design of the Pits

To improve the design of the pits, we experimented with different shapes for different soil conditions.

Fig. 14 A proper slab is not always enough. Here the pit caved in after a heavy rainfall, due to unstable soil. The pit was repaired in a few hours by removing the slab, covering the faeces with sand and then lining the pit with cement blocks.

The Normal Case

When the soil is fairly stable, the slab can be laid over the standard 1.1-m-diameter pit. Generally, this presents no problems but, in a few cases, the pit caves in during a heavy rainfall. Whenever this happens, the slab can be removed, the feces covered with soil, and a lining installed to support the slab and prevent the pit from collapsing; or the latrine can be moved to a better site. The same slab can, of course, be used again in either case.

For Looser Soil

Pits in looser soil (sandy soil) must be lined with blocks. Joints just filled with sand have worked well when the pit is round. The upper two courses (layers) are set with cement mortar to prevent flies from entering the pit if the surface soil is washed away. This also makes it easier to put the slab in place. Also, in such cases, the slab only needs 5 cm support around the edge, making the effective pit diameter 1.4 m.

Fig 15 The simplest way to line a round pit is to stack cement blocks without any mortar. The round form automatically gives the pit stability and the open joints allow water to infiltrate the soil.

As the diameter of the pit is now increased by 0.3 m, the depth of the pit can be reduced without decreasing the volume. Reducing the depth also makes digging the pit safer. The volume can be increased further by giving the lined pit a "bottle" form.

Experiments have been done in which only the upper part of the pit was lined. This has been possible only when the blocks are set in cement mortar. Experiments with top linings with compacted sand have been very stable in the beginning, but tend to fall when the soil is subject to heavy rains. As top linings require careful construction, which is difficult to control, we do not recommend them.

Where it is Difficult to Dig

Where loose soil conditions prohibit the excavation of a deep pit, elevated pits have been built. In these conditions, the pit is dug as deep as possible, lined with concrete blocks with the lining continuing above the level of the ground and back-filled with the excavated soil. The result has been positive, as long as the blocks above the ground level are set in mortar. The team experimented with laying blocks without mortar. This method was abandoned as it gave flies access to the pit through cracks exposed by rain.

Fig. 16 Where it is difficult to dig, elevated pits have been used. The method is the same as for unstable soil, except that the pit is continued up past the ground-level. Courses of blocks above ground, normally two, are set in mortar.

Elevated pits have been used for areas with a very high water table. Here, the water table has been penetrated 20 - 40 cm and the result has been latrines that are free from flies as long as they retain a scum-free water surface in the pit. However, when too much solid matter and paper are introduced, a scum layer has provided a breeding ground for "soldier flies" (bluebottles).

Elevated latrines are also useful in areas subject to flooding as long as care is taken to carry the blockwork up above the maximum probable flood level.

Improvement of Existing Latrines

When improving existing latrines, the pit itself often does not present any problems. However, placing a new slab over the pit can be difficult. The first proposal was to place a 1.5-m slab on top of the existing pit. Experiments, however, showed that the edges of the old pit often were weak.

This problem was solved by placing a smaller, 60-by-60-cm slab (designed for bore-hole latrines) over the existing latrine. This solution presupposes that the existing structure is strong enough to support the slab (35 kg) and the person using it.

In areas where cement is not available, existing latrines could be improved using a wooden box with a separate frame for the foot-rests (Latrine Type SO, Section 7.3). This design has the advantage of being lighter, and the same techniques are used in its construction. It also has elevated foot-rests (which prevent hookworm) and a lid that keeps out flies.

The soil in southern Mozambique is fine sandy soil, normally completely free of stones. In some areas, the water table is also deep (more than 30 m). Under these conditions, we can use bore-hole latrines.

To improve latrines where the pit was difficult to upgrade, but the superstructure was in good condition, bore-hole pits have been tried successfully. As the latrines nearly always have a place for washing, there is always space for at least one bore-hole pit.

Experiments have been made with diameters of 15 - 40 cm. Small diameters are quick to drill, but also fill up quickly; larger diameters require an auger that is quite heavy. It seems that 30 cm is an optimal diameter. However, deep holes with diameters of 30 cm and more are large enough for a child to fall in. To prevent this, a small slab with a socket has been designed (see page 75). The socket should be placed on the ground before the excavation starts. Excavated soil is placed around it to prevent rain water from entering the pit, and when the hole is deep enough, the slab is placed on the socket and sealed with cement.

To extend the life of a latrine, two or more holes have sometimes been drilled at the same time. In those cases, the holes not in use have been covered with slabs with no openings. When the first hole is filled, the slabs are shifted. Using these double latrines as compost latrines was also considered. This idea is described in Section 7.4.

7.3 Standard Types of Latrine Pits

The experiments we have described above have resulted in five standard types of improved pits:

- S0 - The improved traditional pit,
- S1 - The unlined pit with a slab,
- S2 - The lined pit with a slab,
- S3 - The elevated pit,
- S4 - The bore-hole pit.

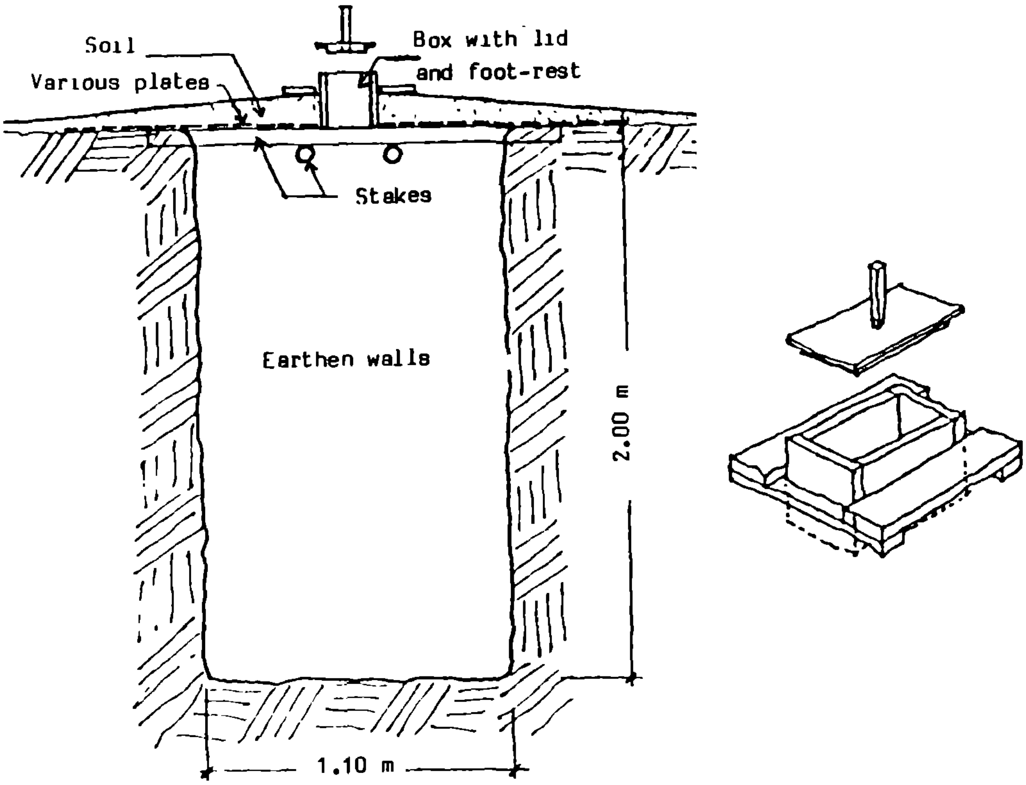


Fig. 17 Latrine pit type S0
The improved traditional pit.

Latrine pit type S0

The traditional latrine that the people build at present has been modified with a "box" for the hole and a lid to make it a bit more difficult for the flies to find their way into the latrine.

The box can be prefabricated at a local workshop or a central factory and distributed to the barrios where it can be used for improving existing latrines. It can also be used for the construction of new ones. The box could be given free or sold at a nominal price.

The frame with the foot-rests is separate and rests on the soil.

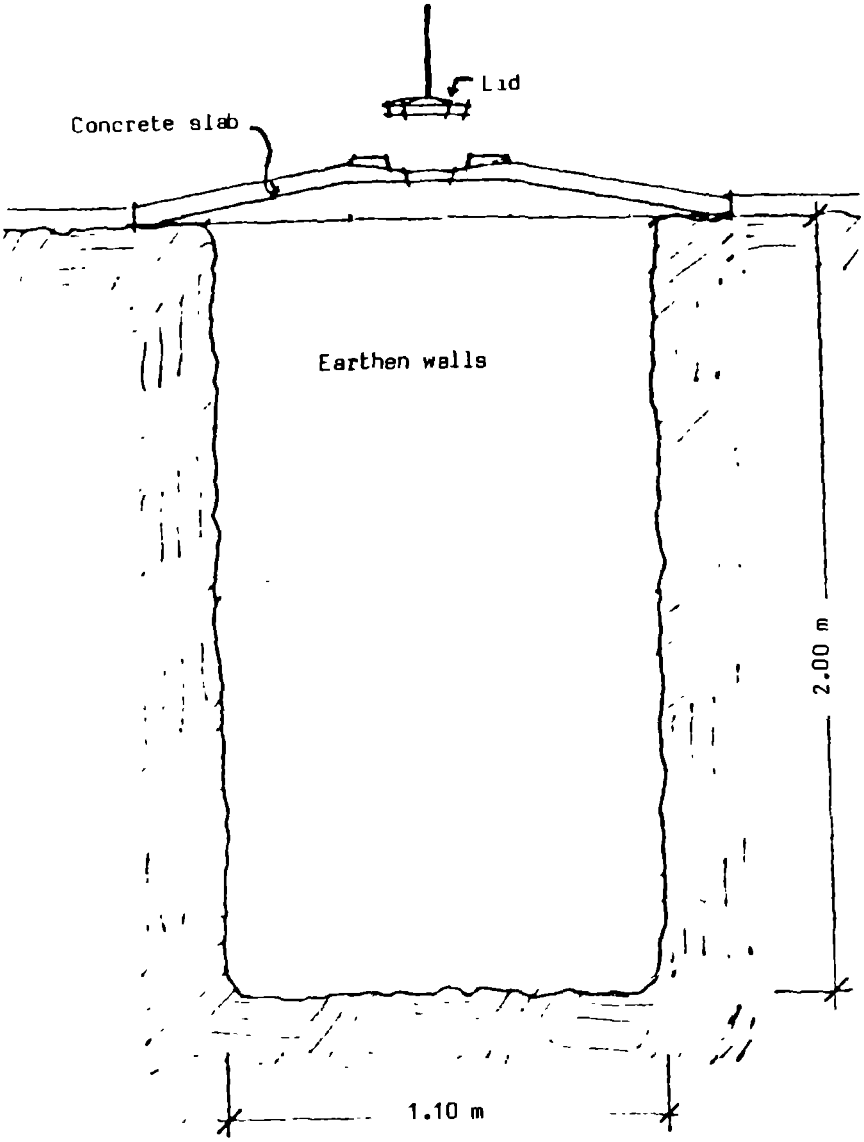


Fig. 18 Latrine pit type S1. The unlined pit with a slab for stable soil.

Latrine type S1

Latrine type S1 is the first and simplest in a series of latrines using the prefabricated slab described in the previous chapter.

To construct a type S1 latrine, one digs a hole 1.1 m in diameter (the length of a normal spade) and covers the hole with the slab. Walls to give privacy can be built of any material. A roof may be added if desired.

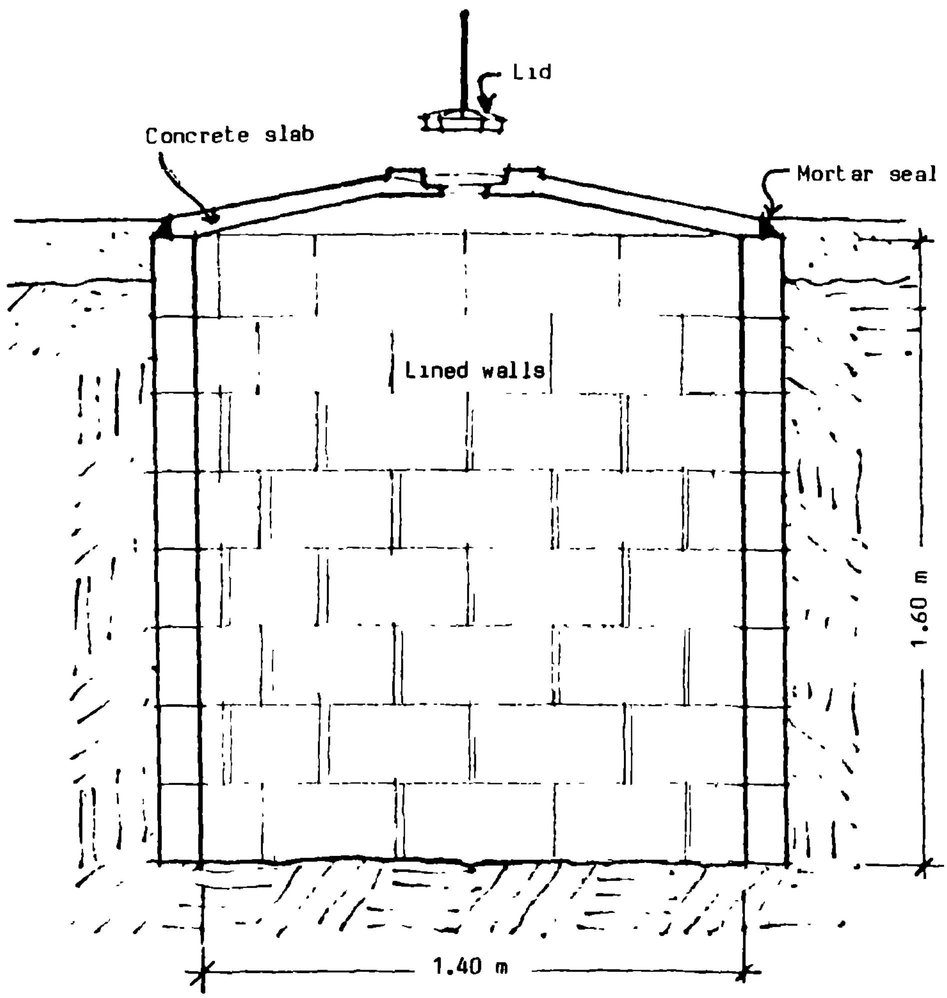


Fig. 19 Latrine pit type S2. For less stable soils.

Latrine pit type S2

This latrine can be built in unstable soil. The lining permits the diameter of the pit to be greater, which either gives a longer lifetime or allows a reduced depth with the same lifetime.

The slab can, of course, be reused for a new latrine when the pit, after about 10 years, is filled, but the same hole can be reused if it is allowed to rest 1 year to eliminate pathogens before redigging.

To construct a type S2 latrine, a 1.60-m-diameter pit is dug, and the walls lined with cement blocks. These can be laid with open joints up to the last two courses. Once the slab is in place the edges are sealed with cement to keep out flies and cockroaches.

To further increase the volume, the pit can be dug 1.80 m in diameter and to a depth of 1.80 m. The cement blocks are laid with 5-cm open joints. For the top two courses, the diameter is reduced to fit the diameter of the slab. This "bottle" form increases the life of the latrine.

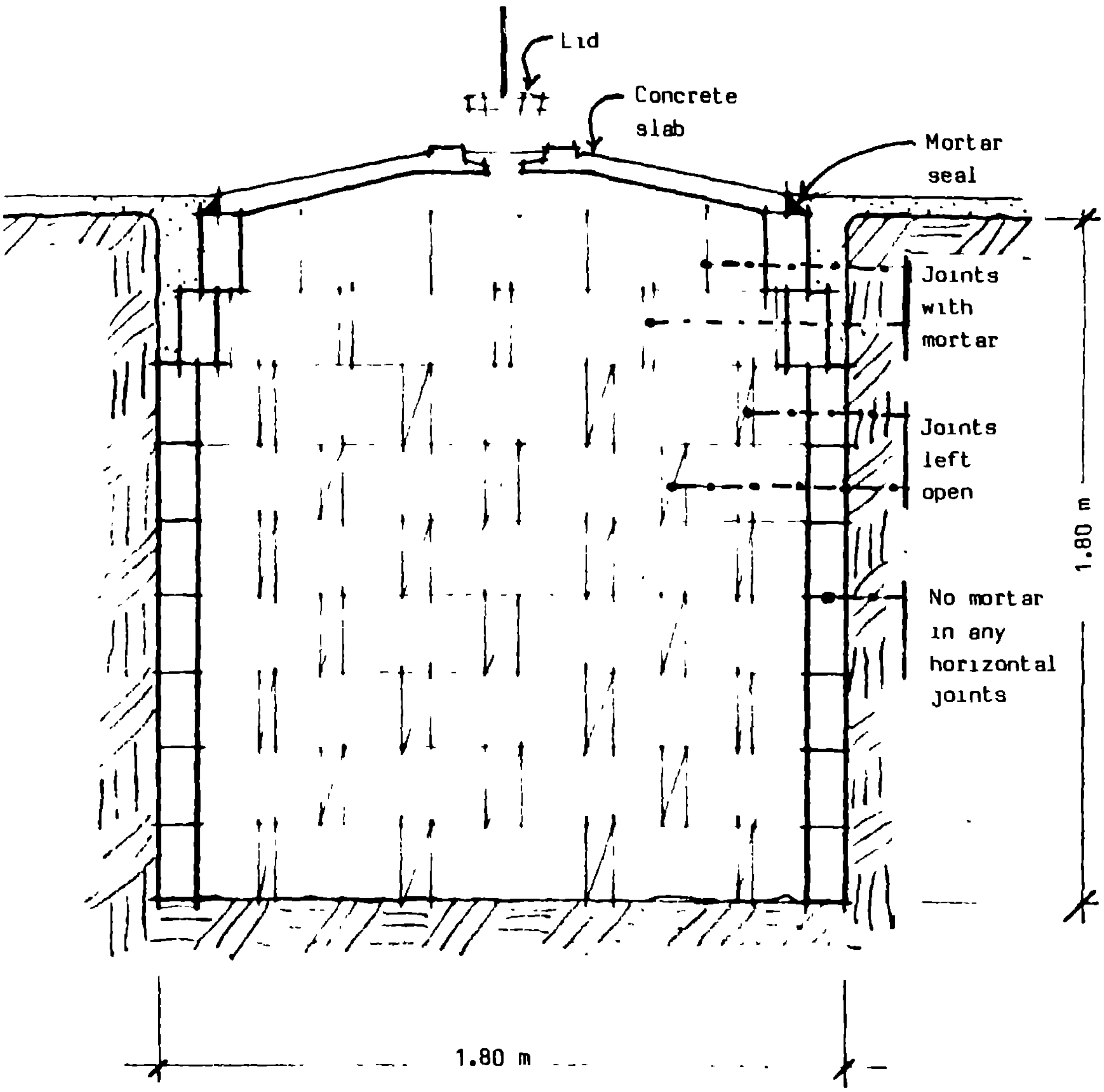


Fig. 20 Bottle-form type S2 latrine.

