Federal Democratic Republic of Ethiopia
Ministry of Health

On-site Household Latrine Technology Option Planning, Design, and Construction Manual

Federal Ministry of Health

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Addis Ababa, Ethiopia
November 2017

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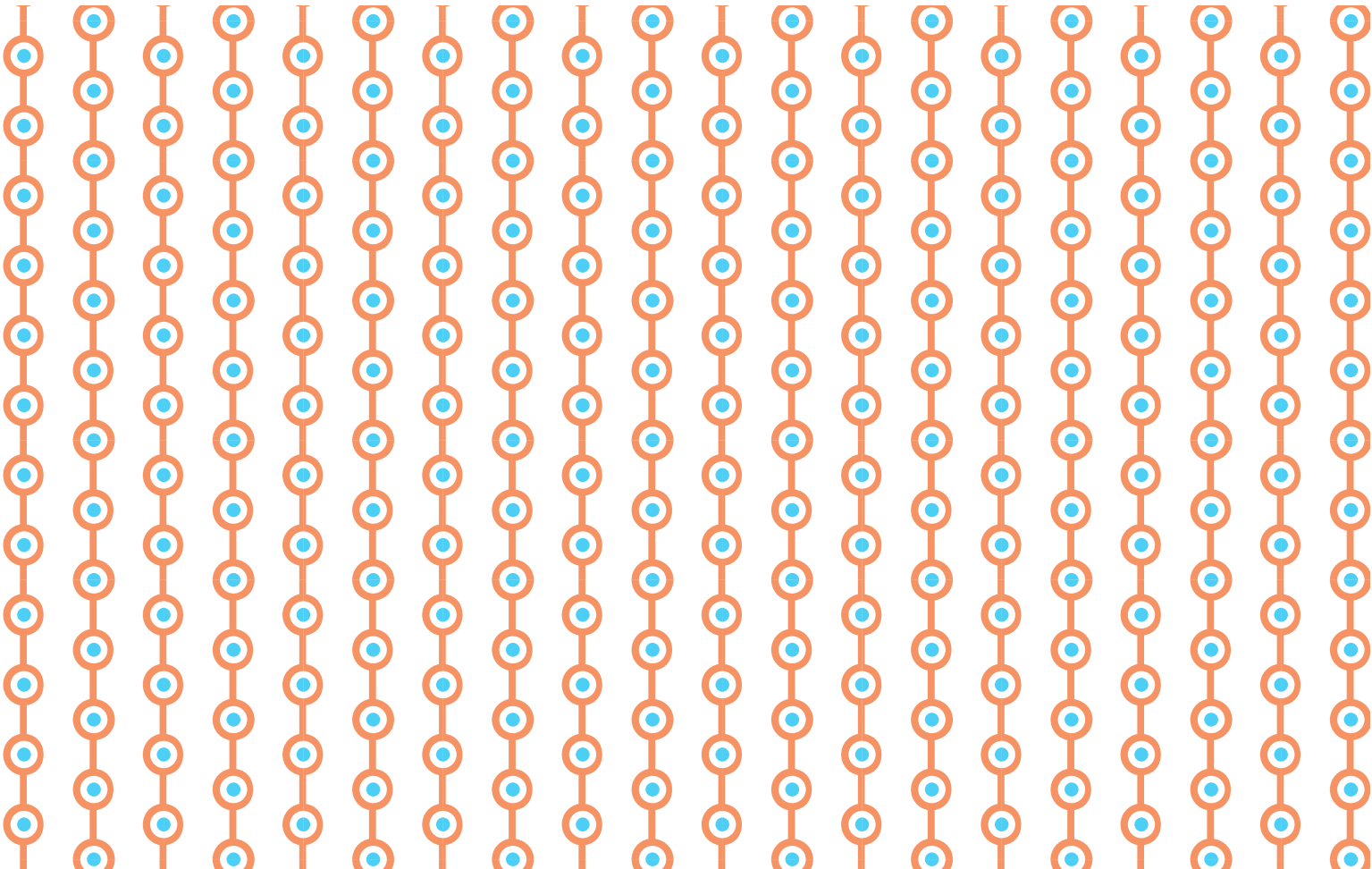

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Foreword

Sanitation is an indispensable element of everyone's life; hence, its availability improves the overall health status of communities and determines an individual's ability to lead a productive life. Every citizen has the right to live in a safe environment, and it is each citizen's responsibility to protect the environment from fecal contamination by using a safe latrine facility.

The FMoH is keen to translate this constitutional right of citizens into practice, and has developed policies, programs, and strategies that mitigate fecal contamination of the environment. The Hygiene and Environmental Health Program is a core element of the ministry's integrated primary health care services, and is being implemented using household- and community-based approaches. The government has also created a conducive environment for WASH sector engagement. Through its concerted efforts, as well as that of sector stakeholders, promising achievements in increasing households' access to basic sanitation facilities have been documented.

Ethiopia did not achieve the MDG sanitation targets, and access to improved sanitation facilities is as low as 28 percent in rural areas. Sanitation- and hygiene-related communicable diseases remain a top public health challenge, which indicates the need to improve the quality of sanitation hygiene services and bring about sustainable change in hygiene practices. Improvement in sanitation services can only be made possible by supporting households' move up to the next sanitation ladder, using sanitation marketing approaches and sustainable behavioral change communication.

The FMoH is taking the promotion of improved sanitation forward. It is implementing sanitation marketing strategies and has completed the development of hygiene and environmental health behavioral communication guidelines. It has also finalized this complementary manual for the planning, design, and construction of on-site household latrine technology options.

This manual aims to provide step-by-step guidance for households to make informed decisions about affordable latrine technologies that are appropriate to local soil formation. The manual also serves entrepreneurs who provide sanitation products and services; stakeholders engaged in hygiene and sanitation promotion; and trainers of entrepreneurs.

Therefore, it is believed that this manual is a living document that will solve the technical and environmental challenges that households face regarding the sustainable use of sanitation facilities, and improve the quality of the household sanitation facility.

Finally, the MoH is fully committed to making sure this manual is used by all sanitation and hygiene stakeholders, and calls upon the private sector, entrepreneurs, and development partner organizations to use the manual consistently to promote improvement in the quality of sanitation facilities across the country.

H.E. Dr. Kebede Worku
State Minister of Health

Acronyms

CIS	Corrugated Iron Sheet
CLTSH	Community Led Total Sanitation and Hygiene
EDHS	Ethiopian Demographic and Health Survey
FMoH	Federal Ministry of Health
GOE	Government of Ethiopia
GTP-II	Growth and Transformation Plan-II
HC	Health Center
HEP	Health Extension Program
HEW	Health Extension Workers
HSTP	Health Sector Transformation Plan
IRT	Integrated Refresher Training
JMP	Joint Monitoring Program
LTO	Latrine Technology Option
OD	Open Defecation
ODF	Open Defecation Free
TVET	Technical and Vocational Education and Training
UNICEF	United Nations Children's Fund
WHO	World Health Organization

Operational definitions

Basic Unimproved Latrine
Sanitation facility that does not provide privacy or separate human excreta from human contact

Durable lining materials
Pit-lining materials that are not damaged by rotting, termites, or flood (e.g., stone, fired bricks, and reinforced concrete ring)

Highest ground water table
Ground water level after the end of the rainy season

Improved Latrine
Improved sanitation facilities are defined as a facility that provides privacy and separates human excreta from human contact

SanPlat Slab
Concrete slab without reinforcement bar

Static ground water table
Ground water level after the end of the dry season

Vertical separation
Distance between the bottom of the latrine pit and highest ground water table

1 Introduction

1.1 Background information

The Government of Ethiopia is committed to the promotion of community- and household-level hygiene and sanitation through its health extension program (HEP). As a result, promising results have been achieved and a large proportion (82 percent) of rural households have started to use basic latrines (EDHS 2011), while several villages and kebeles have managed to achieve primary open-defecation free (ODF) status. However, despite their high coverage, the existing basic unimproved household latrines[1] do not adequately remove feces from the environment or prevent contact with humans, and thus do not halt fecal-oral disease transmission.

Poor quality latrines have a lower lifespan and a higher ongoing maintenance cost. Several factors contribute to the short life span of unimproved latrines, such as their poor construction quality (likely because of the low profile given to the latrine compared to the dwelling house), which often leads to their collapse (as a result of loose soil), as well as termite and flooding problems. These factors consequently undermine other achievements in improving communities' health outcomes, and hinder households from moving up to the next sanitation ladder.

Cognizant of the challenges of existing unimproved latrines, the government, in its Second Growth and Transfomation Plan (GTP-II), has prioritized health service quality improvements and set targets to increase households' access to improved latrine facilities[2] — from less than 28 percent to 82 percent by the end of 2020; and in ODF kebeles, from 18 percent to 82 percent (HSTP 2016-2020).

To sustain achievements and reach the set hygiene and sanitation targets, the FMoH has employed two complementary approaches; (i) demand creation using the Community-Led Total Sanitation and Hygiene (CLTSH) tool, and (ii) sanitation marketing strategy to increase households' access to improved sanitation products and services. Increasing the supply of and access to improved sanitation technologies or products through market-based approaches requires the availability of different options that meet minimum standards for hygiene and other social, economic, environmental, and technical factors.

Therefore, the On-site Household Latrine Technology Option Planning, Design, and Construction Manual aims to provide a menu of technology (product) options to support the selection, construction, operation, and maintenance of latrines.

1.2 Users of the Household Latrine Technology Option Manual

This manual primarily serves the following actors:

i. **Hygiene and sanitation promoters (HEWs and public health professionals):** Supports their routine promotion of improved sanitation, as well as efforts to educate households on the attributes of different types of products so that they can engage with entrepreneurs.

ii. **Entrepreneurs:** Provides a step-by-step guide for the production of latrine technology products and the construction of household latrines, as well as a decision-making matrix for business plan development and marketing phases.

1 Unimproved latrine is a sanitary facility that does not ensure hygienic separation of human excreta from human contact. Unimproved facilities include pit latrines without a slab or platform, hanging latrines and bucket latrines.

2 Improved latrine is a sanitary facility that ensure hygienic separation of human excreta from human contact. They include: flush or pour-flush toilet/latrine to piped sewer system, septic tank or pit latrine; ventilated improved pit (VIP) latrine; pit latrine with slab and composting toilet.

iii. **Technical and Vocational Education and Training (TVET):** Serves as a teaching aid for the training of sanitation entrepreneurs.

In addition, the manual serves other stakeholders, such as:

iv. **Consumers and latrine users:** Guides skilled individuals on how to select, construct, and maintain their own latrine facility.

v. **Civil society organizations:** Supports the promotion of household- and community-level hygiene and sanitation, and serves as a tool for community- and organization-led trainings.

1.3 Safe disposal of human excreta

The containment of human excreta (feces and urine) is the first step for managing human waste in the sanitation value chain. All effective on-site sanitation technology options (whether dry or wet) are designed to safely contain human excreta and prevent their exposure to humans and the environment. However, in the absence of hygienic practices, mere access to adequate sanitation technologies is insufficient to prevent the transmission of diseases. Therefore, keeping latrines clean and washing hands with soap after latrine use are equally important means to stop the transmission of fecal-oral diseases.

In general, household latrine technology options are expected to meet a set of minimum standards to safely manage human excreta and minimize health risks. To address this issue, the FMoH has adopted the criteria set out for improved latrines in the WHO/UNICEF Joint Monitoring Program, and has set minimum requirements for household latrines to qualify as an improved facility (MoH, IRT Manual 2014).

This On-Site Household Latrine Technology Option Planning, Design, and Construction Manual is prepared to facilitate the selection, design, and construction of improved latrine technology options, so as to encourage sustainable and safe hygiene and sanitation behaviors that will directly contribute to the achievement of the government's target to improve communities' health status, and support the Health Sector Transformation Plan (HSTP).

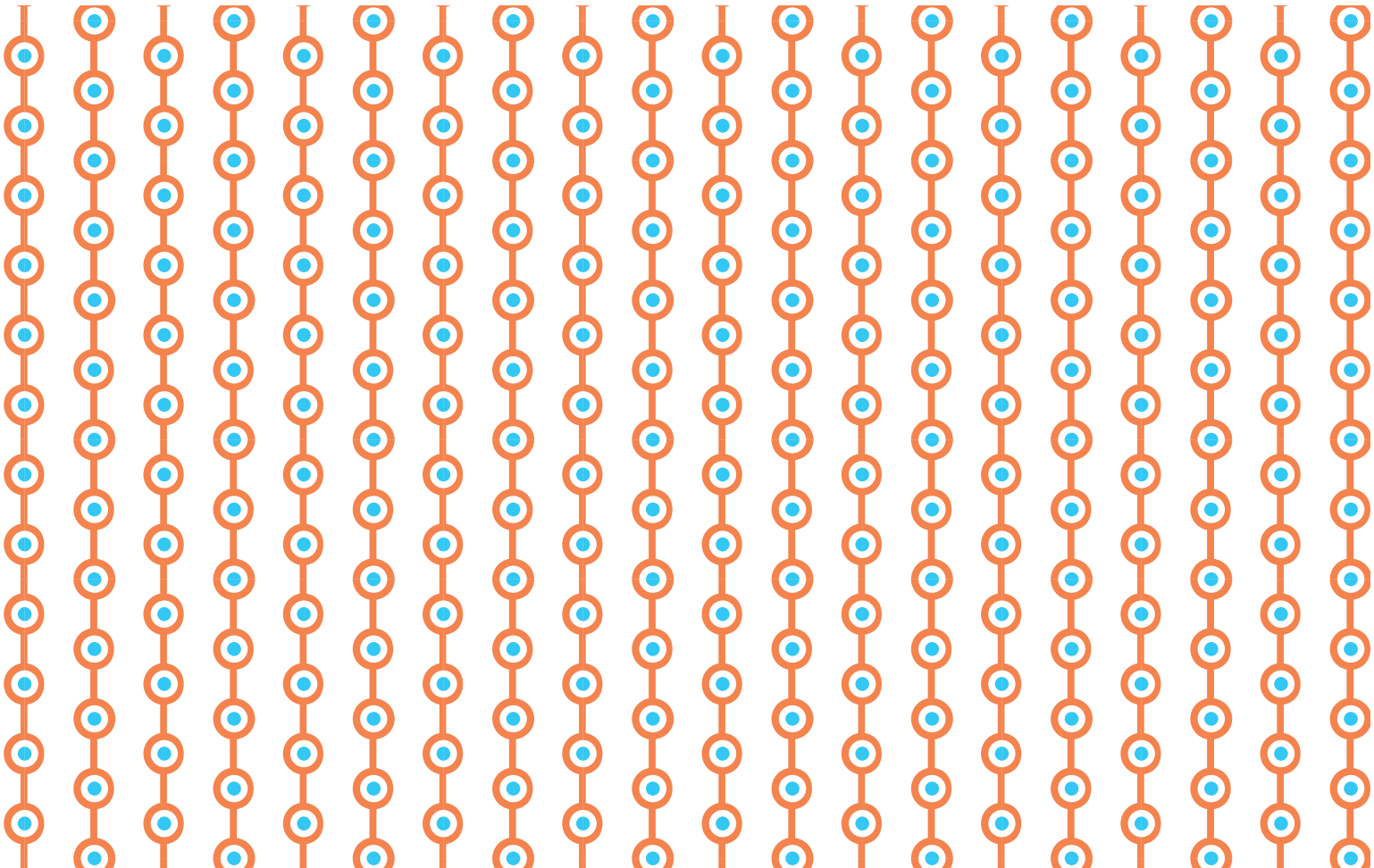
The manual further provides users with the designs, specifications, and drawings of a selection of technology options, as well as step-by-step guidance on how to construct latrine components (substructure, slab, and superstructure), and their associated costs. It also provides guidance to households and service providers on how to operate and maintain the latrines, as well as what safety measures to take during their construction.