Bottle-form type S2

The bottle-form type S2 latrine has become very popular. In the beginning, the project workmen protested because of the large volume - there was so much to dig. However, the expected life of this latrine type is about 25 years. Today the client is asked to dig the pit. We provide him with a stick that is 1.80 m long - the depth and diameter of the pit. When this is done, the workmen from the workshop stack up seven courses of cement blocks (10 x 20 x 40 cm) against the wall of the pit, leaving the joints open. With 40 cm blocks, it takes 11 blocks per course. For the last two courses, the vertical joints are gradually closed and are filled with cement mortar to fit the slab, which is actually smaller than the inner diameter of the pit.

In case of high water tables, the depth of the pit can be reduced and the lining can be built above ground level as for type S3 latrines (Fig. 21).

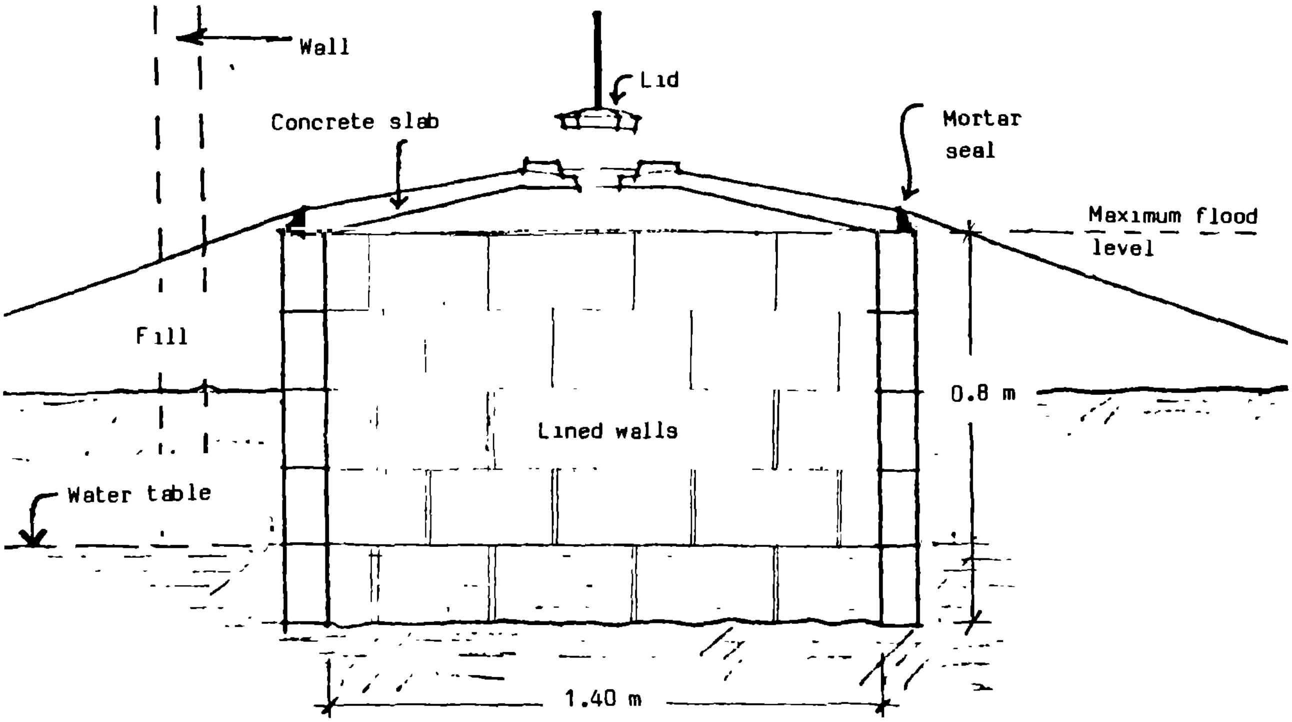


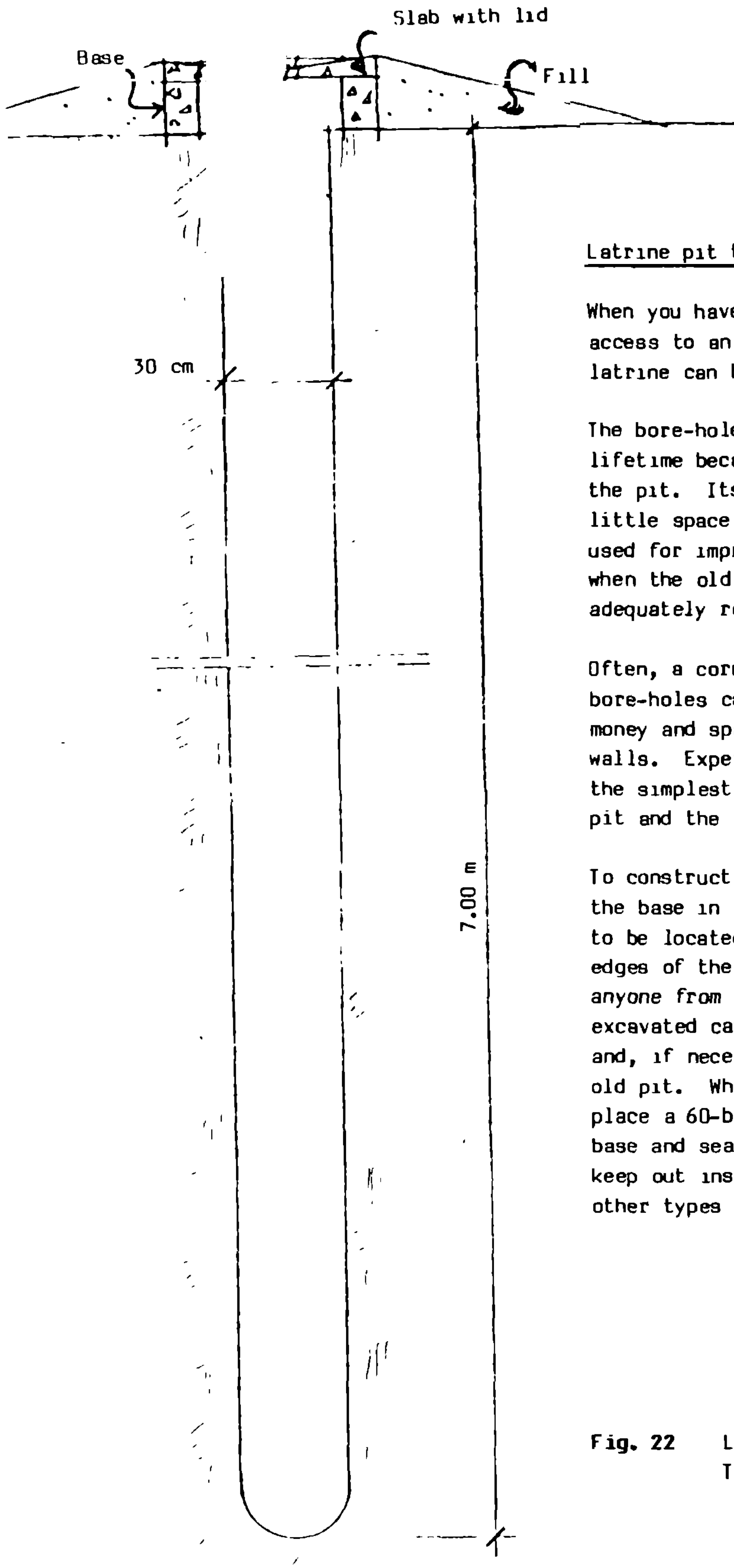
Fig. 21 Latrine pit type S3. The elevated pit.

Type S3 latrine

The type S3 latrine can be constructed where a deep pit is impossible to dig due to a high water table or other obstacle. The wide diameter means that the pit will have a reasonable lifetime even when very shallow. It can also be given a "bottle" form to increase the pit volume and lifetime.

In areas where the ground water is not suitable for domestic use, we recommend that the pit penetrate deeply into the water table. This gives the pit more volume, the water helps to digest the sludge as in a septic tank, and both of these factors extend the lifetime of the pit. Also, in some cases, these latrines are free of flies as fly maggots cannot develop in water.

To construct a type S3 latrine proceed as with type S2, but start by sealing the joints between blocks with cement at ground level. Otherwise, the liquid contents might leak out through the open joints, and flies and cockroaches would have access to the pit.



Latrine pit type S4

When you have a stable sandy soil and access to an earth auger, a bore-hole latrine can be used.

The bore-hole latrine has a limited lifetime because of the small volume of the pit. Its advantage is that it needs little space and consequently can be used for improving an existing latrine when the old pit is filled or cannot be adequately repaired.

Often, a corner for one or two bore-holes can be found, which saves money and space by not building new walls. Experience shows is that even the simplest walls cost more than the pit and the slab.

To construct a bore-hole latrine, place the base in the place where the hole is to be located. This will protect the edges of the bore-hole and will prevent anyone from falling in. The soil excavated can be spread around the base and, if necessary, used to fill in the old pit. When the hole is deep enough, place a 60-by-60-cm slab on top of the base and seal the edge with cement to keep out insects, as is done for the other types of latrines.

Fig. 22 Latrine pit type S4. The bore-hole pit.

7.4 Compost Latrines

Originally the project aimed at introducing biological treatment (composting) in Mozambique. In the preproject phase, some double compartment and continuous moldering latrines were built.

Once the slab technique was developed, simplified double compartment latrines were also constructed.

Preproject Compost Latrines

During the preproject period, the following types of latrines were constructed:

Double compartment compost latrine
Continuous moldering latrine
Multibore-hole latrines

The first two latrine types were extremely complicated and thus expensive. As the compartments are large (2 m^3), it will take many years before we can evaluate how well they function as compost latrines.

Vietnamese Latrines

Eight double compartment latrines with urine separation, or Vietnamese latrines, have been constructed.

In the beginning, there was much resistance to this new type; the masons did not like to construct them and the families did not want to have them. All preferred the elevated latrine that had also been built in the same area.

After a few months, the trend changed. People wanted the Vietnamese latrines instead of the elevated. However, it is too early to draw any conclusions about their acceptability because (1) the elevated latrines, not being permanent, were built with reed walls (canico), whereas the Vietnamese latrines, being permanent, were provided with walls of cement blocks, and (2) only one of the Vietnamese latrines has yet reached to the stage where it is necessary to empty a compartment - the material removed was liquid and not at all attractive.

Visual monitoring shows that these latrines attract lots of flies (bluebottles) and that the contents are far from solid or soil-like. The urine effluent does not seem to be appreciated and cannot be used, as in Vietnam, for irrigation because urinary bilharzia is prevalent.

Fig. 23 Our version of the Vietnamese latrine.

Compost Bore-hole Latrines

Although bore-hole latrines have a small volume, they are easy to make and occupy little space. Two or more holes can be made at the same time.

A movable squatting plate was made and solid lids were cast for holes not in use to prevent people from using more than one hole at a time. When all the holes were filled, the family was supposed to ask for a new hole to be drilled.

However, often the family noticed that the fecal matter lost volume during the moldering process, and again put the squatting place over the first hole until it was completely filled. When all holes were filled, the family built themselves a traditional latrine with a slab bought from the workshop so as not to be bothered with latrines for some years.

Fig 24 Here, two 30-cm-diameter bore-hole pits have been built side by side. When the first pit is filled, the slabs are shifted. When the second pit is filled, we intend to bore out the first again. The bowl in the middle is a urinal with a hole in the bottom and a drain beneath. The habit of urine separation existed prior to the latrine project.

This problem may arise due to bad monitoring but it also illustrates a weak point of double compartment latrines. One cannot be sure that people will use them properly which may result in health hazards while emptying them.

Another problem with the borehole compost latrine is that scrap material that occasionally falls in the pit makes it difficult to bore in the same place a second time.

The Double Pit

Thanks to the latrine program, it became easy to make a stable pit (Type S2). By using the small slabs, one could end up with a pit of reasonable volume in a fairly small space. As an experiment, we made some double pits where one of the slabs had no hole. This could be a solution for those families who want a compost latrine to provide valuable fertilizer.

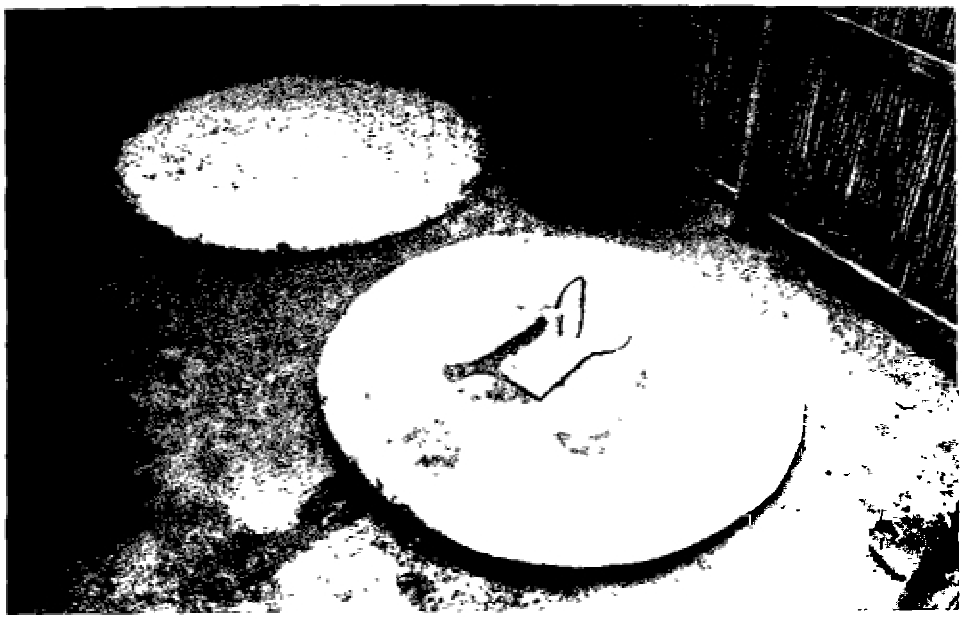


Fig. 25 The double pit.

As it takes quite a long time to fill up a pit, we have not been able to evaluate the latrine in terms of compost production. After 1½ years of service, the first pits built are still only half filled.

7.5 The Latrine Workshop

During the field work, our workshop was in operation continuously for the construction of our experimental and "commercial" latrines.

Because local production was one of the objectives of this project, the workshop itself was monitored, as an experiment.

The following aspects were studied:

production, buildings, administration, transport, physical organization, sale, personnel, and equipment

Production

The first objective of the workshop was to establish a location for construction of experimental latrines.

To find out whether commercial production of the slabs on an open market was possible, production was started on a small scale.

Because sales of slabs were erratic and many families had technical difficulties when building their own latrines, latrines were offered for sale as complete units. However, not enough complete latrines were produced and many orders must still be filled.

About 50 slabs/month were produced, which includes slabs for complete latrines. The low production is not due to the capacity of the workshop, but to low demand. There has never been any difficulty producing as many slabs as could be sold; only in producing complete latrines.

Production capacity with six persons is about 1760 slabs/year at a rate of 8 slabs/day. As an average, one could estimate the production at 1000 slabs/year and use the rest of the capacity to build complete latrines for which experience shows a good market as long as building materials can be guaranteed.

Transport

Although transport of building material to the workshop has been provided free of charge, it has been included in our cost estimates.

Transport of purchased slabs was not provided at the beginning of the project. Since most families had difficulty arranging transport, a hand-pulled, two-wheeled cart was included in the equipment at the workshop. Men from the workshop helped to transport the slab (free of charge) for the purchaser.

Records of local deliveries were kept. They indicate that the workshop has had an influence over a radius of several kilometers, more than what is economical considering transport. About 50% of the slabs have been installed less than 500 m from the shop. It seems that 1000 m is a reasonable maximum distance for local deliveries. This means that an average distance of 2 km between workshops is reasonable from the point of view of transport.

COMPLETE LATRINES CONSTRUCTED BY THE PROJECT (NOVEMBER 1981)

Type	Slab diameter (m)	Number		
		Experimental	Commercial	Total
Type S0				
Improved traditional	-	6	-	6
Type S1	1.20	7	2	9
Unlined pit with slab	1.50	23	2	25
Type S2	1.20	3	6	9
Lined pit with slab	1.50	3	30	33
Type S3	1.20	-	-	-
Elevated pit with slab	1.50	17	-	17
Type S4	0.15	3	-	3
Bore-hole pit*	0.20	2	-	2
	0.30	3	-	7
	0.35	1	-	1
Double pit	1.20	3	-	3
Vietnamese pit		5	3	8
Total		76	47	123

*Diameters refer to the hole.

As most sales are made at the end of the month (after payday), there is a queue for the cart at this time. It is therefore proposed to have two carts per workshop, even though one is sufficient for the average volume of sales.

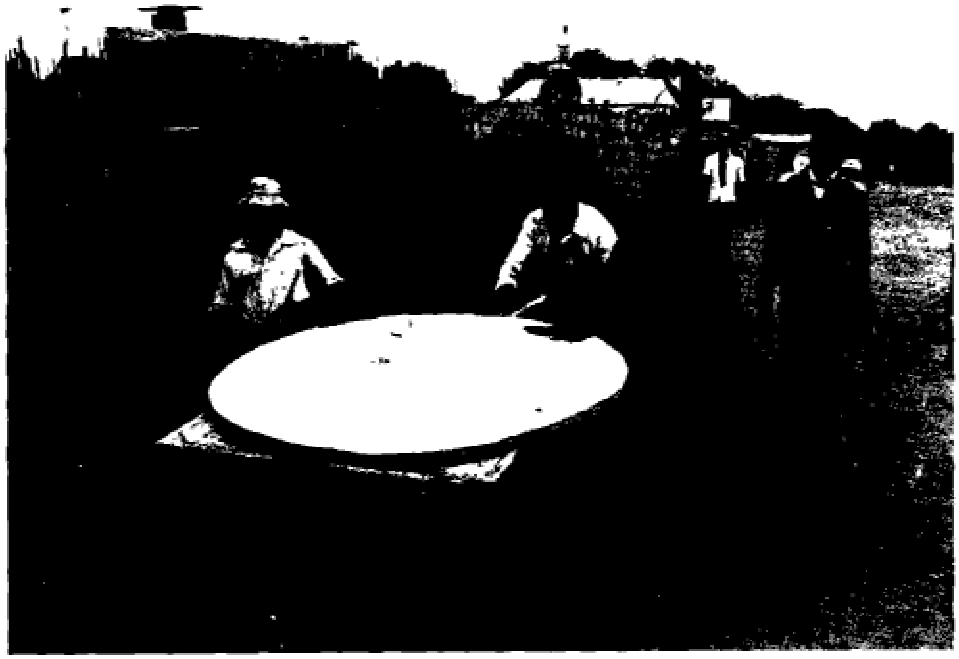


Fig. 26 Here, a slab is transported from the workshop to the purchaser on a two-wheeled cart. One man from the workshop assists.

Administration

The experimental workshop kept records on almost all the details of production. Special forms have been filled out for each slab and each latrine. The financial transactions required bookkeeping.

As a result of the record keeping, simplified routines for new workshops are at present being developed and tested. It is not recommended that a "commercial" workshop have more than the simplest form of bookkeeping.

It is important to depend as little as possible on central administration; it is also necessary to control production particularly because restricted building materials will be distributed.

Buildings

The present workshop has three rooms, each approximately 4 x 4 m. One served as an office; the second for the workmen's needs; and the third as a storage room for moulds, augers, and so on. A small 2 x 4-m room, and a 4 x 6-m storage space were used for storing cement and the cart.

Although the buildings have adequately met out needs, future workshops will need less space as they will not be carrying out research. We estimate the needs to be:

Office and personnel room (3 x 4 m)
Storage room (3 x 7 m)

For security reasons, and to protect the cement from humidity, the building should be erected with solid walls, doors, and roofing. The floor should be 15 cm above the ground with a ramp to allow the cart to easily enter even when loaded.

Casting yard

The casting yard is about 20 x 20 m, which has been sufficient for limited production of slabs. For full production of 7 - 8 slabs/day, with a 1-week hardening period before the slab is taken out of the pile, more space is needed. Because sand and stone were stored at a considerable distance from the place of casting, this resulted in extra transport costs.

An ideal casting yard for intensive production of slabs could measure 18.5 x 34 m, including a place to keep sand and stone. Less space would do, but would make production slower.

However, it also should be kept in mind that the workshop staff might have to do more than produce slabs. Therefore, more land should be reserved for the sale of miscellaneous building materials.

Personnel

Approximately 13 persons, including monitors and a full-time driver, were employed at the experimental workshop. Because of administrative difficulties, we did not employ the optimum number of workmen and always had customers waiting for "commercial latrines".

Safety control of slabs requires six persons. This is, therefore, the minimum staff required during the day at the workshop. In addition, a night guard is required.

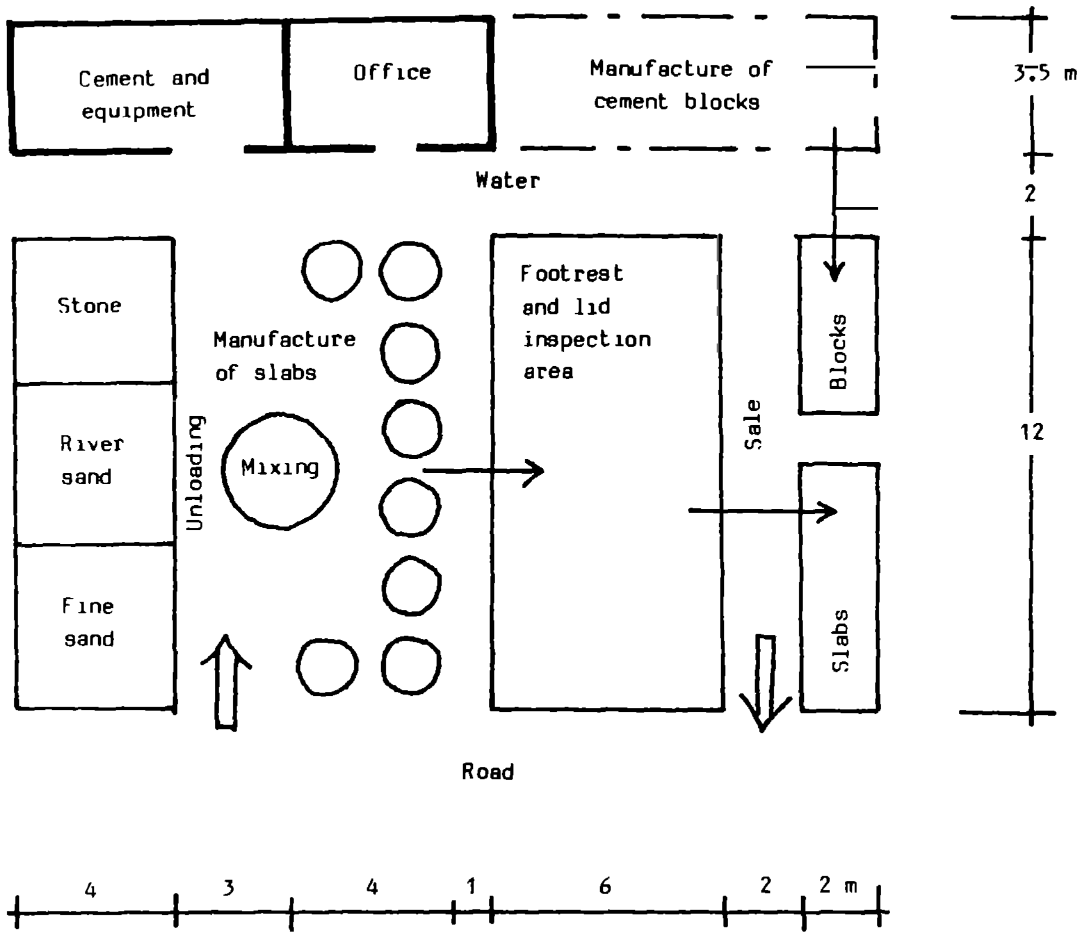


Fig. 27 An example of how a small casting yard (17.5 x 22 m) could be organized.

To start up a workshop, a day-time staff of six is recommended: one foreman (a mason who would also to do simpler administrative work), four workmen, and one person for transport - with a night-time guard, making a total staff of seven.

These men, when well trained, should be able to produce about 8 slabs/day, or 1760 slabs/year. Because this will be more than they can sell initially, commercial construction of complete latrines parallel to the slab production is also recommended.

Equipment

A few special moulds are required for the slab production. These can be produced locally. For local transport, a wheelbarrow and a two-wheeled cart are needed. You also need spades for digging pits and mixing concrete. Finally, mason's tools and a pair of scissors are needed. There should always be a spare set of important items that might break or disappear.

A complete list for the six-person workshop is as follows:

For transport:	2 two-wheeled hand carts 2 wheel barrows
Moulds:	10 sheetmetal moulds, 1.50 m diameter 10 sheetmetal moulds, 1.20 m diameter 2 arch formers, 1.50 m 2 archs formers, 1.20 m 10 hole-moulds 2 foot-rest moulds.
Tools:	6 spades 1 pickaxe (more if the ground is hard to dig) 6 trowels, medium size 3 trowels, small size 2 floor trowels 2 hammers 2 pairs of tongs 2 pairs of scissors

7.6 Training

As new methods have been developed in the project, it has been necessary to implement a training component.

When project results began to justify it, systematic training began. The training program was not limited to local workers as the project wished to support sanitation improvements in other cities. Trainees were invited from Beira, Pemba, and Chimoio.

Because of a lack of hotel accommodation, only a few trainees could be supported. The course aimed at training two workmen and one supervisor from each city in making slabs, building latrines, and taking care of the workshop. A complete training session lasted 30 days and the project's workmen and supervisors served as the teachers.

Experience drawn from conducting the course was as follows:

1. The trainees sent from the provinces generally were at a very low educational level. Some of them could not read or write.

2. The trainees arrived days and even weeks later than expected.

3. Lodging of trainees was difficult as the hotel situation in Maputo is poor and late arrivals caused extra problems.

4. Communication with the provinces was difficult.

5. The trainees arrived without working clothes even though the invitation stated that it was a practical course.

6. The trainees had little difficulty in learning the practical aspects of the course, even those with little technical background. In fact, the workmen from Pemba made slabs more skillfully than our own masons after only a few days.

7. The trainees contributed constructively to the project by confirming or criticizing proposed solutions in relation to local circumstances in the provinces.

8. The administrative aspects of the project presented difficulties, depending on, first, the level of the trainees and, second, administrative routines that are too complex.

For future courses, it is necessary, first, to define the level of the trainees (which is very difficult) and, second, to specify that they need clothes for practical work. The experiment showed that the new technology is easy to transfer, even by untrained instructors.

7.7 Commercialization - Economy

To be effective, a latrine-building program should be self-financed by sales. It is essential that the price of the latrines be acceptable to the community.

In the past, latrine slabs have been offered for sale without any attempt to convince people to buy them. The price has been set to cover all real costs, including a small profit for unexpected expenses.

The lack of sales was a bottle-neck in the beginning and, consequently, has been the subject of a special study. No attempts whatsoever have been made to push sales. It is expected that sales will improve once it is decided to mobilize the population as was done during the National Latrine Building Campaign.

Inquiries also indicated that people want better latrines and are willing to pay for them, but often have difficulty paying the whole sum at once.

A credit system was worked out with the cooperation of a local bank. However, the scheme was never implemented as the bank backed out at the last minute. Besides, traditional forms of saving, such as the rotating credit associations that exist in towns all over Africa, can be used to overcome the shortage of ready cash.

Sale of Slabs

The first step was to offer latrine slabs for sale. No announcements were made except to inform the local authorities in the neighborhood (the Dynamizing Group) about the possibility. Records of sales were kept, which showed an increase in sales from about 5/month in the beginning to over 100 by October 1982. In the first 23 months, a total of 492 slabs were sold.

Inquiry

As the sale of slabs during the first months was low, a survey was conducted to find out the reason.

- In a block of 73 households, 66 families were interviewed.
- 48 of the families knew that slabs were being offered for sale, 18 did not.
- 42 of them had seen the slabs at the workshop, 1 had heard through the Dynamizing Group and 2 had heard about it from other persons.
- 30 of them knew the price, 20 did not.
- After being told the price (350 MT for the 1.20-m-diameter and 500 MT for the 1.50-m-diameter), 6 found it was too expensive, 18 cheap, and 34 reasonable.
- 12 had seen the slabs installed at a home and 19 had seen the demonstration latrines at the workshop.
- All of them indicated that they wanted to buy a slab.

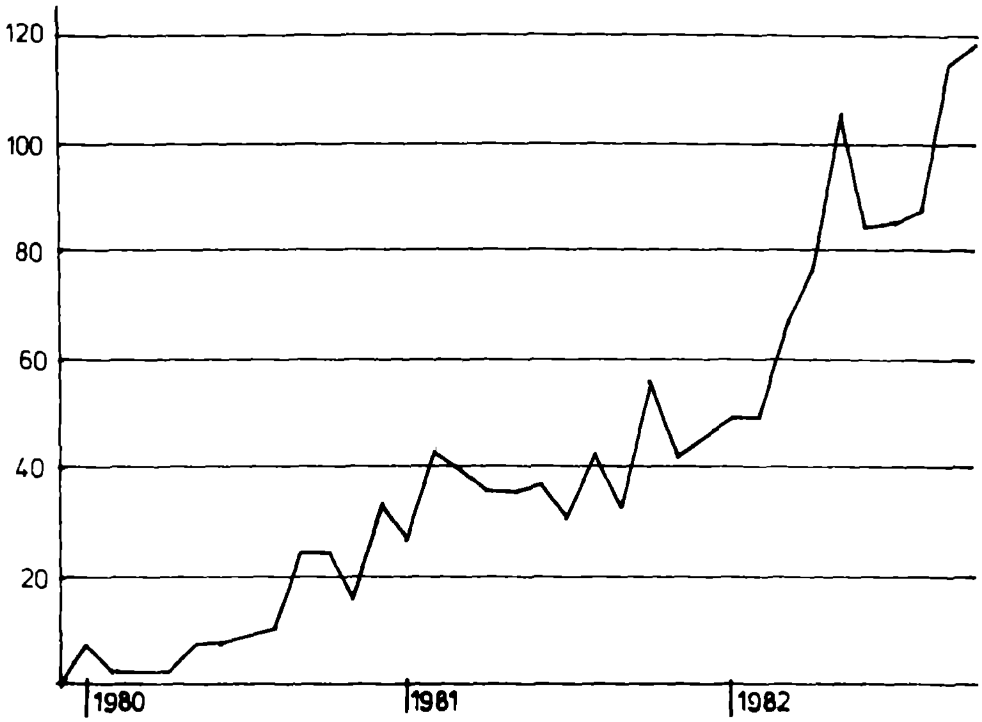


Fig. 28 The monthly sale of latrine slabs from the experimental casting yard in Maxaquene showing the increase in sales without mobilization of the population.

- Asked how much they would be prepared to pay to buy a slab on an installment purchase, they replied as follows:

25 MT/month	1 family
50 MT/month	9 families
100 MT/month	27 families
150 MT/month	6 families
200 MT/month	11 families
250 MT/month	5 families
300 MT/month	4 families
350 MT/month	1 family
500 MT/month	1 family
No answer	1 family

- Concerning a collective loan to a group of families, 63 were positive whereas 3 did not like the idea.

- 42 said that they would buy a latrine if they had authorization to build a new house, 32 would buy if the slabs were cheaper, and 50 if the workshops could arrange transport.

A quantitative interpretation of the inquiry gives a far more positive picture of the situation than reasonably could be true. It is therefore dangerous to draw serious conclusions from making a survey.

It is intended to follow-up the inquiry with a pilot credit system together with a bank (Banco Popular de Desenvolvimento); however, the bank backed out in the end, so the system was never tried.

The only specific measures taken as a result of the inquiry were that we ordered a two-wheeled hand-pushed cart, and we included transport in the price of the slabs.

Sale of Complete Latrines

At the start of the project, requests for complete latrines had already been received. This was found to be an interesting way to publicize the new technology. So the project team started building "commercial latrines", for which the client paid material and labour costs. The "experimental latrines" were paid for by the project.

Of 49 commercial latrines, 36 were Type S2, which means that they had pits lined with blocks.

The general shortage of cement blocks is one explanation of this type's popularity. Others found it difficult to build a block-lined pit themselves and therefore pefered the commercial type.

There is, however, a waiting list for "commercial latrines" that has existed since the project began. This is important, because this demand provides economic security for the workshop people; they will not run short of work.

Economic Aspects

Although there are records of all the activities of the workshop, the fact that experimental activities were conducted makes it impossible to accurately compare costs.

The slabs are sold for 500 MT and 350 MT, for 1.5-m and 1.2-m slabs respectively, or an average of 425 MT. The average production cost (labour, material, and transport) is 225 MT, which is 52% of the production cost, and the remaining 48% would reasonably cover the overheads such as equipment, administration, etc.

Complete latrines are sold for the commercial price of the building materials(though the workshop can buy it cheaper) plus labor. This selling price is not enough to cover the overheads.

Conclusion

For proper evaluation of the financial aspects of a workshop, it is important not to combine technical experimentation with economic experimentation.

There is also the question of subsidies. At present, the city council is providing latrines free of charge in some areas. Because sewer systems are often subsidized, latrines could also reasonably deserve a subsidy.

It is not clear whether the workshops can be 100% self-financed. If they cannot, how should the subsidies be administered?

7.8 Ventilation Pipes for Fly Control

Reports from Zimbabwe show an important reduction of flies from pit latrines using screened ventilation tubes.

Female flies seeking to lay their eggs are attracted by the smell from the vent pipe, but are unable to pass the screen. Should any enter, the light from the tube attracts the young flies trying to escape from the pit. Judging from experiences in Zimbabwe, the flies die in the pipe and fall back into the latrine.

There is no reason to doubt the impact of the pipe, if it is properly built and properly screened. There is also good reason to believe that it essentially reduces the smell because wind causes an updraught in the tube. A number of ventilated latrines that have been built by the project are confirming this theory.

The weak point in this solution is the lifetime of the mesh. Glass fibre or stainless steel is recommended. If mesh is not used, or is broken, the ventilation pipe might be an easy way for the flies to enter into and out of the latrine.

Another risk is that the reduced smell would make people forget to replace the lid over the hole.

In Mozambique, at present, two types of fly-mesh are available: galvanized steel and plastic. The galvanized steel mesh corrodes in a few weeks, due to corrosive gases leaving the pit. The plastic mesh has a longer lifetime, but the plastic material is sensitive to ultraviolet light from the sun. Cockroaches can also bite through a plastic mesh, thus giving flies a free way in and out. The vent pipe can also be a complication as its construction might become an obstacle in the implementation phase of the program.

The seriousness of the fly problem can also be a subject for discussion. Recent studies carried out in Maxaquene showed a limited fly production from dry pit latrines (0-13 flies/day). Earlier investigations had given numbers around 300/day, which could be very serious. No explanation for the difference has yet been found.

Until more is known about the life of the fly-mesh and the effectiveness of unroofed latrines, the vent pipe has only been recommended in special situations where the mesh can be checked and replaced regularly.

8. IMPLEMENTATION

One of the objectives of the latrine workshop was to study the problems of implementation. In an implementation program, slabs and construction service should be provided from a large number of workshops within neighborhoods rather than from a single centralized factory.

Various organizations could be considered for establishing workshops: state execution, state enterprise, cooperative enterprise, private enterprise, or self-help construction. The problems of the first and the last forms have been studied through our work in Maxaquene and Polana Canico. Plans for creating a building cooperative are now at an advanced stage, and one private entrepreneur has trained workmen for slab production through the project.

A systematic study of the workshops as centres for latrine production would be a natural continuation of the project.

8.1 Neighborhood Workshops

Within neighborhoods, construction workshops could have wide functions in the field of housing and general settlement upgrading. However, because of the present shortage of planned areas for permanent housing; executive, financial, and control capacity; and an acute need for better sanitation; latrines, and maybe wells, should be the first task for the workshops. Also, because of shortages of building materials, it would be better to concentrate on latrines as the quantity of cement used for one normal house is enough for 200-300 latrine slabs or for 100 elevated latrines built with cement blocks.

8.2 State Enterprise

The staff at the latrine workshop at Maxaquene have been employed by the state (the City Council and the National Directorate of Housing). This has caused administrative and practical problems, but has facilitated requisition of transport and of building materials.

Being a research project, money from sales of slabs and complete latrines could be used to pay workmen and buy more building materials. Normally, this is not possible and income from sales returns to the Ministry of Finance. This problem can be solved by creating a statal firm (Empresa Estatal), although this implies a bureaucratic procedure.

A serious difficulty with this strategy is recruitment of workmen. This, by law, must be administered through the Ministry of Labor, which has its own rules for recruitment. Good workmen could easily be recruited directly by the workshop from people who are known and who live close to the workshop.

8.3 Cooperative

Bureaucratic problems could be overcome by creating cooperatives, where the workmen themselves take the responsibility. Politically, this kind of democratic production is strongly encouraged by the Mozambique Government, and a pilot construction cooperative is being set up in the neighborhood of Inhagoia.

The workmen in Maxaquene were asked whether they were interested in forming a cooperative and, if so, where they would like to start it. After discussions among the workmen, the neighborhood of Inhagoia was chosen, and two workmen who live in the area were appointed as representatives in the preparation of the project.

A proposal for the cooperative has been detailed. It has been accepted by the National Director of Housing, who is responsible for the experiment, the Directorate of Construction and Urbanization, which is responsible for the distribution of cement and transport, and finally by the local government in the neighborhood unit, the Dynamizing Group, which is responsible for the activities in their area.

8.4 Private Enterprise

One private entrepreneur has, without economic support from the project, found workmen from the workshop at Maxaquene and is starting commercial production of slabs and complete latrines. His main problems are transport and the supply of cement.

Preliminary inquiries have been made with other private firms located in areas where latrine building is difficult beccause of high water tables. If extra cement could be provided, they would be interested in producing latrine slabs. High costs for transport of sand and cement are mentioned as serious obstacles.

8.5 Self-Help Construction

Self-help construction is traditional in latrine building. As mentioned earlier in this report, it has technical difficulties in hygiene and safety. The workshop program has been proposed as a complement to overcome such difficulties, but the enormous capacity of the people can only be harnessed if the most complicated element, i.e., the slab, is provided as a prefabricated unit.

Self-help construction is, therefore, an important aspect of a latrine-building program, if the workshop program is included.