In general, household latrine technology options are expected to meet minimum criteria so as to safely manage human excreta (feces and urine) to minimize health risks.

2

General considerations for
Selecting an Appropriate Latrine

This chapter provides information to help users and producers select the most appropriate type of latrine technology, and discusses technical, socio-economic, and environmental considerations.

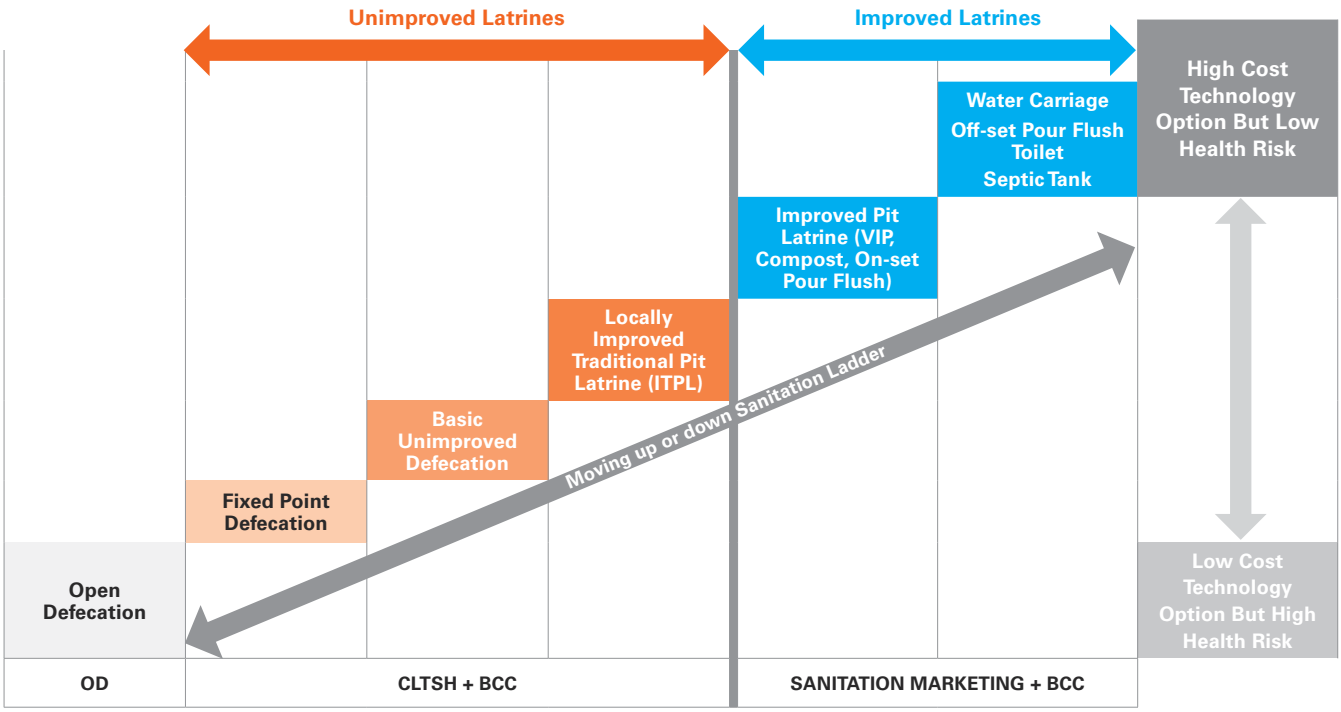


2.1 Existing rural latrine technology options, and their related merits and demerits

Ethiopian households construct a wide range of latrine technologies to dispose human excreta (Hygiene and Sanitation Protocol 2006). The basic or unimproved technology options at the bottom of the "sanitation ladder" (Figure 1) are low cost, but likely to pose a high health risk to users and the community, as they do not adequately separate excreta from humans, flies, and the environment. Households are encouraged to move up the sanitation ladder by adopting improved sanitation technologies that interrupt fecal-oral disease transmission.

As the vast majority of rural households (98 percent) do not have running water, this manual mostly addresses dry, on-site technology options.

Figure 1: Ladder for household latrine technology options



The following table (Table 1) describes the different types of latrine technologies to be considered and their corresponding merits and demerits.

Table 1: Household latrine technology options: advantages, disadvantages, and factors for selection

Existing Household Latrine Technology options	Description	Advantages	Disadvantages
Improved Pit latrines (IPL)	An Improved Pit Latrine (IPL) consists of an excavated pit, covered with cleanable mud-plastered wooden materials, and/or with a concrete SanPlat slab with no rebar (washable) and with a squat-hole fitted with a tight squat-hole cover, through which excreta falls into the pit. Improvements made include a wall that provides adequate privacy, the absence of openings on the floor other than a squat-hole, and a substructure that is constructed from stable/durable materials and provided with hand washing facilities.	– Easy to build using locally available construction materials – Suitable for people using leaves, paper, or hard/bulky materials for anal cleansing – Mud plastered floor with no opening (except squat hole) and fitted with tightly fit squat-hole cover – Floor easily cleanable – Does not need water to operate and suitable for most rural households – Easy to operate and maintain – Appropriate and affordable for low-income households – With some guidance, can be constructed easily using unskilled labor	– If the entire depth of the pit wall is not lined with durable material, a new latrine will have to be constructed when the existing latrine becomes full (i.e., re-digging of pit) – Mud plastered floor is not washable – Not appropriate where access to space/land is a problem – Floor can easily decay or be affected by termites
Ventilated Improved Pit (VIP) latrines	A Ventilated Improved Pit latrine is a pit latrine where the movement of odor and flies is effectively controlled by a vent pipe. The atmospheric air enters through the squat-hole and pushes out the odorous gases (hydrogen sulfide and methane gases) generated in the pit through a vent pipe. The semi-dark inside of the superstructure causes emerging flies to be attracted to the sunlight that comes through the vent pipe and not the squat hole.	– Easy to build using locally available materials – Relatively low cost of construction – Suitable for people using bulky anal cleansing materials (leaves, paper, or hard materials) – Suitable for water scarce areas (does not need water to operate) – Significantly reduces smell in the latrine and flies – Floor/slab is washable – Does not need squat-hole cover – Easy to operate and maintain	– Requires masonry and carpentry skills – In areas without hollow bamboo available, PVC vent pipes will have to be purchased (additional cost) – A new latrine must be constructed once the existing latrine is full – Interior part of the superstructure should be kept dark to discourage fly movement and egress through the squatting hole – Not affordable for low-income households