8.6 Transport

Transport is a major problem in Mozambique. Shortage of skilled staff reduces the lifetime of the vehicles, and shortages of spare parts complicates repairs.

To start implementation of the improved latrine program, three trucks with spare parts have been requested from the Netherlands Government: two 7-ton tippers (four-wheel drive) and one 20-ton truck (four-wheel drive), with spare parts.

8.7 Restricted Products

As mentioned earlier, cement and iron are strategic materials in the development of the country and thus are subject to restrictions. As basic sanitation is considered a national priority, negotiations have been initiated with DIMAC, the unit responsible for distribution of building materials, to assure supplies.

9. INSTITUTIONAL ORGANIZATION

It was within the scope of the project to propose an organization and define the division of responsibility for the implementation of the improved latrine program.

Every program for implementation must have an organisation that is responsible for its execution. This organisation can be determined in terms of specialization (housing, health, etc.), and geographical responsibility (nation, city, province, neighborhood unit, etc). It is in our long-term interest to define objectives for implementing the results of this project and to integrate sanitation into a program for the general up-grading of the environment in suburban neighborhoods. The problem of up-grading rural areas is not included here as the project has been limited to peri-urban, self-built settlements as explained earlier.

With a traditional concept of latrine building as "digging holes in the ground," health workers could assume the whole responsibility for the program. With more sophisticated technical solutions, however, engineering requirements become more important. For sewage systems, for example, the role of the health workers is reduced to periodic monitoring, whereas the responsibility for project execution, maintenance, etc., is with the engineering bodies of the City Councils and the Ministry of Public Works, with Housing as the responsible ministry.

For improved latrines, the importance of the participation of health workers is clear. The existence of latrines is an absolute necessity for maintaining environmental hygiene in dense settlements and the impact of a latrine-building program on public health might be marginal if it is not accompanied by health education.

Organization of workshops for latrine building and other activities for the general improvement of the urban environment is not normally the role of health workers. According to the National Director of Preventive Medicine, "a ministry of doctors should not try to enter into the field of the engineers."

The project therefore proposes that the Ministry of Public Works and Housing and its suborganizations assume the responsibility for the engineering component of the program as well as for organizing workshops, training workmen and technicians, and distribution of building materials, while the Ministry of Health dedicates itself to sanitary education.

9.1 National Level

The National Directorate of Water, the responsible body for sewered sanitation, employs sanitary engineers some of whom have been involved in this research program. However, in discussions on how to divide responsibilities, it was concluded that communal sewers are the responsibility of the Ministry of Public Works but latrines belong to Housing. The process of construction and maintenance as well as the responsibility for financing the two systems are different and should not be mixed: the latrine, as is a dwelling, is a private responsibility, whereas roads and sewers are public. It is therefore reasonable that latrine building should be the responsibility of the National Directorate of Housing.

The National Directorate of Water should also be involved in the future because latrine-building programs might threaten the quality of drinking water. Their participation should be limited to monitoring the latrine-building program, unless it is combined with a water-supply program.

The role of the staff from the Ministry of Health is critical, as it is they who are responsible for the health of the people. The National Directorate of Preventive Medicine indicates when and where latrine-building programs should be initiated, and the technical preparation is done by the National Directorate of Housing. The Directorate of Preventive Medicine's role is to ensure that the program advances in accordance with public health needs.

Another important task of the health workers is sanitary education, without which the impact of any latrine-building program is limited.

9.2 City Level

A general line in the resolution from the first National Meeting of Cities and Communal Neighborhoods in Mozambique is that the City Councils (Conselho Executivo da Cidade = The City's Executive Council), together with the Dynamizing Groups (Grupos Dinamisadores) in the neighborhood units, are responsible for implementing programs that concern the cities and communal neighborhoods.

It has been the Mozambique Government's plan to create parallel institutional structures at both national and city levels. Thus corresponding bodies can be found at both levels, even if, at the city level, two or more organizations have been grouped together that exists as separate institutions at the national level.

For various reasons, this system is not followed completely. However, the project has tried to maintain the division of responsibility proposed at the national level, and at the level of the City's Executive Council. The project, therefore, proposes that the executing responsibility for latrine-building programs stay with the Directorate for Construction and Urbanization, the body at the city level that corresponds to the Ministry of Public Works and Housing, a gouvernmental body which includes the National Directorates of Water and Housing. This organization should deal with all planned or reorganized settlement areas. Eventually, the Directorate of Urban Services will be responsible for sanitation in existing areas. In any event, the question is still subject to discussion.

The City's Health Directorate (Direccao de Saude a Cidade) corresponds, at the city level, to the Ministry of Health. It includes the Preventative Medicine Centre (Centro de Profilaxia), which corresponds to the National Directorate of Preventive Medicine.

The responsibility for the health situation in the city is, therefore, under the responsibility of the City's Health Directorate, who through the Preventative Medicine Centre indicates where and when latrine-building campaigns should be organized.

Execution of a campaign should then be carried out through the City Council's Directorate of Construction and Urbanization, who also are responsible for setting up workshops and guaranteeing the necessary building materials and their transport. Eventually this will be done in cooperation with other branches of the City Council.

9.3 Neighborhood Level

As the City Council (Conselho Executivo da Cidade) is the government at the city level, the Dynamizing Group is the responsible authority at the neighborhood level. Again, in the Dynamizing Groups, there exist divisions of responsibility. Thus, there are representatives for health and housing also in the Dynamizing Groups.

Each neighborhood unit is divided into cells (cellulas) with the number of cells depending on the size of the neighborhood unit. Each cell is divided into quarters (quarterões). At cell and quarter levels, representatives are chosen by the people. Even here one can find persons who are responsible for health aspects such as vaccinations and hygiene.

In a program for building improved latrines, the Dynamizing Group should be responsible for dissemination of information to potential buyers. The person responsible for housing should organize implementation activity while the health people concentrate on the health aspects and promote sales.

10. CONTINUATION AND FOLLOW-UP

This project has been limited to developing sanitation technology for ultra low-cost peri-urban housing. However, it is recommended that technical solutions for rural and moderate-cost urban housing also be developed. The question of fly control needs special attention.

On the basis of the experience during this project, an organized latrine-building program was included in the proposal of the Central State Plan for 1982, as well as the prospective indicative plan for the decade 1981-90.

By 1990, the total need for improved pit latrines is estimated to be about 700,000 units (proposal of September 1980). To reach this target, decisions will have to be made about training, organization, and so on. Research into these areas is a priority.

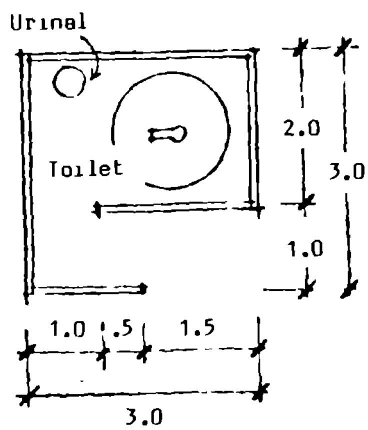
Appendix A

LATRINE TYPES AND THEIR PREFABRICATED ELEMENTS

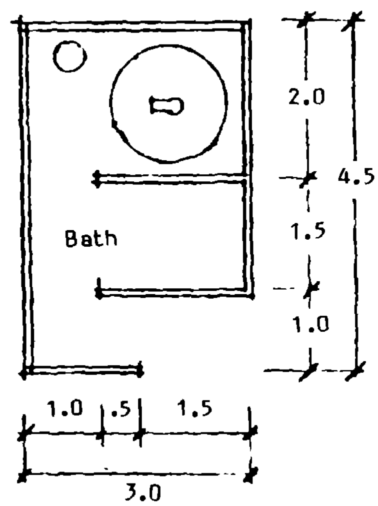
The production of slabs and the moulds needed are presented in Appendix B "Production of thin latrine slabs of nonreinforced concrete."
The useful life of the latrines is calculated on the basis of a sludge-accumulation rate of 30 litres per person per year.

Plan of Single and Multiple Latrines

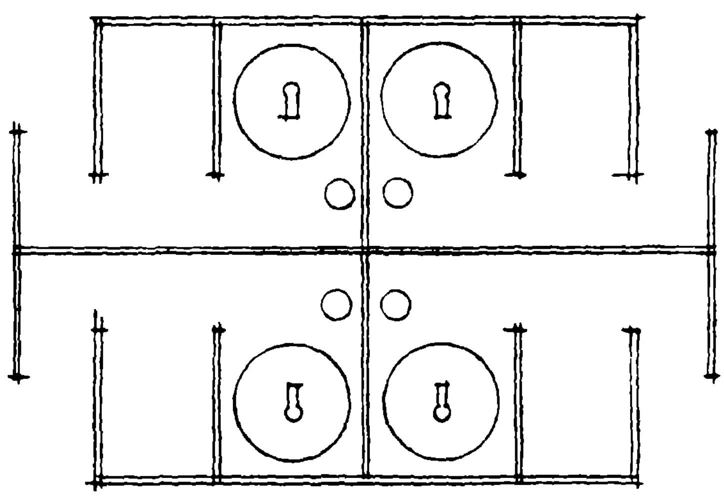
Dimensions are in metres.



Latrine alone



Latrine and bath

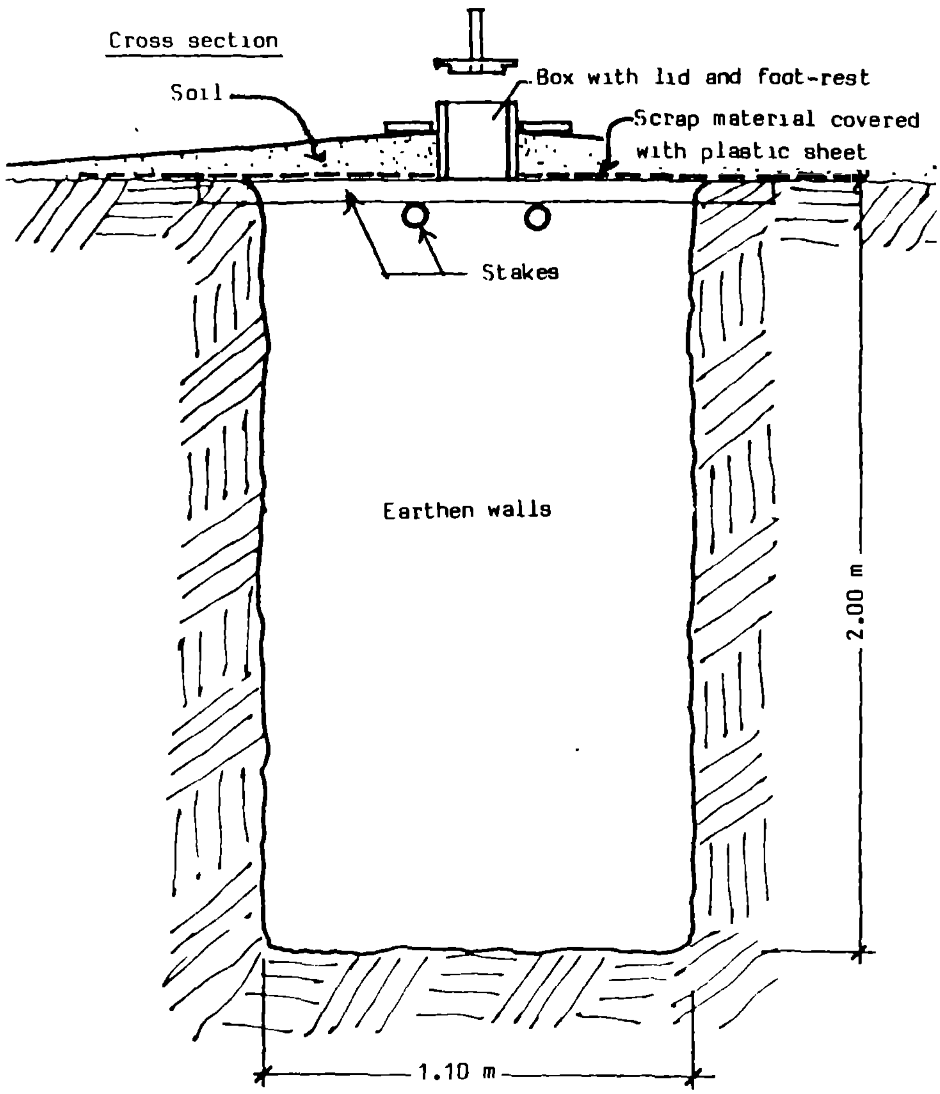


Set of 4 units

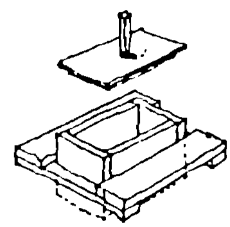
Note: For type S1 to S3 slabs, the diameter should be 1.5 m not as shown.

Latrine Type 50 Improved Traditional Latrine

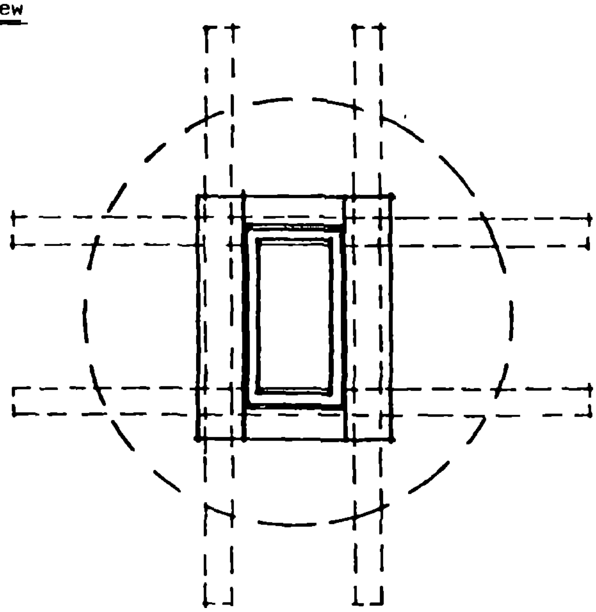
Cross section



Perspective of box with lid and foot-rest



Top view



Type: Improved traditional pit

Soil: Stable

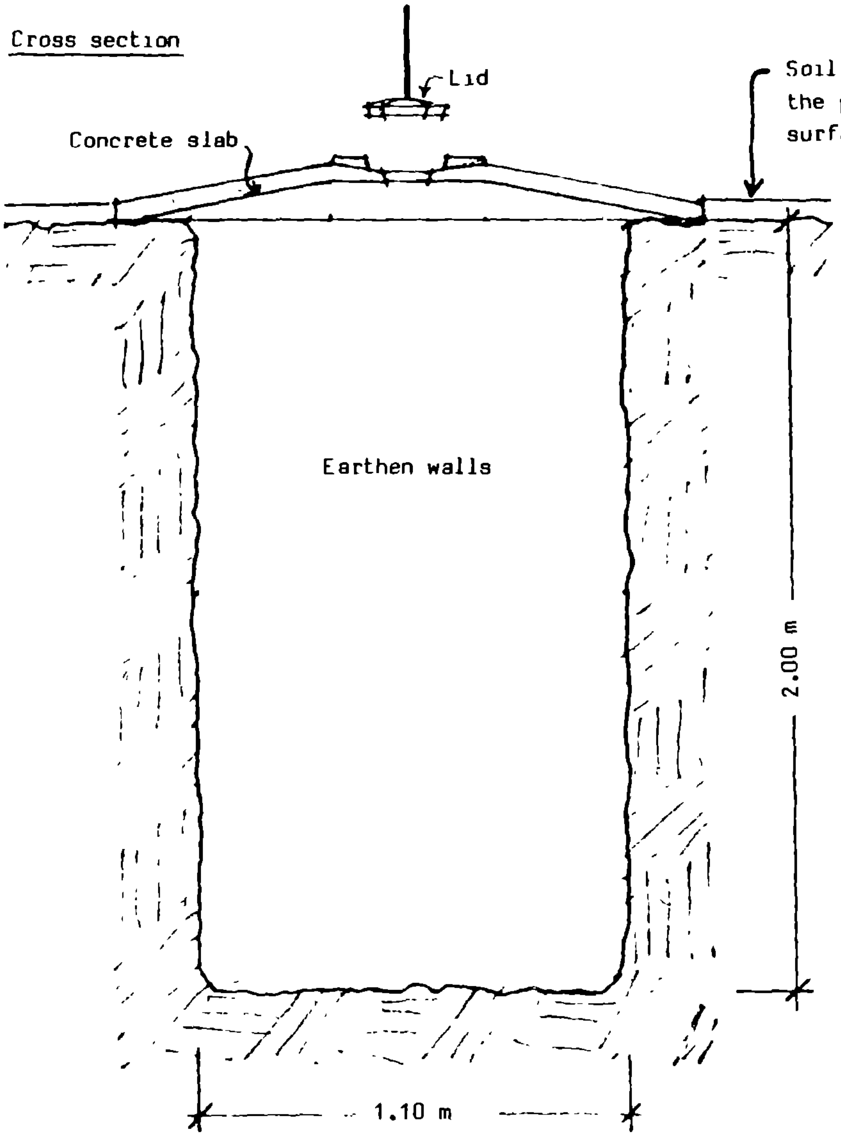
Water table: 3 m or more

Useful volume: 1.70 m^3

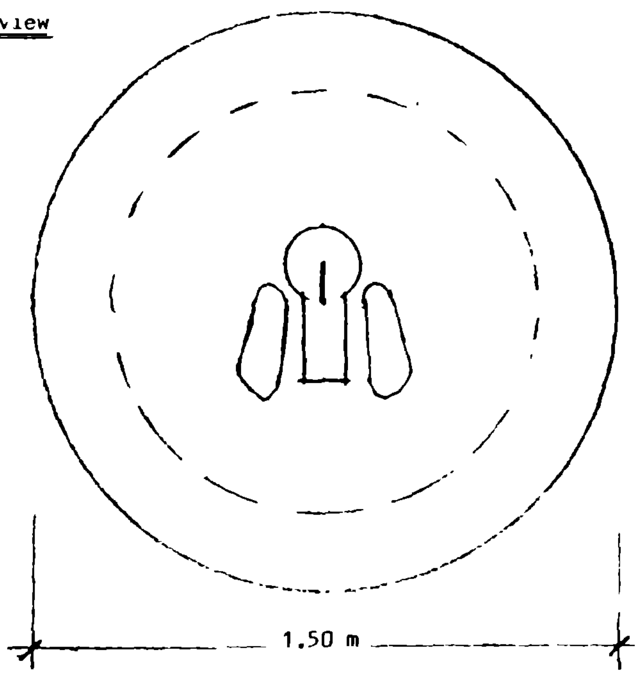
Useful life: 11 years per 5 persons (if wooden parts are not destroyed by rot and termites)