Existing Household Latrine Technology options	Description	Advantages	Disadvantages
Compost latrine (Arborloo and double vault compost latrine)	Varying types of compost latrines are among the dry pit latrines suitable to areas with rocky soil formation that makes it difficult to excavate a pit to the required depth. Households can close the old pit and use the area to grow fruit trees, and construct and use a new pit. Compost latrines are also a suitable option for households living in a densely populated settlement where space for the construction of a latrine is a critical problem. It allows households to empty and reuse the pit. In addition, after a period of two years, adequately decomposed excreta can be used for soil conditioning (fertilizer).	– It is a dry latrine option for areas with rocky soil formation (i.e., difficult to dig) and a shallow water table – Suitable for households willing to use decomposed excreta for fertilizer – No risk for ground water contamination – Can be built close to the dwelling house – A double vault composting latrine is sustainable and can be alternatively used for a long time – Slab can be transferred to new pit when old one becomes full – A tree can be planted in the old pit of an Arborloo latrine to take advantage of the compost	– Conservative cultures less likely to approve the use of latrine content for fertilizer/soil conditioning – Needs saw dust and ash to cover the feces after defecation – An Arborloo compost latrine requires space as it needs to be rebuilt once the old latrine fills up – An Arborloo latrine is not suitable for densely populated areas where space is a problem, and in areas affected by frequent flooding – Planting vegetables in recently abandoned Arborloo pit latrines (under a year since last used) is hazardous to public health – Arborloo pit latrines require the training of households on handling and preparation of compost, and use of fecal matter
Off-set pour-flush latrine	A pour-flush latrine is a type of wet latrine that uses 2-4 liters of water to flush or convey fecal matter from a pedestal or squatting pan to a soak pit. A soak-away pit can be located directly below the pan or can be offsite. In case of an offsite pit, a drainage pipe that conveys excreta to the pit is connected to the outlet of the pan's water seal and to the soak pit at an angle of 30 degrees.	– It is a wet latrine option that needs water for day-to-day use (2-4 liters of water per flush). It is an appropriate option for households that have running water at least in the yard (living plot) – The water seal prevents flies from breeding and bad smells – Installation needs masonry and plumbing skills	– Cannot operate where water is not available for flushing – Installation and maintenance costs are relatively expensive (high) – Owners without masonry and plumbing skills cannot maintain or repair the latrine and may revert to open defecation immediately after the system fails to function – Requires toilet paper or water for anal cleansing as latrine will easily clog if solid materials are used

2.2 Special considerations to select types of latrines, and their ideal site location

A number of important factors must be considered to determine the type, design, and placement of latrines.

Table 2: Description of factors that determine the type, design, and location of household latrines

Factors	Explanations
Soil type	Soil type and permeability affect the selection and design of latrines, as these factors determine the depth of the pit to be excavated, as well as the vertical separation between the pit's bottom and the highest ground water table. Different types of soil vary in terms of: a) load carrying capacity; b) self-supporting properties (i.e., properties that prevent the pit against collapse, as is the case with cohesive soil); and c) levels of risk related to ground water pollution and soil infiltration rate (to determine desired depth of pit). Microorganisms move into porous soil quickly compared to compacted soil. Therefore, to reduce the transfer of pathogens through filtration, dilution, predation, and die off, vertical separation (soil thickness) between the bottom of the latrine pit and highest ground water table should not be less than 5 meters.
Level of ground water table	Knowing the ground water table's highest level is important to determine the pit's depth and select the ideal type of latrine to be used. In addition, the latrine's seating (location) should consider the owner's and neighboring households' existing ground water sources. Pit latrines can pose a contamination risk to groundwater. While the pit's bottom may be above the water table during the end of rainy season, the pit's liquid contents may seep into the surrounding soil to contaminate/enter the aquifer.
Location: proximity to water sources	If the latrine is built uphill from the existing water source, the latrine's liquid contents could seep into the soil, flow downhill, and contaminate the water source. Therefore, the latrine should be located downhill 30-50 meters away from the water source.
Accessibility to users	Latrines located far away are less likely to be utilized by certain family members such as pregnant mothers, small children, the elderly, and those with disabilities. They are also unlikely to be used during the night and bad weather. Therefore, latrines should be located six to 15 meters from the dwelling house, in the backyard.
Access to construction materials and Cost	Materials to construct latrine products (for lining pits and producing slabs, walls, and roofing) are not uniformly available in different parts the country. Wooden materials are scarce in northern Ethiopia, while stone is rarely available in the south and west. The unavailability of durable construction materials locally increases the cost of production for sanitation products. In addition, households select latrine technologies based on their ability to pay for the construction of the latrine, as well as its operating and maintenance costs. Low-income households may not have enough cash to buy improved sanitation and hygiene products. As a result, they face difficulties in climbing up the sanitation ladder. Such households are encouraged to improve their basic latrines by using locally available materials.
Availability of water	Easy access to water is important to consider when selecting a latrine option. Households that select a wet latrine technology option must rely on the continuous supply of running water. If the household has no running water, dry pit latrines are the most appropriate technology option.
Culture (traditional beliefs)	Ethiopia is a diverse country with a wide range of traditional belief systems held by the communities that comprise its various nations and nationalities. It is important to consider social and cultural issues when selecting a site for the latrine. Site selection should consider factors such as whether family members, especially women and children, can easily access latrine facilities at night without fear of violence and wild animals. In some areas, arrangements for latrine use should consider family relationships (e.g., using the same latrine as your father in-law is taboo in Gedeo and Sidama communities), as well as cleansing practices, and housing density. Latrines should be accessible during bad weather, and located away from roads. In addition, Muslims do not like to face in a north-eastern direction (towards Mecca) while using the latrine, so the latrine and slab footrest should face in another direction. They also prefer to use a squatting pan rather than a sitting type. Most Ethiopians are not accustomed to the use of biologically degraded fecal matter as a soil conditioner and fertilizer, and people may not feel comfortable touching compost.

3

Basic components of **Household Latrines**

This chapter provides information on (i) the basic components of the pit latrine and the materials that can be used to construct these components; (ii) the functions of the components, and reasons why pit latrines are often not operated and maintained properly.

3.1 Basic components of pit latrines

Pit latrines have three basic components: the substructure (the pit and pit lining), floor (slab and mound), and the superstructure (wall, roof, and door).

3.1.1. Substructure

The substructure is located below the ground and includes the pit and its lining.

- Used to store human excreta (feces and urine) and supports the pit cover (slab) and shelter
- Shape can be circular, square, or rectangular
- Volume of pit is determined using family size, desired number of years for operation, and ground water table
- The pit wall's top 500 millimeters of depth is lined using durable material (stone, bricks, or concrete) to prevent the entrance of rodents and run-off
- Pit should be lined if the soil type is loose (sand, clay/silt) and the ground water table is high
- Lining pit with durable materials prevents the pit wall from collapsing (caving in)
- A pit lined with durable materials is reusable

A pit could be lined with stone, bricks, precast concrete ring, Ferro cement, wooden logs, or bamboo.

3.1.2. Floor

The floor is the component above the substructure. It comprises of a slab and a mound.

- The slab is the term used to describe the cover of the pit
- The slab supports the user and the wall
- If the latrine is VIP, it has two holes (a squat-hole and another hole for vent installation)
- If the latrine is not VIP, it should have a squat-hole cover
- The slab can be made of plastic, reinforced concrete, or wooden materials
- The slab can be circular, rectangular, or square – the same as the shape of the pit

Mound

- The mound refers to compacted soil or durable materials around the latrine, above the ground
- It prevents the entrance of run-off and rodents
- A recommended size would be 150 – 200 millimeters above the ground

3.1.3. Superstructure

The superstructure comprises of a wall and roofing.

- Walls provide the user privacy
- Walls and roof shield the user from rain, wind, sunlight, and heat
- Prevents the wooden slab from rotting because of rain
- Wall can be constructed from locally available materials, such as stone, bricks, corrugated iron sheets, wood, bamboo, grass, or polyethylene plastic sheets
- Roof can be constructed from corrugated iron sheets, grass, or polyethylene plastic sheets
- Walls above the door can be left open, screened with iron mesh for lighting and ventilation
- If the latrine is VIP,
  - > The inside of the latrine is kept dark to discourage flies from coming out through the squat-hole
  - > Vent is installed inside or outside of the wall, with a height of 500 millimeters above the rooftop, and is covered with mesh wire/fly screen

Latrine construction requires different types of masonry, carpentry, and plumbing hand tools.

4

Hand tools for
Latrine Construction

Essential hand tools are listed in Table 3 below.