Latrine Type S1 for Stable Soil

Cross section



Top view



Type: Earth pit

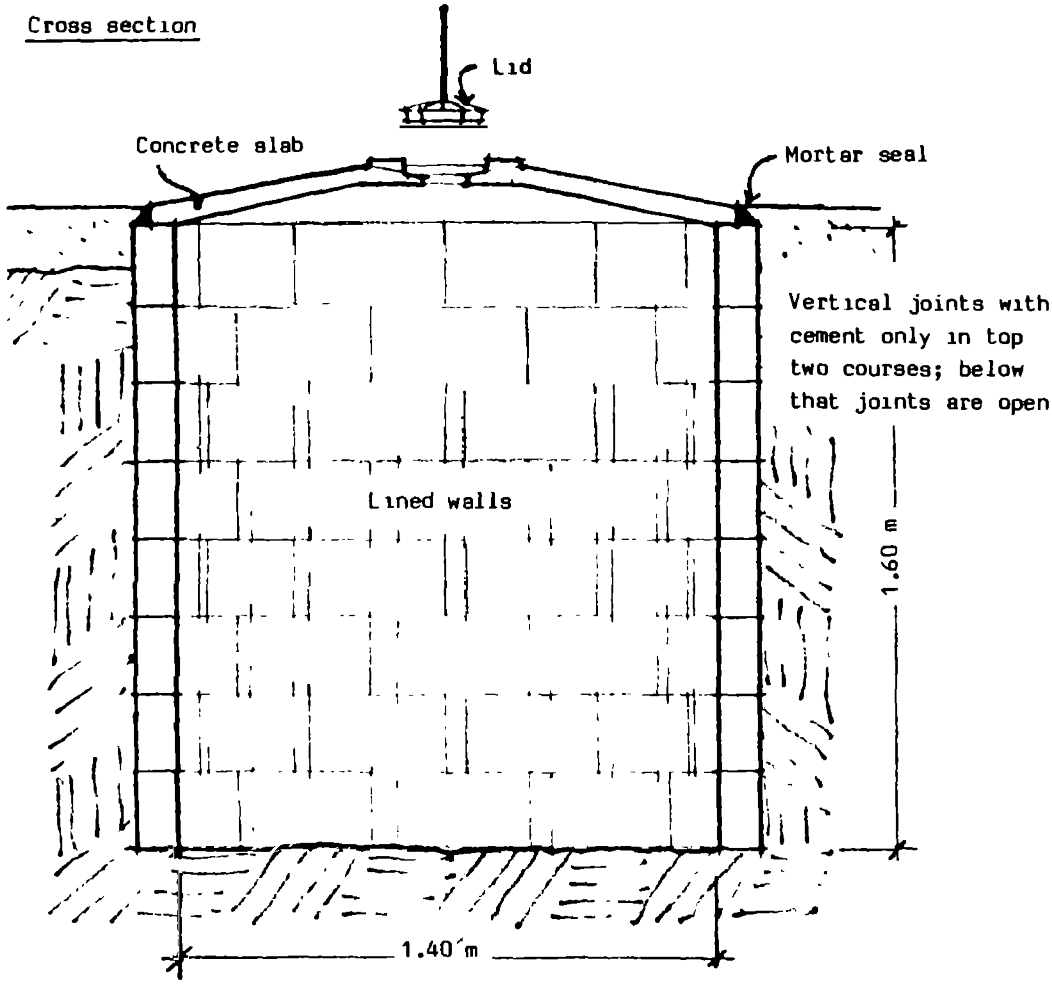
Soil: Stable

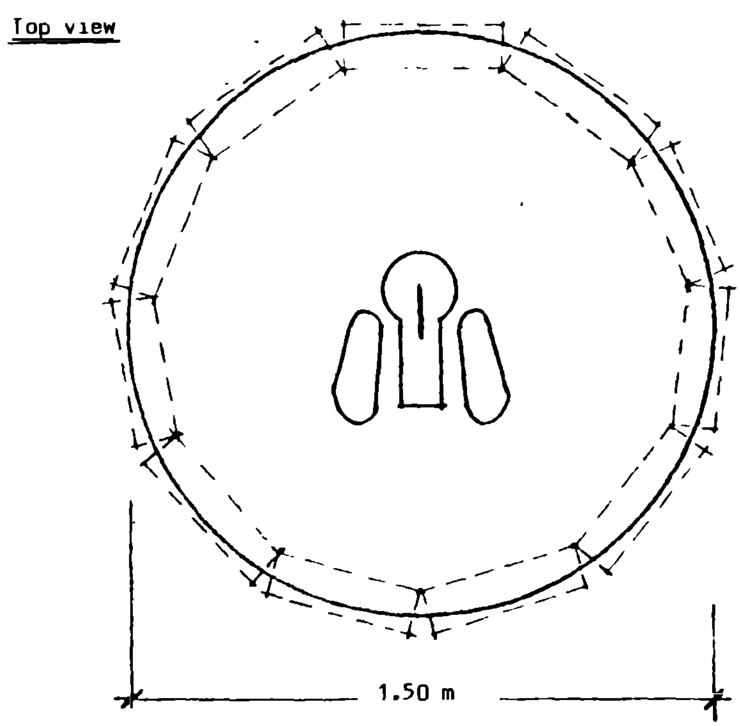
Water table: 3 m or more

Useful volume: 1.70 m^3

Useful life: 11 years per 5 persons

Latrine Type S2 for Less Stable Soil





Type: Lined pit

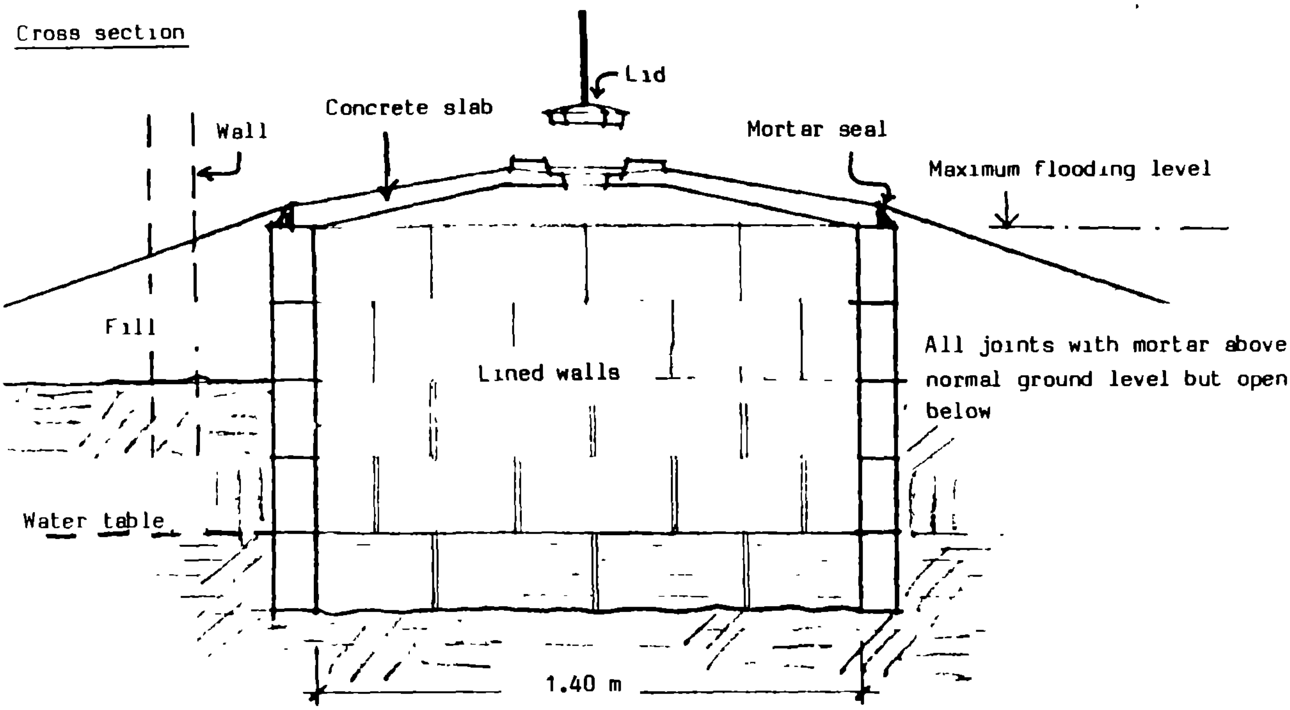
Soil: Less stable

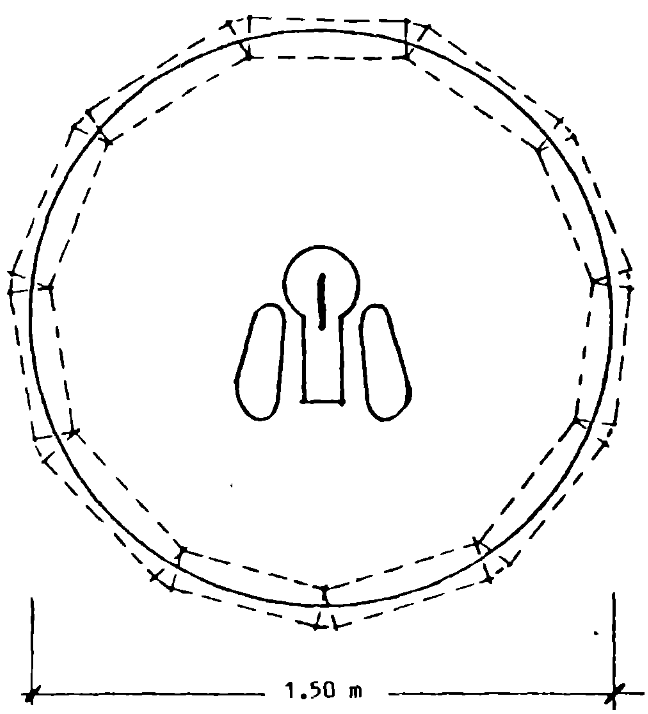
Water table: 2.4 m or more

Useful volume: 2.20 m^3

Useful life: 14 years per 5 persons; can be increased if the pit is made deeper and wider at the bottom

Latrine Type S3 Elevated Latrine





Type: Elevated pit

Soil: Less stable

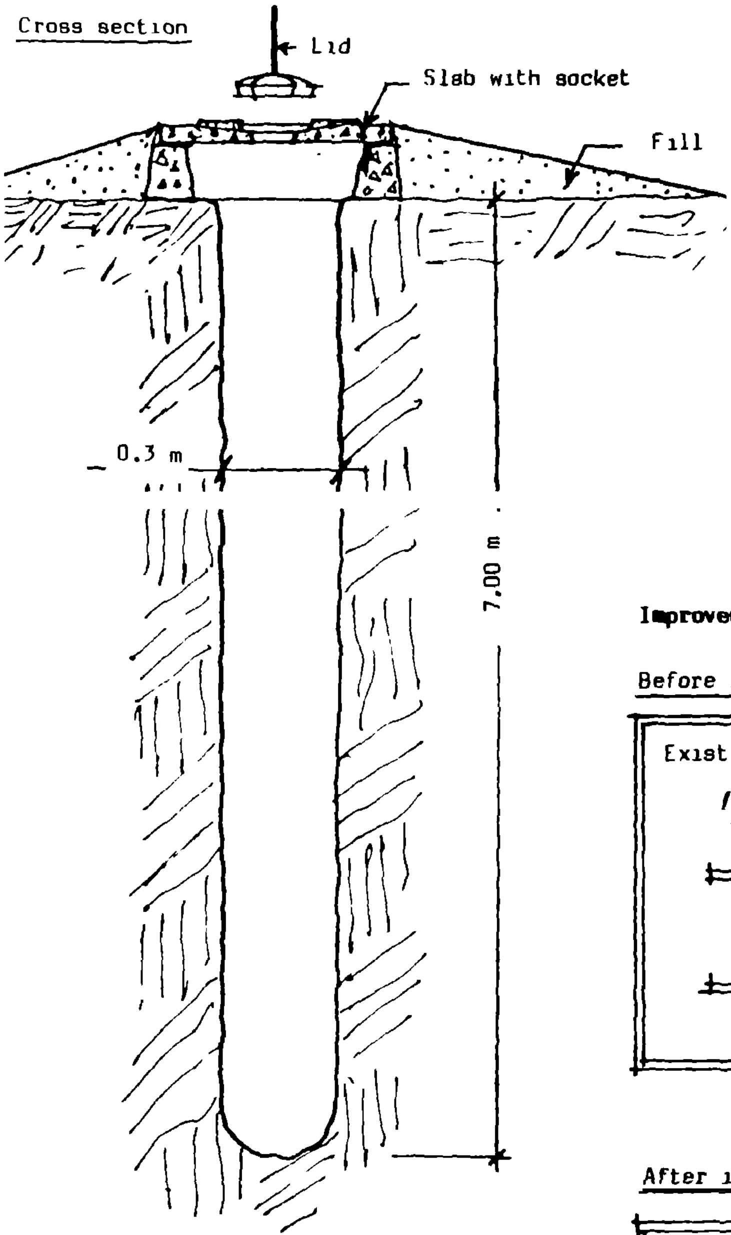
Water table: Very high (ground water not for domestic use)

Useful volume: 1.2° m^3

Useful life: 8 years per 5 persons but possibly more as the water may cause better digestion of the contents

Latrine Type S4 Bore-Hole Latrine

Cross section



Type: Bore-hole pit

Soil: Stable sand (stoneless)

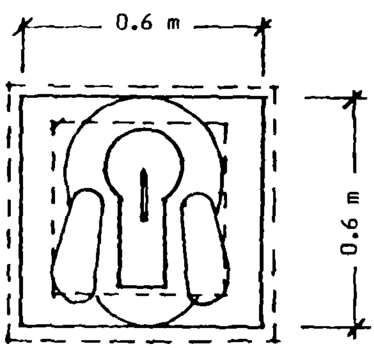
Water table: 8 m or more

Useful volume: $0.5\ m^3$

Useful life: 1 year per 5 persons

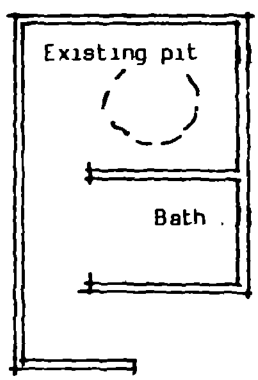
Note: Because the smaller diameter gives little compaction of the contents, the rate of accumulation is higher.

Top view

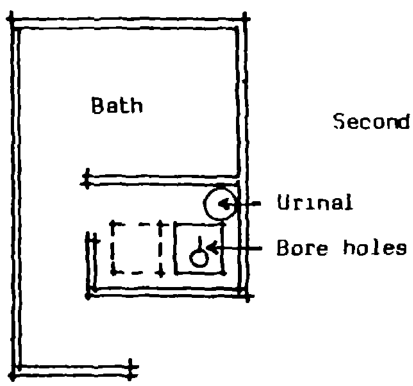


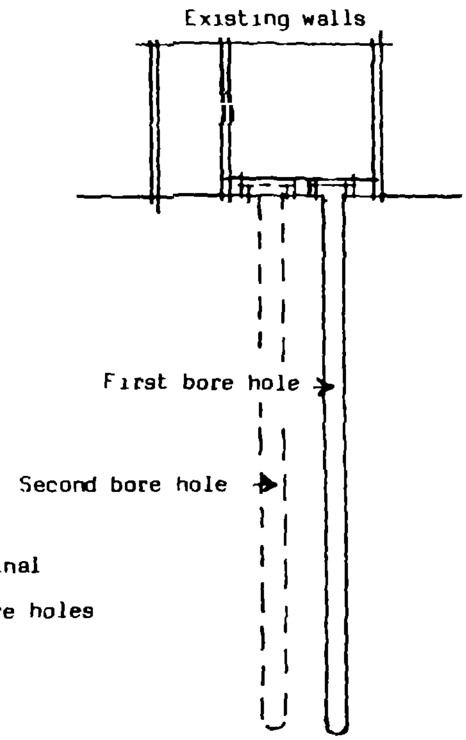
Improvement of an existing latrine

Before improvement



After improvement



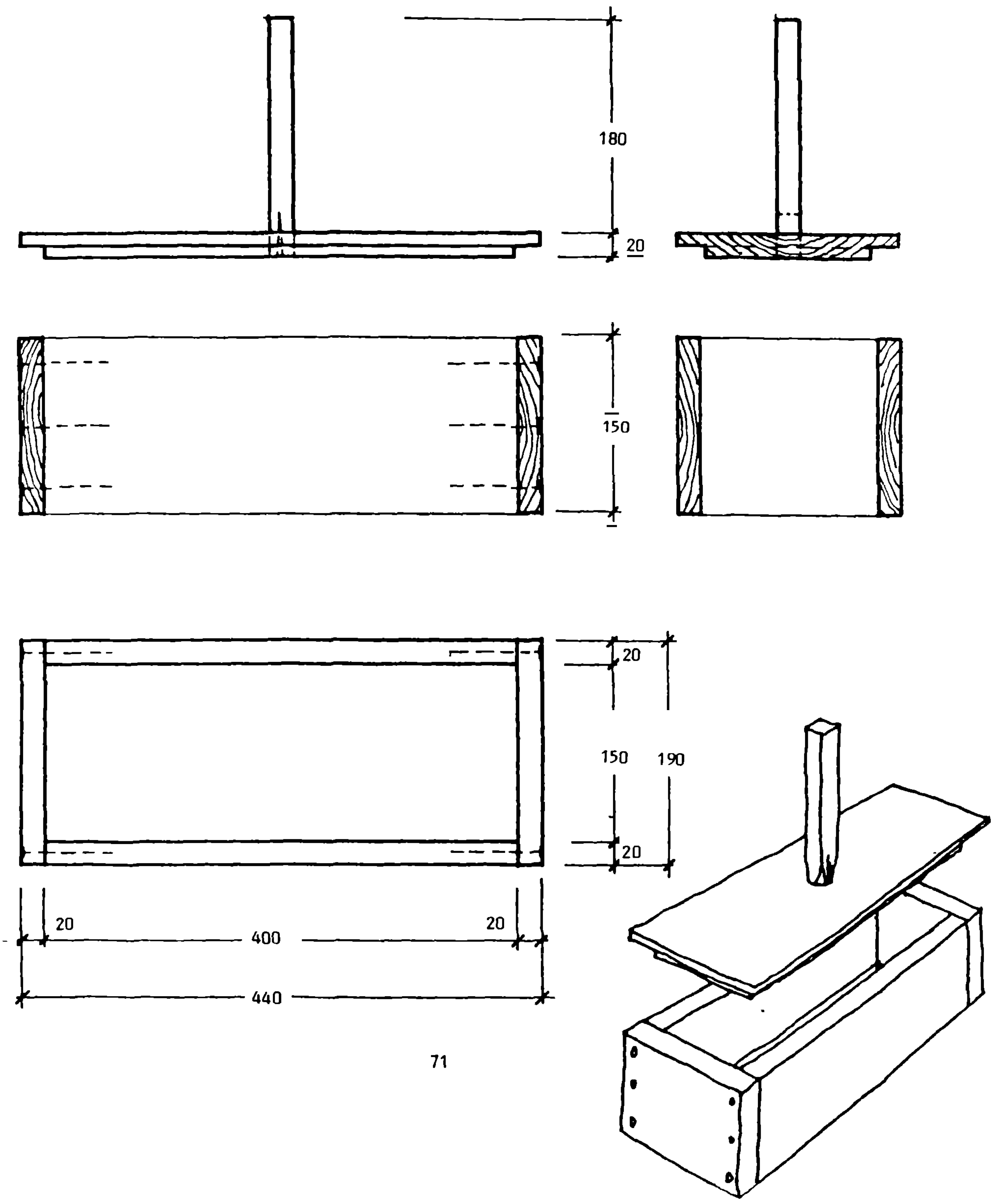


Hole-box With Lid for Latrine Type SO

Measurements in millimetres

Material: Well dried wood of any quality, treated with motor oil diluted with diesel oil (1 + 1).

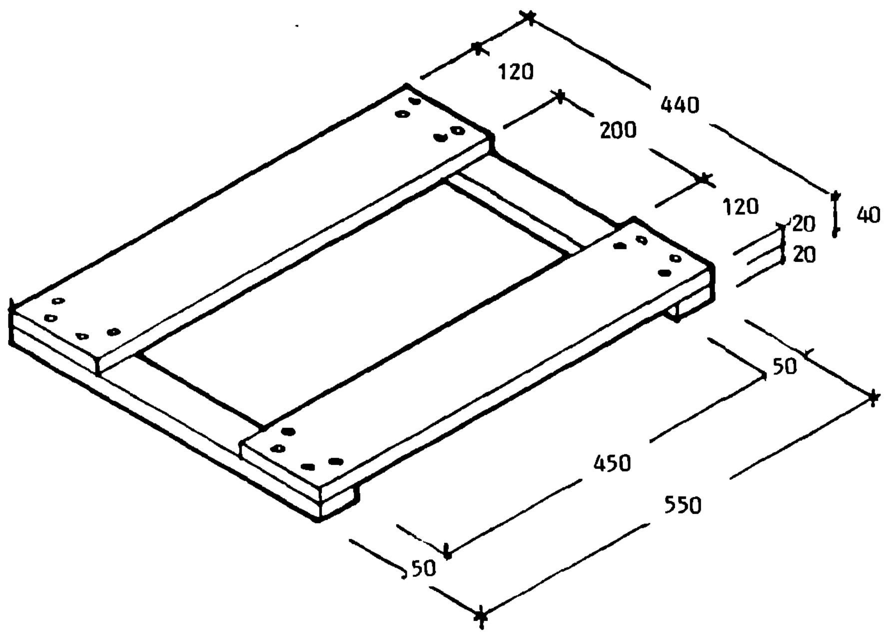
Handle should be firmly fixed with wedge from the bottom to ensure that it does not come out.



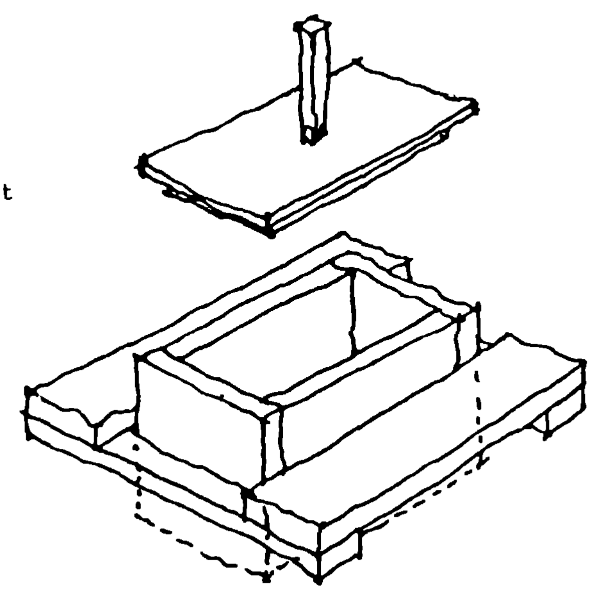
Foot-rest Frame for Latrine Type SO

Measurements in millimetres

Material: Wood of any quality treated with motor oil diluted (1 : 1) or with diesel oil.

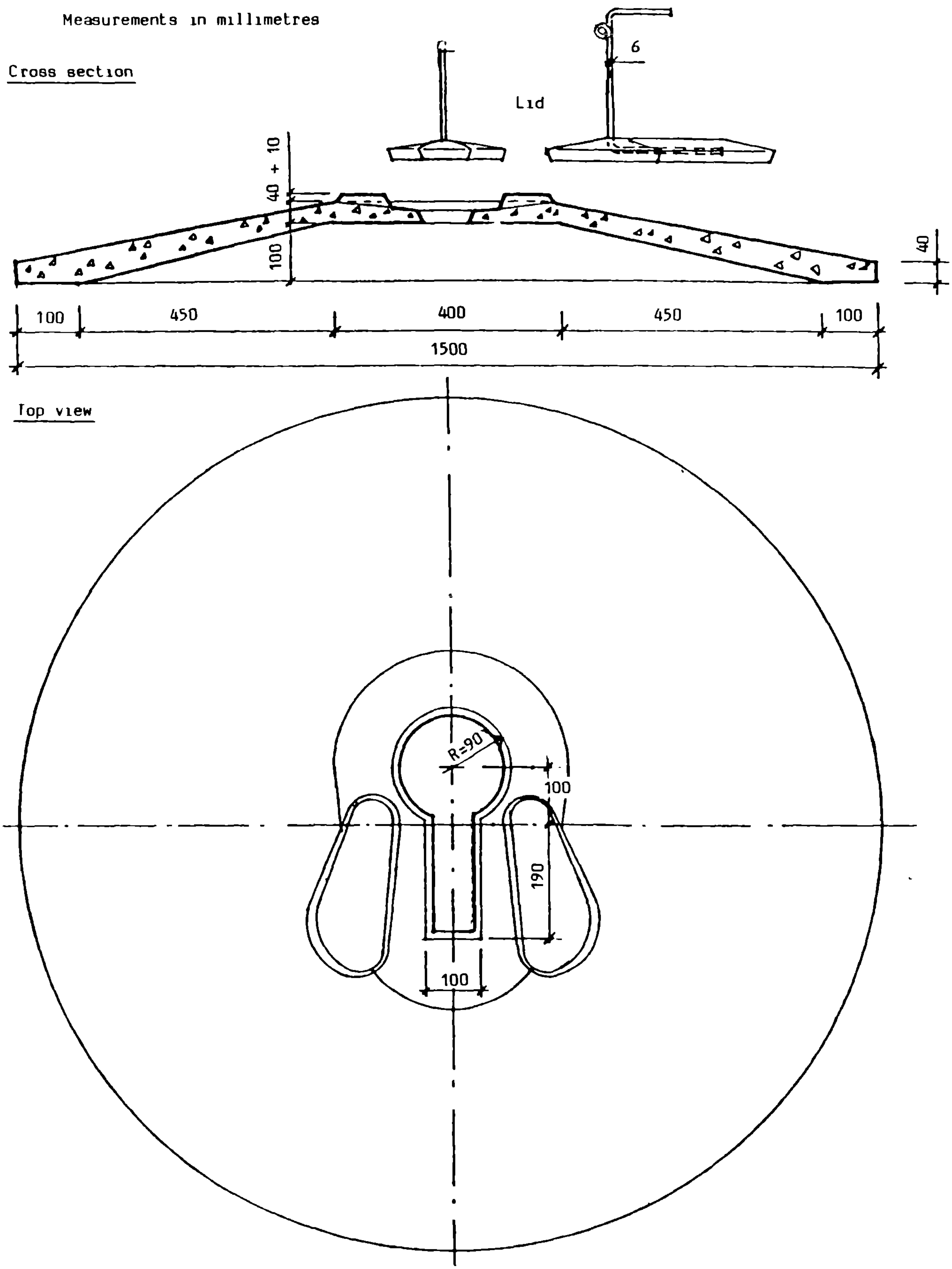


Note: The frame should fit easily around the wooden box.



1.50-m-Diameter Nonreinforced Concrete Slab for S1-S3 Latrines

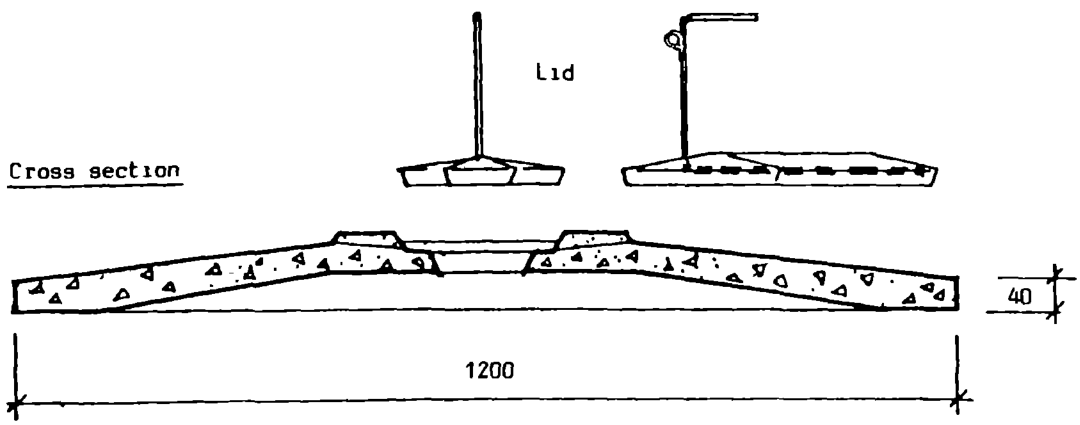
Measurements in millimetres



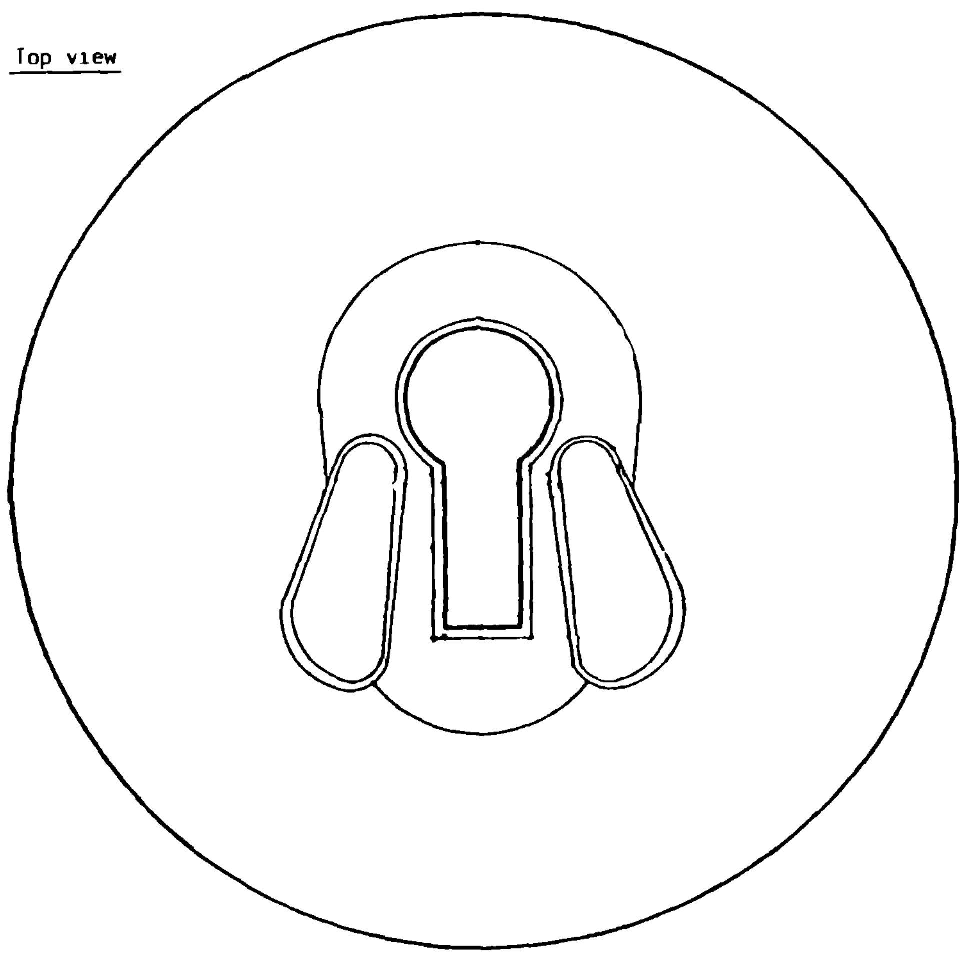
1.20-m-Diameter Nonreinforced Concrete Slab for S2 Latrines