Table 3: List of hand tools for construction

	Description of essential hand tools
A	**Hand tools for masons and plumbers**
1	Mason's hammer
2	Shovel
3	Spade
4	Wire cutter (pinsa)
5	Hacksaw with blade for cutting iron bars
6	Sprit level
7	Mason's plum bob (tumbi)
8	Metal trowel for smoothening/finishing of concrete
9	Wood for screeding
10	Squat-hole mold
11	Wooden floats
12	Foot rest mold -left and right
13	Straight, smooth, and clean wooden frame (formwork) thickness for preparation of mold (slab, foot rest, and squat-hole)
14	Personal protection devices (plastic helmet, eye goggles, pairs of leather or rubber shoes, and heavy-duty gloves)
15	Rope, 0.5 millimeters thick
16	Measuring tape of 3 meters
17	Plastic sheet for shading in square meters
18	Jerry can of 20 liters
19	Bucket (shenkelo)
B	**Hand tools for carpenters**
1	Carpenter hammer (martello)
2	Carpenter's sprit level
3	Carpenter's plum bob (tumbi)
4	Hand saw
5	Measuring tape of 3 meters
6	Rope, 0.5 millimeters thick
7	Personal protection equipment (eye goggles, pairs of leather or rubber shoes, and pairs of heavy duty gloves)

5 Selection and Construction of Latrine Components

5.1 Identifying soil types

Soil type may vary from site to site in the same village. Information about the soil type of a particular site enables the selection of the most suitable latrine, and the materials that will be used to construct the substructure, floor, and superstructure. The following table describes the basic characteristics of different types of soil.

There are three major types of soil, namely sand, silt, and clay. Each type has distinctive characteristics.

A. Sand:

Sandy soil is loose (not sticky), rough to touch, and each particle size is relatively large compared to other soil types, ranging from 0.05 millimeter – 2 millimeters in diameter. Sandy soil is porous due to the large spaces between sand particles, and cannot retain water. This soil type is useful for soaking away the latrine's liquid contents into the surrounding soil.

B. Silt:

Silt is slightly sticky with an irregular shape, and moderately absorbs and retains water. Its particle size ranges from 0.002 millimeter – 0.005 millimeter in diameter.

C. Clay:

Clay is highly sticky, and its particles are flat but difficult to see with the naked eye (particle sizes are less than 0.002 millimeter in diameter). Clay has high water absorption and retention capacity.

In summary, it is important to consider the consistency and stickiness of the soil in a particular site to calculate the dimension of the latrine pit; determine whether to partially or fully line the pit wall and bottom; and select appropriate lining materials. Therefore, Table 4 provides information that may be useful to anyone who intends to promote or construct latrines, including individual households, PHCU staff, and entrepreneurs.

Table 4 : Description of soil type, and its consistency and stickiness

Soil characteristics	Description
I. Soil consistency	
1. Loose	– Will not stick together upon touching
2. Soft	– Soil mass is weakly coherent and fragile – Breaks into a powder – Individual grains are under very slight pressure
3. Slightly hard	– Weakly resistant to pressure – Can be broken between thumb and forefinger
4. Hard	– Moderately resistant to pressure – Can be broken apart by hand without difficulty – Hardly breakable between thumb and forefinger
5. Very hard	– Very resistant to pressure – Can be broken apart by hand only with difficulty – Not breakable with thumb and forefinger
6. Extremely hard	– Very resistant to pressure – Cannot be broken apart by hand
II. Soil stickiness when wet: pressing with thumb and forefinger	
1. Not sticky	– After release of pressure, no soil material adhered to thumb and forefinger
2. Slightly sticky	– After release of pressure, soil material adhered to thumb and forefinger, but comes off after cleaning
3. Sticky	– Soil material tends to stretch
4. Very sticky	– Soil material adheres to thumb and forefinger strongly

5.2 Determining the size and materials for the substructure

5.2.1 Choosing between pit lining materials

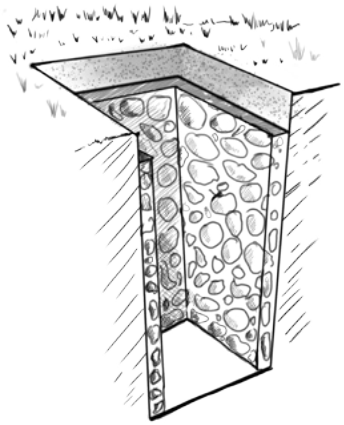
The selection of appropriate pit lining materials depends on the area's soil type and characteristics. Table 5 provides information on how to choose suitable and affordable pit lining materials strong enough to prevent the pit from caving in, and to support the slab, user, and superstructure.

Table 5: Soil type and materials suitable for pit lining

	Suitable pit lining materials		
Soil Type	**Durable lining materials**	**Other alternative lining materials**	**Remark**
1. Stable soil	Selected soil material, stone, bricks, or concrete beam	Selected soil material	Top 500mm depth to prevent entrance of runoff and vermin
2. Sandy (fragile and loose)	Precast reinforced concrete ring	-	
3. Silt/clay soil	Stone, fired bricks, or precast reinforced concrete ring	Wood or bamboo	Full or partial lining of the wall by durable material
4. Rocky (hard to dig) soil	Stone or fired bricks above the ground	-	Soil mounding is needed around the structure above the ground
5 Higher water table and water logging	Watertight concrete bottom/ base, precast reinforced blind concrete ring	-	Pit digging during the dry season and watertight lining protruded above the ground

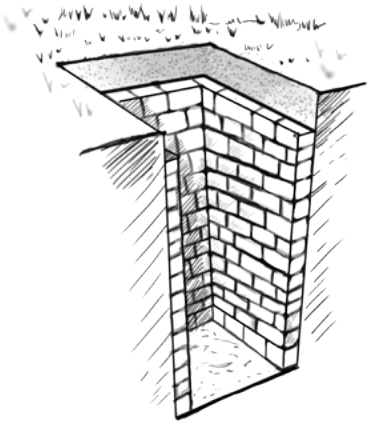
Pit Lining Options

Figure 2: Lining with Stone



Lining with Stone

Figure 3: Lining with Bricks

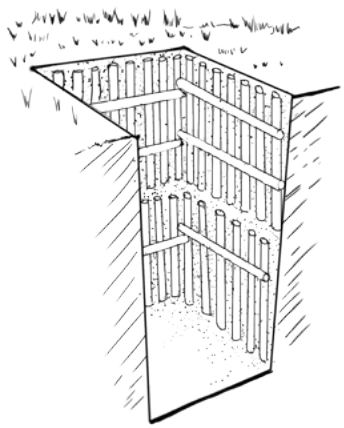


Lining with Bricks

Figure 4: Precast Reinforced Concrete Ring

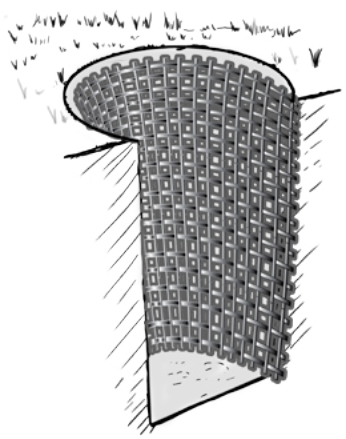
Precast reinforced concrete ring

Figure 5: Lining with Wooden Log



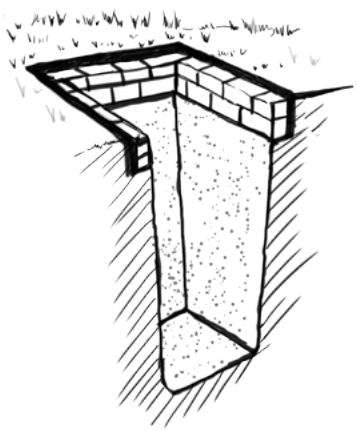
Lining with Wooden log

Figure 6: Lining with Woven Bamboo



Lining with Woven Bamboo

Figure 7: Lining top 500mm with stone or bricks



Lining top 500mm with stone or bricks

5.2.2. Determining the pit dimension and volume of lining materials

Some key characteristics of a latrine pit include:

- Adequate capacity to store feces/sludge and materials used for anal cleansing (such as water, leaves, or paper)
- Sufficient space/depth to cover contents
- Appropriate depth to prevent the contamination of surface water and soil with disease pathogens
- Pit wall should allow for the infiltration of the liquid content of feces during its operational life
- In addition, the required dimensions of the latrine pit (length, width, depth, and diameter) is determined based on the minimum space (working area) needed for a person to excavate the pit, the type of lining materials to be used, and the space available in the compound.

Factors to determine pit size

- Annual fecal sludge accumulation rate (SAR)
- For dry latrines, SAR = 0.09m^3/person/year
- For wet latrines, SAR = 0.06m^3/person/year
- Family size (varies from household to household, although the average is five persons per household)
- Design period (desired year of operation)
- Lining material to be used
- External diameter of the pit
- Highest ground water table
- Total depth of the pit (effective depth + top 500 millimeters for pit sealing)

Note:

- **A pit with a wider diameter incurs additional costs, because of the need for additional lining material, as well as a larger and thicker slab that would need reinforcement with a thicker iron bar. Other costs include additional cement, sand, gravel, labor, and transportation.**

Pit has both internal and external volume

- A pit's internal volume is the empty space that serves as storage for the human excreta
- A pit's external volume is the sum of internal volume and the volume of the pit's lining materials and space for back filling

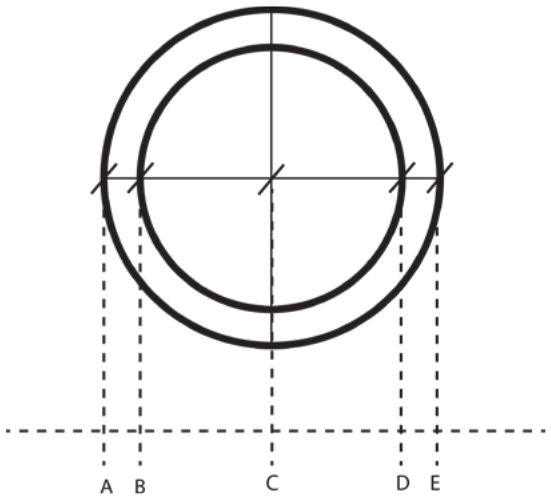
A pit's external volume varies depending on the thickness of the lining materials and the space for back filling between the lining and the surrounding soil

- Stone lining occupies more space (400 millimeters) including 10 millimeters space for back filling
- Bricks (120 millimeters + 100 millimeters = 220 millimeters) including 10 millimeters space for back filling
- Reinforced concrete ring (110 millimeters)
- Wooden log (100 millimeters + 100 millimeters = 200 millimeters), including 100

Note:

- **Choice of lining material primarily depends on soil type, availability of materials in the area, and cost of materials and labor.**
- **Woven bamboo and wooden logs are not durable lining materials as they do not last more than 2 ½ to 3 years. Moreover, their support function is weakened if the pit's effective depth is deeper than 2 meters.**

Figure 8: Pictorial description of internal and external diameter of a circular pit



AE (external diameter of the pit) – varies depending on the lining material to be used

BD (internal diameter of the pit) – is the same for all lining materials (e.g. 1000 millimeters or 1 meter)

BC = CD (internal radius of the pit) – is the same for all lining materials (e.g. 500 millimeters or 0.5 meters)

AB = DE (thickness of the lining materials and back filling space) – varies between lining materials

AC (external radius of the pit) – varies between lining materials

Table 6: Internal and external dimensions of circular pit and lining material options (Example)

Lining material	Circular latrine pit				
	Internal diameter of the pit (bottom)	Internal radius of the pit (at bottom)	Thickness of the lining material	External diameter of the pit (bottom)	External radius
Stone	1000mm	500mm	400mm	1800mm	Radius 900mm
Bricks	1000mm	500mm	220mm	1440mm	Radius 720 mm
Concrete ring	1000mm	500mm	150mm	1300mm	Radius 650mm
Wooden log	1000mm	500mm	100mm	1200mm	Radius 700mm
Woven bamboo	1000mm	500mm	50mm	1100mm	Radius 550mm

Example: Determining effective pit size (dimension)

Ato Abebe's family comprises of five people. His family started using a latrine in 2006 EC, and he has since then built three latrines (one every year) after each rainy season. He now plans to build a long lasting dry pit latrine that can serve for at least five years, and has an internal diameter of 1000 millimeters (1 meter). The area's soil type is clay, which is unstable, and can cause the pit to easily collapse. All types of pit lining materials are available in Ato Abebe's village, as well as in the neighboring village. Masons and day laborers are also available in the nearby town. Ato Abebe wants to learn about the affordability, quantity, and cost of lining materials, as well as the cost of labor for excavating and lining the pit.

Given:

- Latrine type is a dry pit latrine
- Soil type is loose (silt-clay soil type)
- Family size = 5 persons
- Desired number of years of operation = 3 to 5 years
- Internal diameter of the pit (circular) = 1000 millimeters or 1 meter at its bottom
- Sludge accumulation rate (SAR) = 0.09m3/person/year
- All types of lining materials are locally available
- Masons and day laborers are available in the nearby town

Using the above case,

- Determine the effective pit size (volume, pit area, and depth) for sludge accumulation
- Determine total pit size (volume) to be excavated, considering different lining materials
- Determine volume of different lining materials
- Estimate the cost of the lining material, as well as the cost for unskilled and skilled labor for substructure construction

Step1. Calculate the EFFECTIVE VOLUME for the storage of excreta by multiplying the number of family members (five people) by the desired number of operation years (for example, five years for durable materials such as stone, bricks, and concrete ring, three years for wood, and two and a half years for bamboo), and then multiply by factor for sludge accumulation rate for dry pit latrine (0.09m3/person/year).

For durable lining materials (stone, bricks, and precast reinforced concrete ring)

- Effective pit volume (durable) = 5 people x 5 years x 0.09 m^3/p/y Sludge accumulation rate = 2.25 m^3
- Effective pit volume (wooden) = 5 people x 3 years x .09 m^3/p/y Sludge accumulation rate = 1.35 m^3
- Effective pit volume (bamboo) = 5 people x 2½ years x .09 m^3/p/y Sludge accumulation rate = 1.13 m^3

Step 2. Calculate the EFFECTIVE AREA of the pit using the formula ($A = \pi r^2$), where πr^2 = 3.14 and r = radius of effective pit = 0.5 m, then Internal Area = 3.14 x 0.52 = 0.79 m^2

Step 3. Calculate the EFFECTIVE DEPTH of the pit by dividing the effective volume by the effective area for each of the pit lining materialsTotal depth for durable lining material = 2.85 m + 0.5 m = 3.35 m

- Effective depth for durable materials = 2.25 m^3 divided by 0.79 m^2 = 2.85 m
- Effective depth for wooden material = 1.35 m^3 divided by 0.79 m^2 = 1.71 m
- Effective depth for bamboo materials = 1.13 m^3 divided by 0.79 m^2 = 1.43 m

Step 4. Calculate the TOTAL DEPTH of the pit by adding 0.5m to the effective depth

- Total depth for durable lining material = 2.85 m + 0.5 m = 3.35 m
- Total depth for wooden lining material = 1.71 m + 0.5 m = 2.21 m
- Total depth for bamboo lining material = 1.43 m + 0.5 m = 1.93 m

Step 5. Calculate INTERNAL VOLUME of the pit by multiplying the internal area of the pit by the total depth

- Internal volume (durable materials) = 0.79 m^2 x 3.35 m = 2.65 m^3
- Internal volume (wooden materials) = 0.79 m^2 x 2.21m = 1.75 m^3
- nternal volume (bamboo materials) = 0.79 m^2 x 1.93 m = 1.52 m^3

Step 6. Calculate the EXTERNAL AREA of the pit using the formula ($A = \pi r^2$), where πr^2 = 3.14 and r= external radius of pit (this varies for each of lining materials)