Measurements in millimetres

Cross section



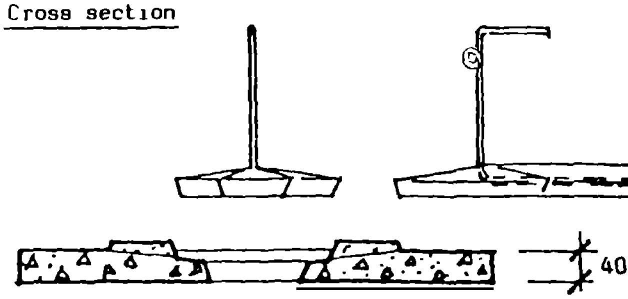
Top view

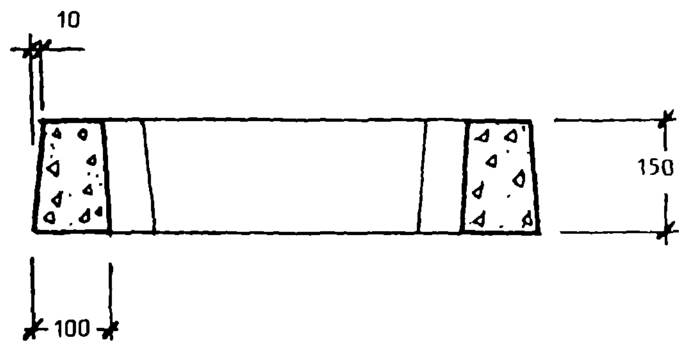


60-cm-Square Nonreinforced Concrete Slab and Base for S4 Bore-hole Latrine

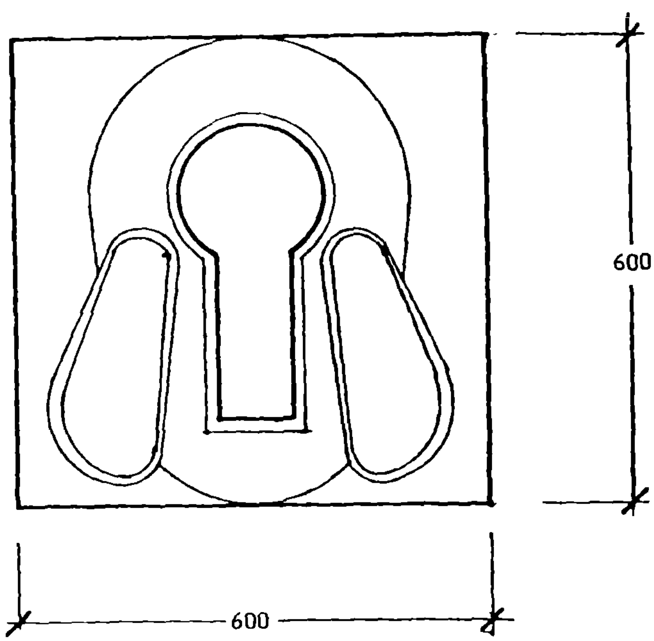
Measurements in millimetres

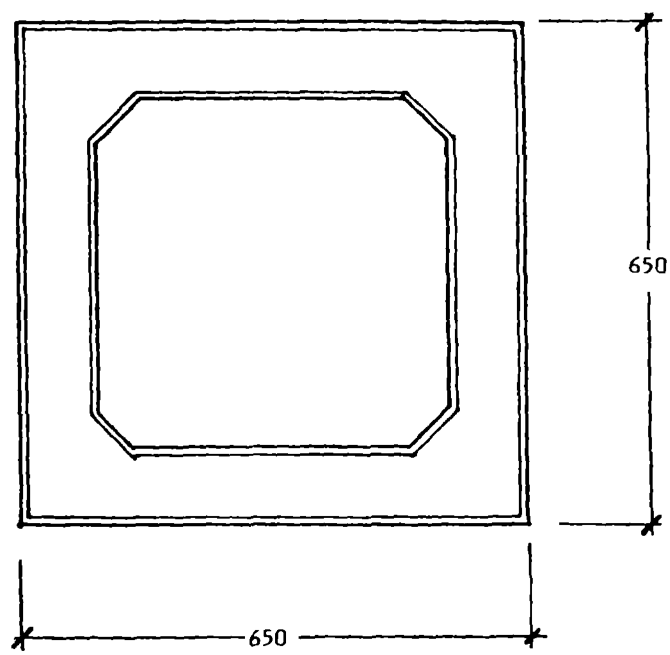
Cross section





Top view





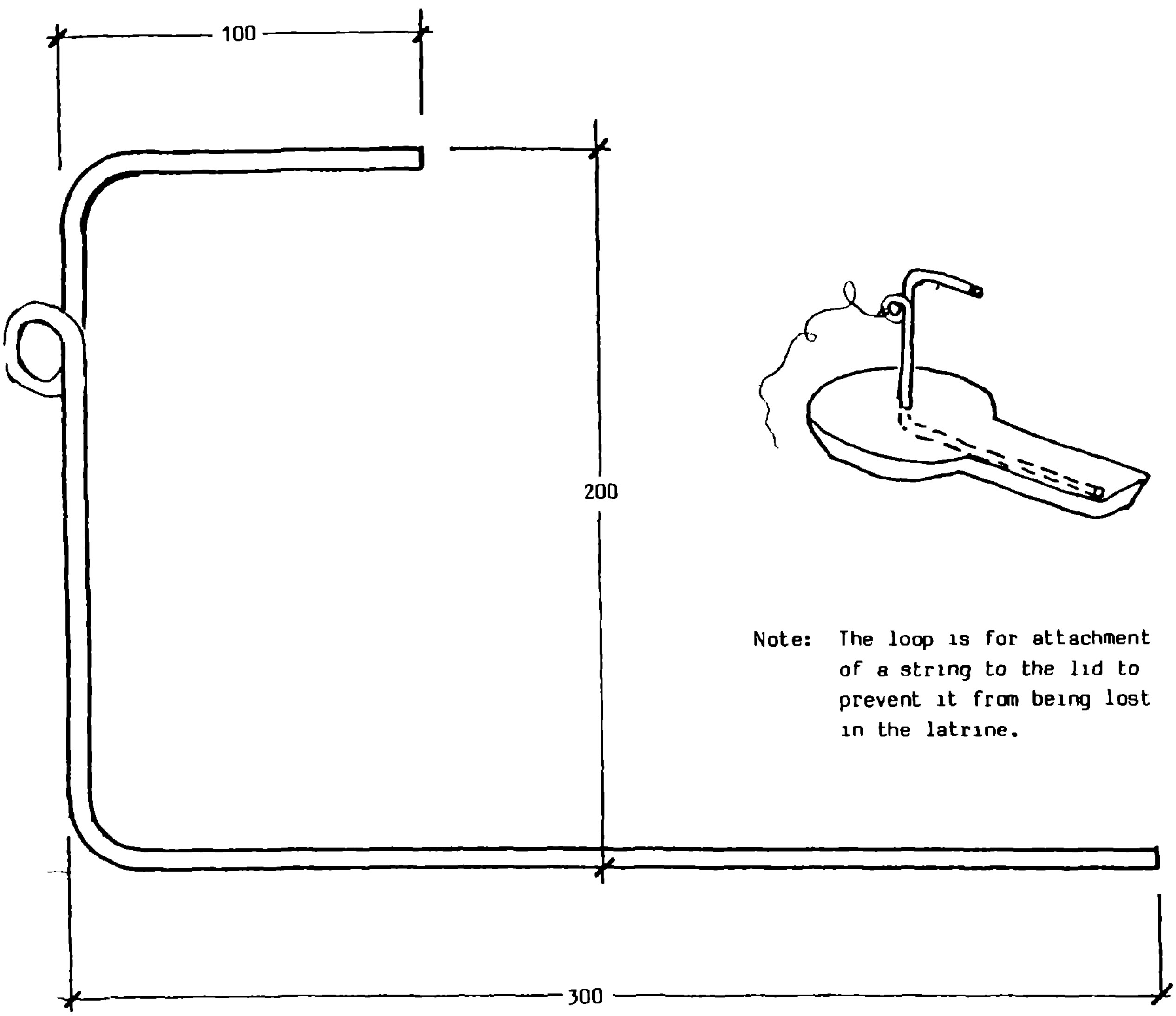
Slab

Base

Handle for the Lid

Measurements in millimetres

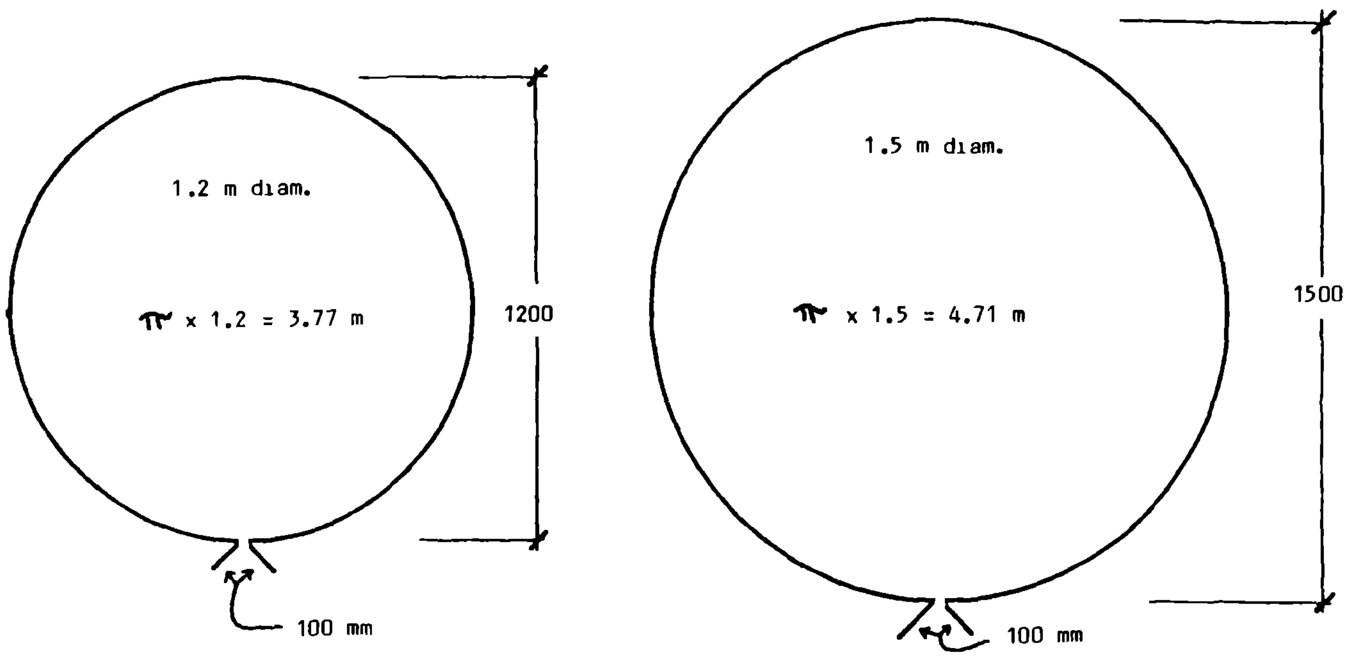
Material: Reinforcing iron 6-mm diameter; total length 700 mm



Note: The loop is for attachment of a string to the lid to prevent it from being lost in the latrine.

Peripheral Sheet Metal Moulds

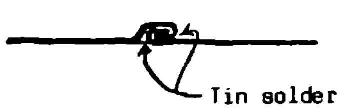
Material: Preferably 1.0 mm galvanized sheet metal



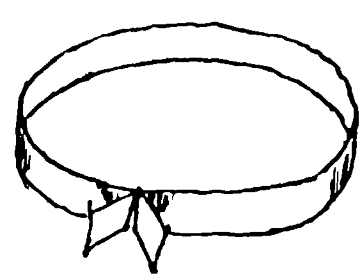
Note: To achieve the necessary length, the sheet metal normally needs to be joined. This is normally done as "hook-lapping". As the lifetime of the mould normally depends on the joints, the laps must be as small as possible, well hammered, and preferably soldered.

Measurements (in millimetres) for cutting and bending

1.20-m mould: Cutting 100 X 3970. Bending 100 + 3770 + 100
1.50-m mould: Cutting 100 X 4910. Bending 100 + 4710 + 100



Hook lap

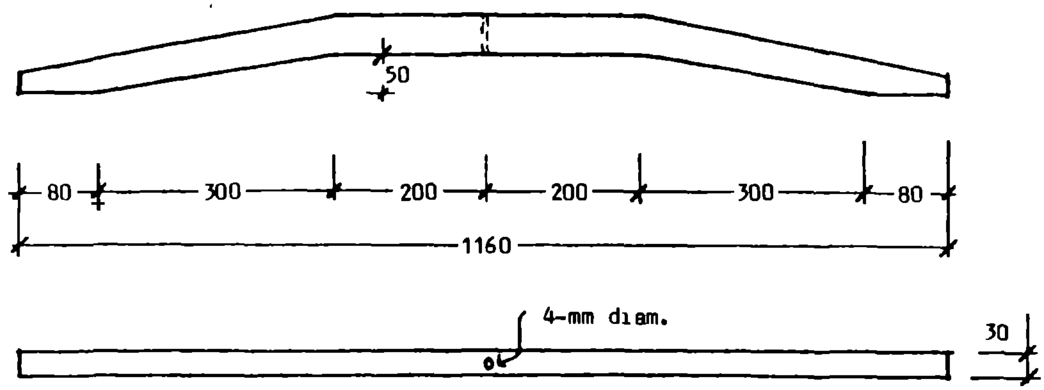


Rotating Arch Formers

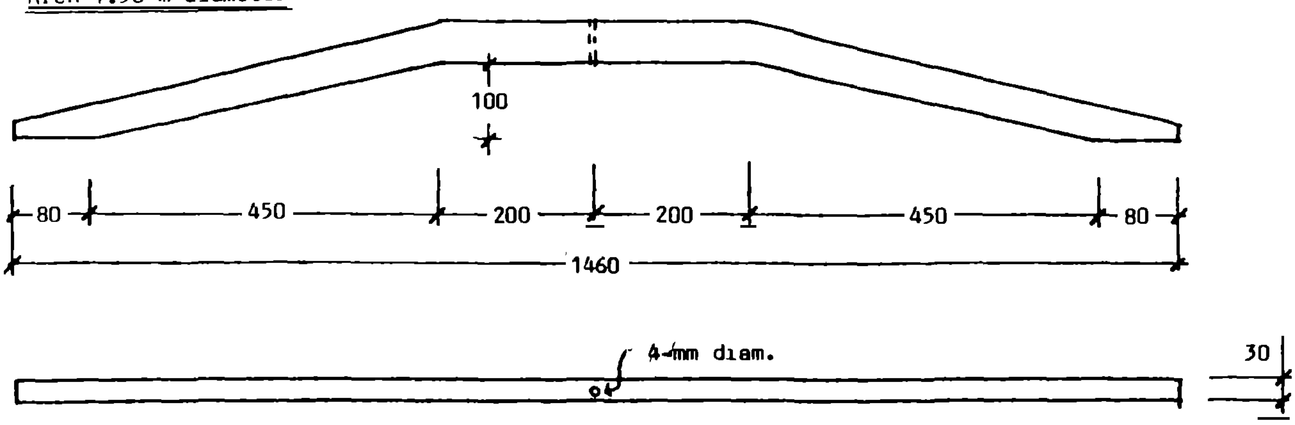
Measurements in millimetres

Material: Preferably hardwood

Arch 1.20-m diameter



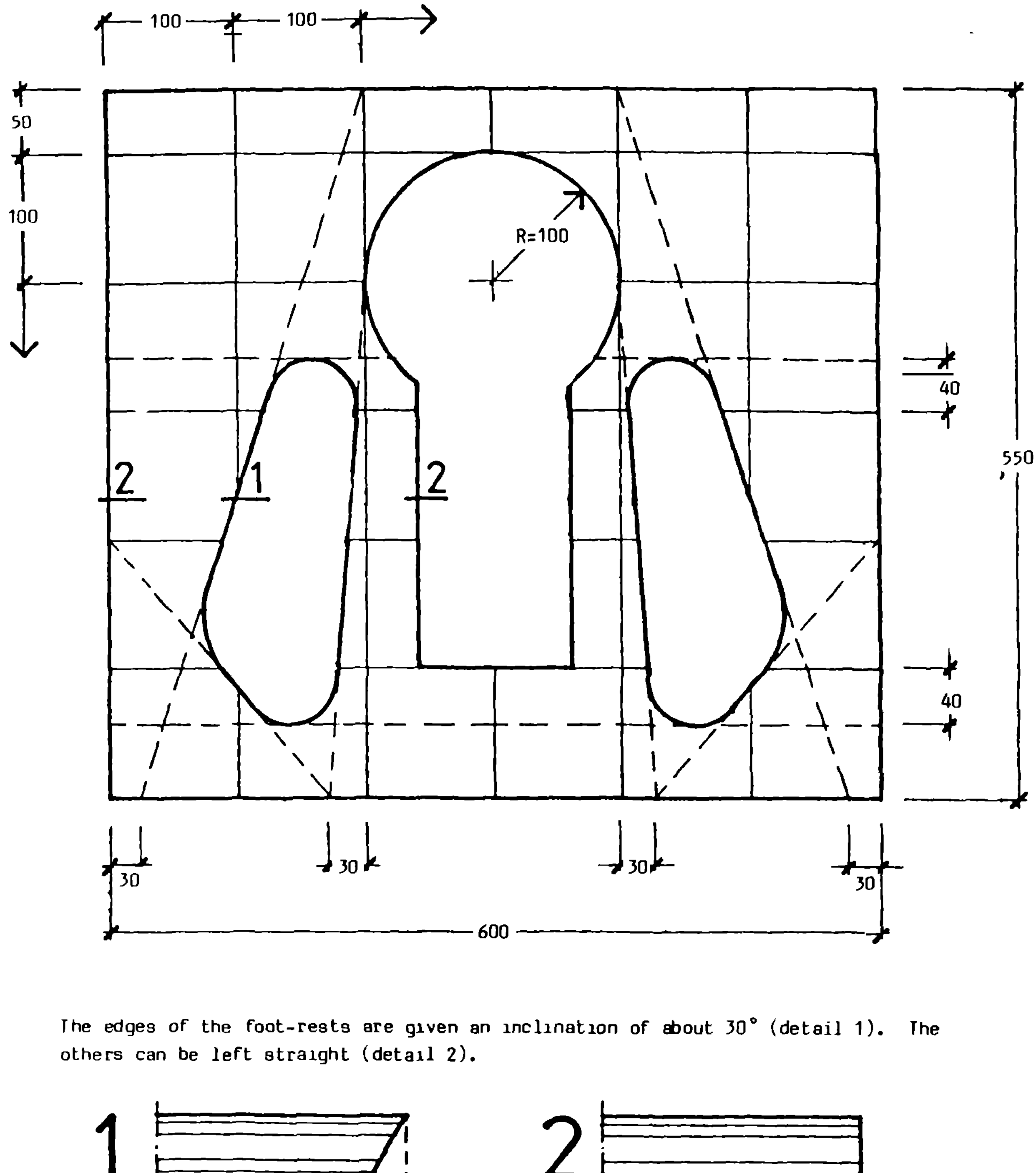
Arch 1.50-m diameter



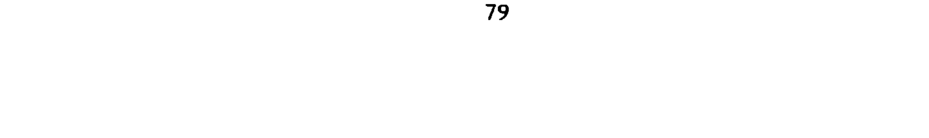
The Foot-Rest Mould

Measurements in millimetres

Material: Preferably 10 mm water-resistant plywood. If treated regularly with motor oil, a nonwater-resistant quality will do.



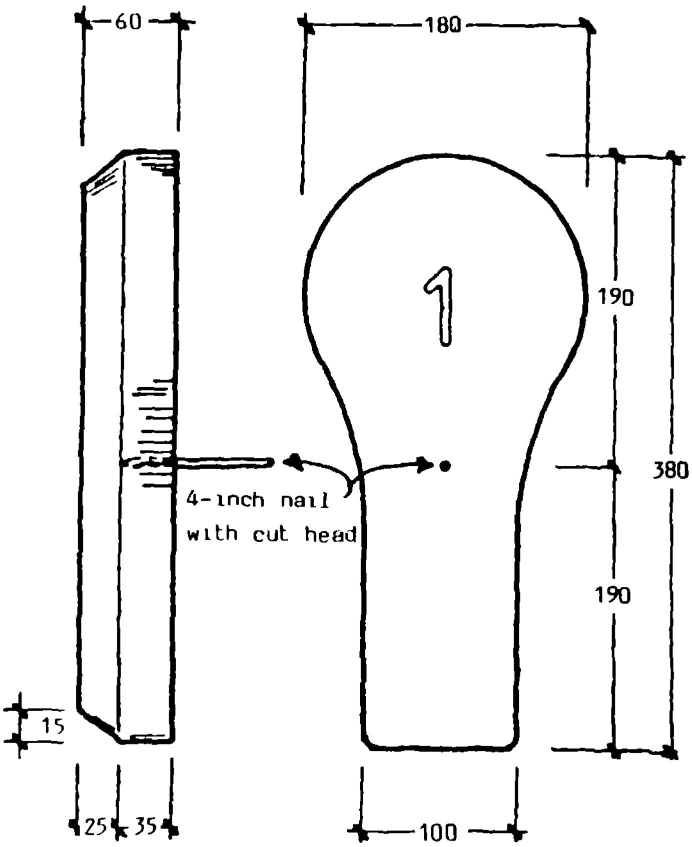
The edges of the foot-rests are given an inclination of about 30° (detail 1). The others can be left straight (detail 2).



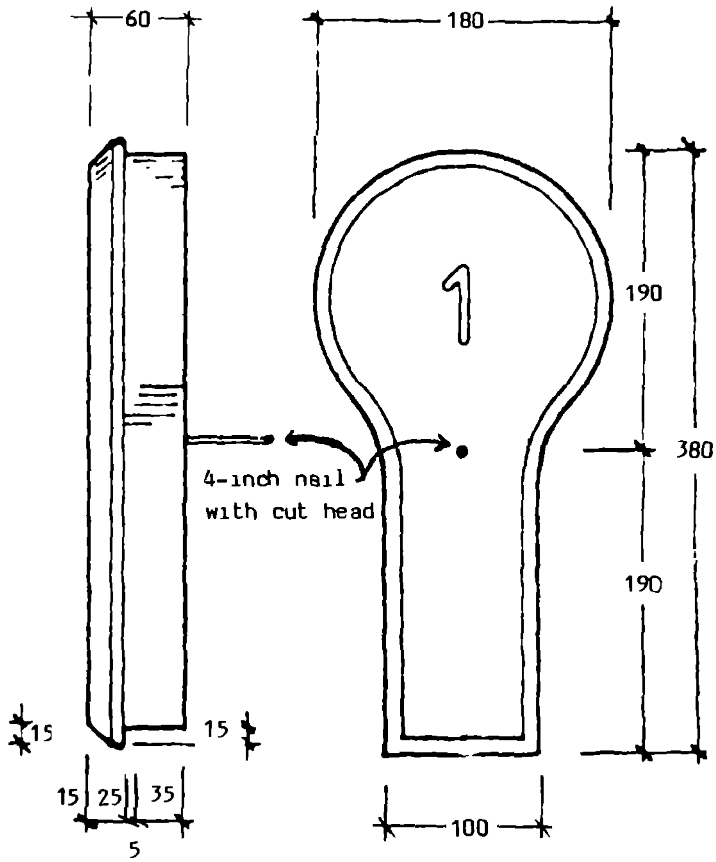
Hole Moulds

Measurements in millimetres

Material: Preferably hardwood (right) but softwood can be used (left) where carpentry machinery is not available and the mould must be made by hand.



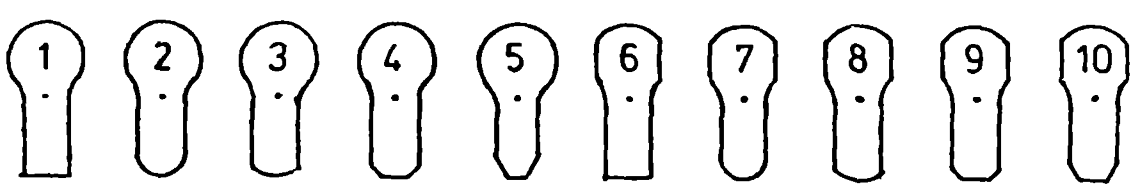
Softwood Mould



Hardwood Mould

A workshop with a reasonable production of slabs will need more than one hole mould because a lid will not fit exactly in a slab made with a different mould. So that the lid fits perfectly, each hole mould used is made with a small noticeable difference. Thus one can always find the lid that fits exactly into the hole of the slab.

Numbers help to identify the different moulds.



Appendix B

PRODUCTION OF THIN LATRINE SLABS OF NONREINFORCED CONCRETE

This appendix shows how slabs are cast, complete with lids and foot-rests, and how they are tested and transported.

The photos were taken while the method was being developed. In a few cases, the photos show old models of moulds and handles. The drawings in Appendix A show the final design.

Complete latrines are presented in Appendix A "Latrine types and their prefabricated elements".

Fig. A-1 The sheet-metal mould is placed on flat ground, and the ends are fixed with a piece of string or iron wire.

Fig. A-2 The hole mould is placed in the centre of a heap of sand.

Fig. A-4 More sand is placed in the mould, and the arch is rotated to produce the bottom form of the slab.