- EXTERNAL AREA of the pit (durable stone) = 3.14 x 0.9 m^2 = 2.54 m^2
- EXTERNAL AREA of the pit (durable bricks) = 3.14 x 0.72 m^2 = 1.63 m^2
- EXTERNAL AREA of the pit (durable concrete ring) = 3.14 x 0.65 m^2 = 1.33 m^2
- EXTERNAL AREA of the pit (wooden logs) = 3.14 x 0.7 m^2 = 1.54 m^2
- EXTERNAL AREA of the pit (bamboo) = 3.14 x 0.55 m^2 = 0.95 m^2

Step 7. Calculate the EXTERNAL VOLUME of the pit by multiplying its external area by its total depth

- External volume of the pit (stone): 2.54 m^2 x 3.35 m = 8.5 m^3
- External volume of the pit (bricks): 1.63 m^2 x 3.35 m = 5.46 m^3
- External volume of the pit (concrete ring): 1.33 m^2 x 3.35 m = 4.5 m^3
- External volume of the pit (wooden logs): 1.54 m^2 x 2.21 m = 3.4 m^3
- External volume of the pit (bamboo): 0.95 m^2 x 1.93 m = 1.83 m^3

Table 7: Summary of pit size/dimension for different pit lining materials [Example]

Pit dimension parameter	Step	Dimensions for a dry, on-site, circular latrine pit for a family of five, with an internal bottom diameter of 1000mm (1m), and a sludge accumulation rate of 0.09 cubic meters per person per year. Desired number of operational years is 5 years for durable lining materials, 3 years for wooden logs, and 2 ½ years for bamboo.					
		Lining with Stone	Lining with fired bricks	Lining with precast reinforced concrete ring	Lining with wooden log + top 50 cm	Lining with woven bamboo+ top 50cm	Only top 50 cm lining with stone/ bricks
Average number of family size	Given	5	5	5	5	5	5
Desired number of operational years	Given	5	5	5	3	2.5	5
Sludge accumulation rate per person per year for a dry pit latrine (SAP)	Given	0.09	0.09	0.09	0.09	0.09	0.09
Effective pit volume in cubic meters	Step 1	2.25	2.25	2.25	1.35	1.13	2.25
Effective area of the pit in square meters	Step 2	0.79	0.79	0.79	0.79	0.79	0.79
Effective pit depth in meters	Step 3	2.85	2.85	2.85	1.71	1.43	2.85
Total depth of the pit in meters	Step 4	3.35	3.35	3.35	2.21	1.93	3.35
Internal volume of the pit in cubic meters	Step 5	2.65	2.65	2.65	1.75	1.52	1.57
External area of the pit in square meters	Step 6	2.54	1.63	1.33	1.54	0.95	1.96
External volume of the pit in cubic meters	Step 7	8.5	5.46	4.5	3.4	1.83	

Note:

- **The external volume of the pit is equal to the total volume of the pit to be excavated**

5.2.3 Volume and cost of pit lining options

Unstable, loose, and less compacted soil formation that easily collapses needs to be lined with durable materials. In addition, pit lining materials are also important for the prevention of ground water contamination in areas where the ground water table is high, or in areas where water logging and flooding is prevalent.

The correct quantities (volume) of pit lining materials and their corresponding costs vary depending on the size of the pit and the type of lining materials chosen (Table 5.2.3). In addition, pit lining work

requires additional material inputs. For example, stones, bricks, and concrete rings need cement mortar to fix joints together and smooth surfaces. Wooden logs need nails to be fixed together, and the top levels of both wood and bamboo lining need a depth of 500 millimeters to be lined with either stone or bricks, joined by cement mortar. All lining work, irrespective of the material type, requires unskilled labor to cart away the excavated soil and assist the skilled laborer.

The availability of information about the cost of pit lining materials is important to decide which lining materials are suitable for the area's soil formation and can be constructed at an affordable cost. However, the cost of pit lining (both materials and labor) may vary from region to region, woreda to woreda, and from season to season, depending on the availability of construction materials, and the area's labor market for skilled and unskilled workers.

Table 7 provides information on how to determine the volume of the pit to be lined, using different material options, including a space for backfilling between the pit lining and the surrounding ground. Information on the pit's external and internal volume is taken from examples given to calculate the parameters of pit size under section 6 above.

Table 8: Example how to determine the volume of the pit to be lined with different lining materials

Lining material options	External volume (volume of soil to be excavated)	Internal volume (open pit for accumulation of excreta)	Volume of pit to be lined
Stone lining	3.14 x 900mm x 900mm x 3350mm = 8.52m^3	3.14 x 500mm x 500mm x 3350mm = 2.7m^3	**5.82m^3**
Brick lining	3.14 x 720mm x 720mm x 3350mm = 5.45m^3	3.14 x 500mm x 500mm x 3350mm = 2.7m^3	**2.75m^3**
Concrete ring lining	3.14 x 650mm x 650mm x 3350mm = 4.45m^3	3.14 x 0.5 X 0.5 x 3350mm = 2.7m^3	**1.75m^3**
Wooden logs	3.14 x 700mm x 700mm x 2210mm = 3.4m^3	3.14 x 0.5 X 0.5 x 2210mm = 1.6m^3 +Top seal 1.57m^3	**3.22m^3**
Woven bamboo	3.14 x 550mm x 550mm x 1930mm = 1.83m^3	3.14 x 0.5 x 0.5 x 1930mm = 1.51m^3 +Top seal 1.57m^3	**3.1m^3**
Top 50cm stable soil	(3.14 x 1m X 1m x 0.5m) = 1.6 m^3	3.14 x 0.50. x 0.5 = 2.63m^3	**4.2m^3**

Lining material and cost estimation

In the previous section, information was provided about the volume of the pit to be lined using different lining materials. The next section discusses the preparation of specifications and the quantification of materials and labor required for the lining of the pit. Durable lining materials need cement mortar to hold them together, whereas wooden logs and bamboo require nails. A mason is needed to construct durable lining material, while a carpenter is needed for lining with wooden logs and bamboo. Unskilled labor is also required for the excavation of the pit, removal of excavated soil, back filling of the space between the lining and surrounding soil, as well as to assist the skilled laborer. Lining materials and costs can be estimated based on the assumptions outlined in Box 5.2.3, and a sample bill of quantities and cost estimation is presented in Table 5.2.3 below.

Box 1: Assumptions to quantify and cost pit lining materials

Assumptions to quantify lining materials

- Proportion of mortar to stone for masonry work/bricks work= 0.37 Mortar: 0.63 Stone (Bricks)
- Mortar = Cement to Sand ratio = 1: 3 parts
- Wastage rare 25%
- 1m3 of cement = 3.5 quintals
- 1 unit of brick = 0.0017m3
- Wooden log diameter of 100mm
- Bamboo diameter of 50mm
- Back filling space between lining and surrounding soil= 100mm (thickness)

Assumptions to estimate cost

- Unskilled labor for pit excavation, and the removal of the excavated soil away from the area,
- Semi-skilled labor (assistant mason/carpenter)
- Skilled labor (mason/carpenter)
- Purchase and transportation costs for lining materials (stone, bricks, cement, gravel, nails, wood, or bamboo)

Table 9: Pit lining material specification and cost estimation

Pit lining material options	Description of materials and works	Unit	Quantity	Unit price	Total price
Lining of pit with **stone joined by concrete mortar** and back filling of the open space between the lining and the surrounding soil Ratio of cement mortar = 1-part cement :3 parts sand	Excavation of 8.6 cubic meter circular pit (diameter of 1800mm and depth 3400mm)	Cub. m	8.6		
	Removal of excavated soil 50 meters away from the construction site/ location	Man day	10		
	Dry masonry stone	Cub. m	5		
	Sand	Cub. m	3		
	Cement (50 kg Bag)	Bags	6		
	Gravel	Cub. m	1.9		
	Backfilling of open space with 1.92 cubic meter gravel between lining and the surrounding soil (100mm x5650mm x 3400mm)	Man day	3		
	Semi-skilled labor (two assistants)	Man day	8		
	Skilled labor	Man-day	4		
	Total cost for lining pit with stones				