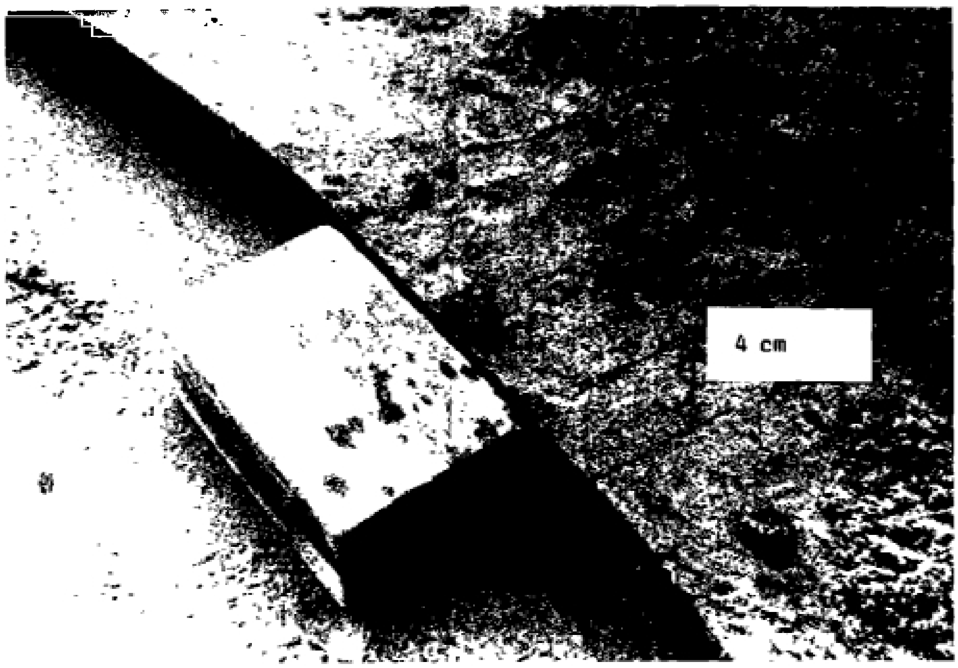


Fig. A-5 The height of the sheet-metal mould is checked with a piece of wood of the required size. In this case, the correct height is 4 cm.

Fig. A-6 The sand is covered with paper from cement bags or newspapers. (The scissors are not absolutely necessary.)

Fig. A-7 While the mould is being prepared, the concrete is mixed in the proportions 1.5 : 3 : 2 cement, river sand, and 0.5-inch stone respectively. These volumes are measured with a bucket. However, the proportions should be tested at new workshops as the composition of the sand can differ from place to place. The stone often contains sand so that proportions may have to be adjusted.

Fig. A-8 The concrete is carefully spread over the sand between the hole mould and the sheet-metal, leveled off, and compacted with a piece of wood.

Fig. A-9 The inclination inwards around the hole is made by hand with a mason's trowel. Note that there should be a distinct inclination <u>inwards</u> to guarantee that fecal matter enters the pit at the time of cleaning. This is especially important at the rear part where the slab might be fouled by diarrhea.

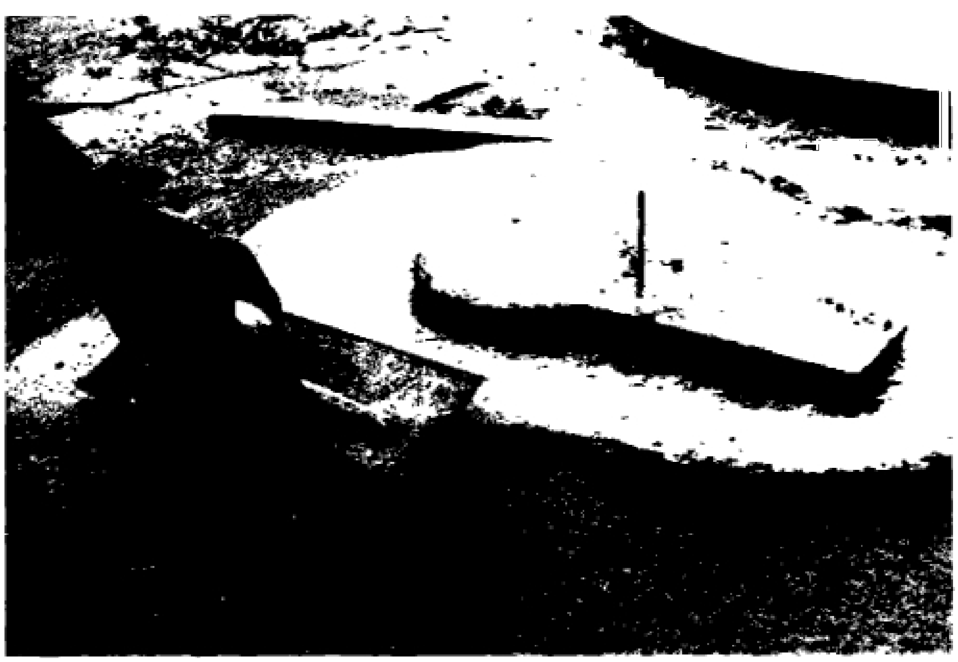


Fig. A-10 The surface of the slab is then smoothened out.

Fig. A-11 When the concrete has hardened a bit, the hole mould can be removed - this is made easier if the mould is tapped gently first.

Fig. A-12 To ensure the proper placement of the foot-rest, the foot-rest mould is centred carefully over the hole.

Fig. A-13 The surface is scratched to allow the cement to bond better.

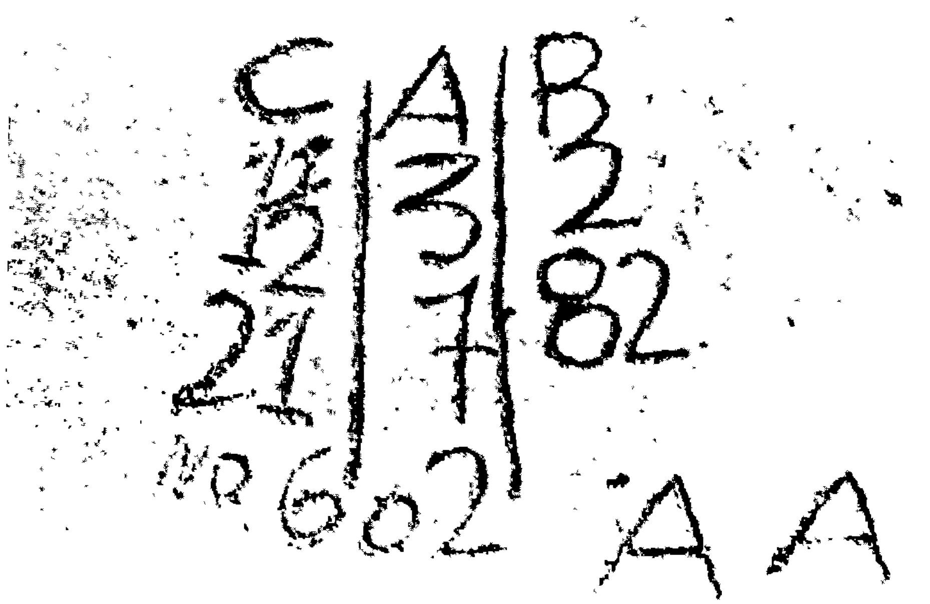


Fig. A-14 For record purposes and to identify errors in production, the following items are written in the fresh concrete: cement mixture (buckets of cement, river sand, and 0.5-inch stone), date of casting, and a continuous number, as a record of production and sale, and to identify the lid that is cast in the hole of the slab, and bears the same number. The initials of the mason identify the person responsible if there are any errors, and also encourage good craftsmanship. The number of the hole-mould is written "behind" the hole to help in replacing any lost lids.

Fig. A-15 To make a new slab, the sheet-metal mould is pulled up with a pair of pliers. It is then easy to make a new sand mould on top of the slab that is hardening.

Fig. A-16 By raising the mould, several slabs can be made one on top of another, casting a new one each day. After 1 week, the pile is dismantled to make the lids and foot-rests.

Fig. A-17 The lid is cast in the hole of the slab in which it is to be used. The iron is bent for the handle. The mason who made the slab also makes the lid and foot-rests. He then has a personal responsibility for the final product. As his initials are on the slab and the lid, any weaknesses in his work can be easily identified and corrected.

Fig. A-18 To prevent fresh concrete from sticking to the slab, wet paper is used. As the concrete is hardening, a groove is made (in the middle) to insert the handle.

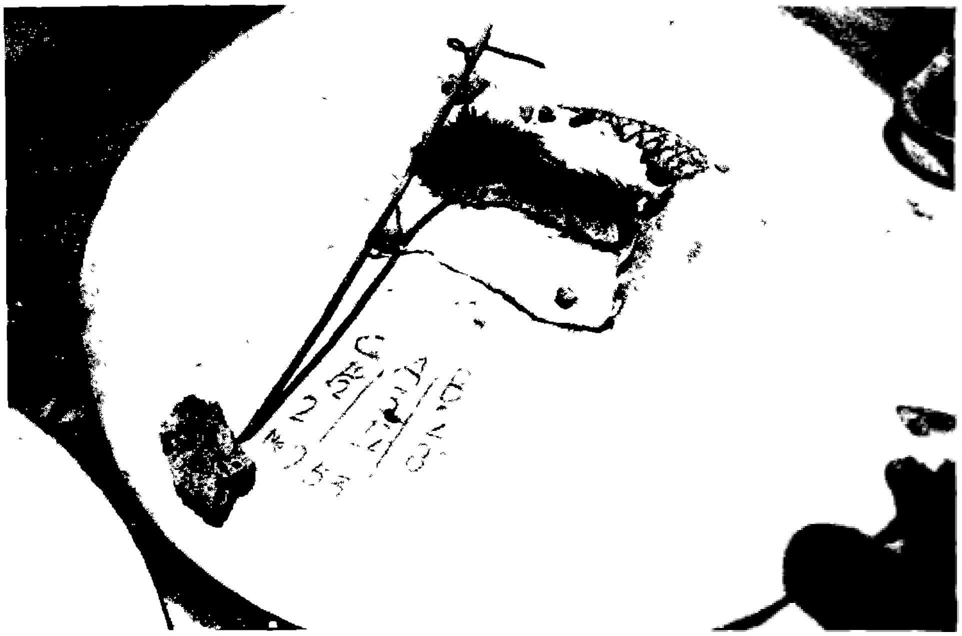


Fig. A-19 The iron base of the handle is placed in the groove and covered with cement. Here it is being supported with a piece of reed and a stone while the concrete sets.

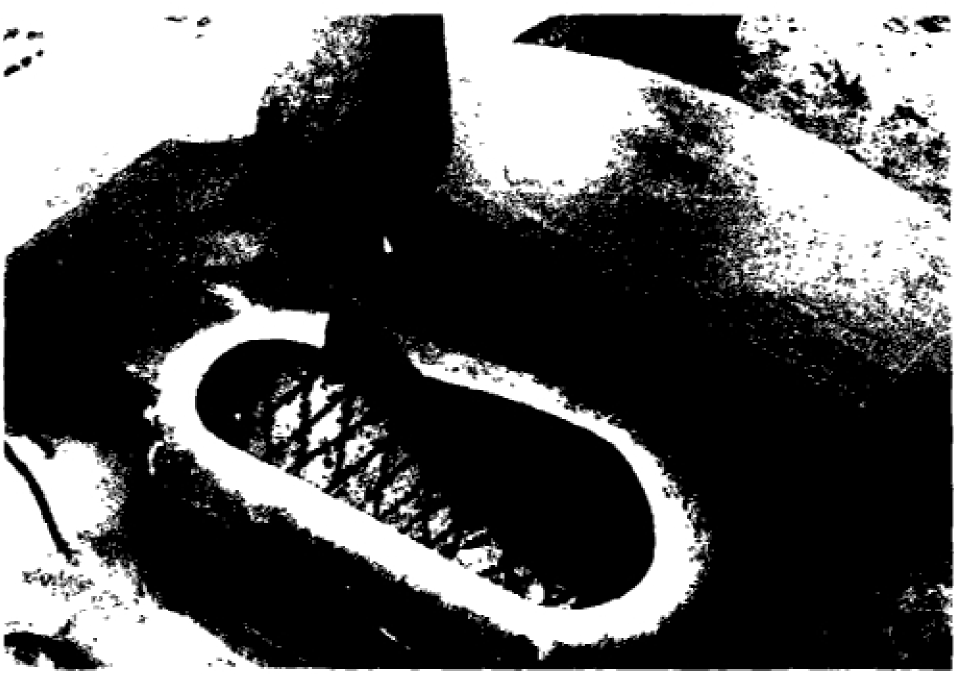


Fig. A-20 The foot-rests are made of stone-free cement mortar (1 part cement : 3 parts river sand). The mason starts by cleaning and wetting the scratched surface.

Fig. A-21 The foot-rest mould gives the correct form and position.

Fig. A-22 The mould can be taken away after a few minutes, but this must be done carefully so the cement does not lose its form.

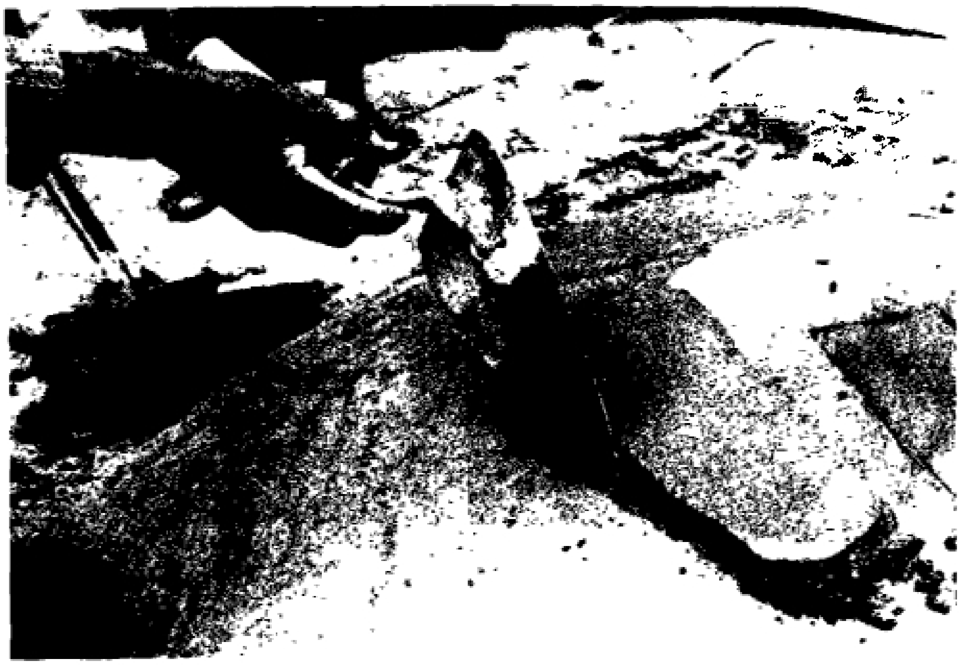


Fig. A-23 When the cement hardens a bit, the edges are smoothed.

Fig. A-24 After 1 week's curing, the latrine slab is ready for the security test. To do this, the slab is placed on four wooden wedges, and "loaded" with six persons standing in a line that runs between the wedges. Note: no one should stand over a supporting wedge.

Fig. A-25 Slabs are made in the mornings, and lids and foot-rests in the afternoons, from Tuesday to Friday. Mondays are for test loading of the previous production period and for internal transport of slabs. On Saturdays, the equipment is cleaned and checked. Slabs must be kept wet over the weekend. Slabs are not put in an upright position until security tested. This ensures that slabs are not sold until after test loading.

Fig. A-26 To transport the slab a two-wheeled cart is used. One man from the workshop accompanies the cart to ensure that it will be returned to the workshop.

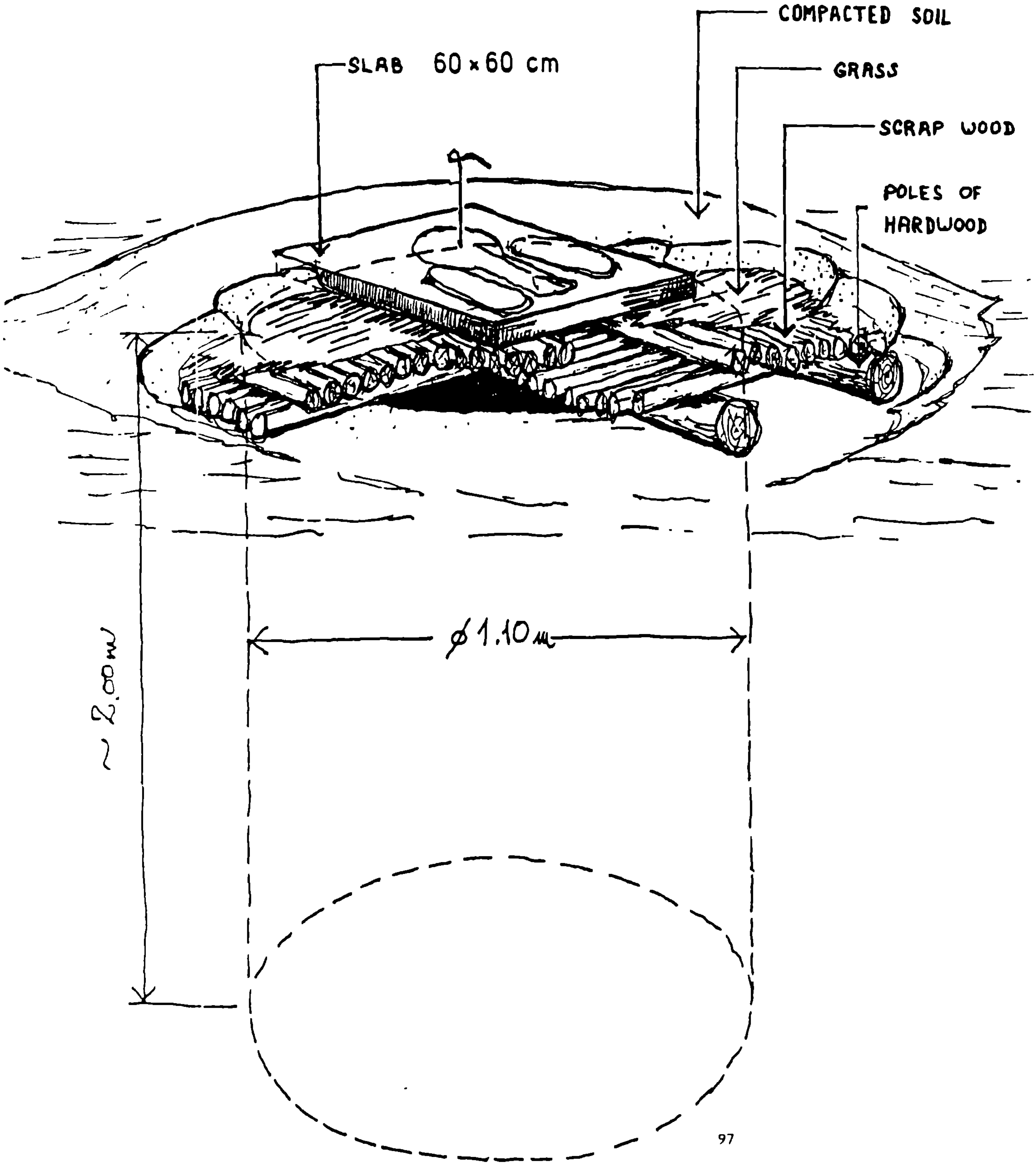
Fig. A-27 Here the slab is installed, ready to be used.

Appendix C

IMPROVED TRADITIONAL LATRINES

For rural areas and other places where it is difficult to install latrine workshops for casting round slabs, as illustrated in Appendix B, the smaller, 60 cm square slab (page 75) can be used to improve hygienic conditions for traditional latrines as an alternative to the "wooden box" (page 66 and pp 71-72).

IMPROVED TRADITIONIAL LATRINE FOR NORMAL SOIL



IMPROVED TRADITIONIAL LATRINE FOR HARD SOIL