Pit lining material options	Description of materials and works	Unit	Quantity	Unit price	Total price
Lining of pit with **fired bricks joined by concrete** mortar and back filling of the open space between the lining and the surrounding soil Ratio of cement mortar = 1-part cement :3 parts sand	Excavation of 6 cubic meter circular pit (diameter of 1500mm X 3400mm depth)	Cub. m	6		
	Removal of excavated soil 50 meters away from the construction site/ location	Man day	8		
	Fired bricks (60mm x 120mm x 2400mm)	Cub. m	3		
	Sand	Cub. m	2		
	Cement (50 kg Bag)	Bags	3		
	Gravel	Cub. m	1.9		
	Backfilling of open space with 1.8 cubic meter gravel between lining and the surrounding soil (100mm x 5400mm x3400mm)	Man day	3		
	Semi-skilled labor (2 assistants)	Man day	6		
	Skilled labor	Man-day	3		
	Total cost for lining pit with fired bricks				
Lining for unstable / sandy and clay soil, and for areas prone to water logging, with precast reinforced **concrete ring** and back filling of the open space between the lining and the surrounding soil Ratio of cement mortar = 1-part cement :3 parts sand	Excavation of 3.8 cubic meter circular pit (diameter of 1200mm x 3400mm depth)	Cub. m	3.8		
	Removal of the excavated soil 50 meters away from the construction site/location	Man day	5		
	Precast reinforced blind concrete ring internal diameter 1000mm, thickness 100mm, and depth 500mm	Each	9		
	Stone	Cub. m	1		
	Sand	Cub. m	1		
	Cement (50 kg Bag)	Bags	4		
	Gravel	Cub. m	1.9		
	Backfilling of open space with 1.92 cubic meter gravel between lining and the surrounding soil (100mm x 5650mm x 3400mm)	Man day	2		
	Semi-skilled labor (2 assistants)	Man day	6		
	Skilled labor	Man-day	3		
	Total cost for pit lining with precast reinforced concrete ring				

Pit lining material options	Description of materials and works	Unit	Quantity	Unit price	Total price
Lining of unstable / loose soil, with **wooden log** and back filling of the open space between the lining and the surrounding soil Ratio of cement mortar = 1-part cement :3 parts sand (for top 500mm depth)	Excavation of 3.4 cubic meter circular pit (diameter of 1300mm x 3400mm depth)	Cub. m	3.4		
	Removal of the excavated soil 50 meters away from the construction site/location	Man-day	5		
	Wooden log (thickness 100mm diameter, each 4000mm long)	Each	40		
	Wooden logs (thickness 5cm diameter, each 5 meters long)	Each	8		
	Nails (8 grams)	Gram	1,250		
	Stone	Cub. M	1		
	Sand	Cub. m	1		
	Cement (50 kg Bag)	Bag	2		
	Backfilling of open space with 1.4 cubic meter gravel between lining and the surrounding soil (100mm x 4000mm x 3400mm)	Man day	1		
	Semi-skilled labor (2 assistants)	Man day	6		
	Skilled labor	Man-day	3		
	Total cost for pit lining with wooden logs				
Lining of unstable / loose soil, with **bamboo** and back filling of the open space between the lining and the surrounding soil Ratio of cement mortar = 1-part cement :3 parts sand (for top 500mm depth)	Excavation of 3.4 cubic meter circular pit (diameter of 1200mm x 3400mm depth)	Cub. m	2.5		
	Removal of the excavated soil 50 meters away from the construction site/location	Man-day	2		
	Bamboo stick/pole 30mm diameter thickness each 4 meters long	Each	25		
	Bamboo 30mm diameter thickness each 8 meters long	Each	210		
	Stone	Cub. m	1		
	Sand	Cub. m	1		
	Cement (50 kg Bag)	Bag	2		
	Semi-skilled labor (2 assistants)	Man day	6		
	Skilled labor	Man-day	3		
	Total cost for pit lining with bamboo				

Pit lining material options	Description of materials and works	Unit	Quantity	Unit price	Total price
Lining top 500mm depth of the **stable soils with stone and concrete mortar (**no back filling)	Excavation of 2.5 cubic meter circular pit (diameter of 1000mm x 2.9m depth) + top 2m diameter with 500mm depth	Cub. m	2.5		
Ratio of cement mortar = 1-part cement :3 parts sand	Remove the excavated soil 50 meters away from the construction site/ location	Man-day	2		
	Stone	Cub. m	1		
	Sand	Cub. m	0.5		
	Cement (50 Kg Bag)	Bag	2		
	Semi-skilled labor (2 assistants)	Man day	4		
	Skilled labor	Man-day	2		
	Total cost for lining pit's top with stone and mortar (500mm depth)				
Construction of **double vault dry compost** latrine wall with an external thickness of 12cm and a vault compartment wall thickness of 12cm, and basement thickness 10cm – Internal volume = length 2.52m width 1.2m and depth 1.5m and – External volume = length 2.76m width 1.44m x 1.6m depth – Volume of bricks for external wall and compartment thickness of 12mm and compartment = $6.63m^3 - 4.54m^3 = 1.82 m^3$ cover slab (1.44m x 2,76m x 0.1 = $0.4m^3$ Ratio of cement mortar = 1-part cement :3 parts sand	Excavation of 6.36 cubic meter circular pit (diameter of 1500mm * 3400mm depth)	Cub. m	6		
	Removal of the excavated soil 50 meters away from the construction site/location	Man day	8		
	Fired bricks (size 24cm x 12cm x 6cm)-67% total 1.82m3 = 1.5m3	Each	870		
	Sand (for mortar and cover slab concrete work)	Cub. m	5		
	Cement (50 kg Bag) for mortar and cover slab concrete work	Bags	5		
	Gravel	Cub. m	0.3		
	Reinforcement iron bar (diameter 8mm)	Kg	21		
	Wire	Kg	1		
	Semi-skilled labor (2 assistants)	Man day	6		
	Skilled labor	Man-day	3		
	Total cost for lining pit with fired bricks				

5.3 Construction of substructure

5.3.1 Latrine pit excavation

General considerations before excavation:

- Understand the characteristics of soil type
- Determine the shape and external volume of the pit (consider the type of lining material you are going to use)
- Determine the depth of the pit (consider the ground water table)
- Determine whether the pit needs lining, and if so, whether it should be partially or fully lined
- Select and prepare suitable lining materials, if appropriate
- Select latrine location
- Locate/adapt pit dimensions on the ground
- Excavate/dig the pit according to the design's required depth (shape and dimension), including the top 500 millimeters

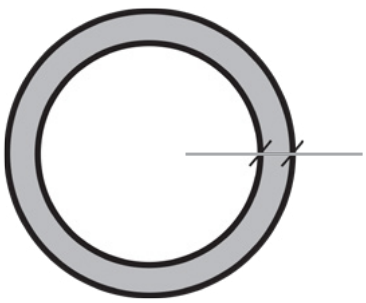
If the soil type is loose (sandy, silt, clay, or water logged)

- Dig pit depth equal to the height of the concrete ring/culvert (to prevent wall from caving in) and continue to dig the pit inside of the ring to the same depth. Insert second ring/culvert, and continue in the same manner up to the desired depth.
- If the soil type is loose (clay or silt), dig a V-shaped pit (narrower bottom and wider top, as in Figure 3), to eliminate the chance of the pit collapsing/caving in before work on lining begins. Start lining immediately, and dig the pit by sloping inward 100 millimeters at every interval of 1000 millimeters.

5.3.1.1 Digging stable and loose soil formation

1. Determine latrine type, shape, size, volume, and depth of the pit, and lining materials.
   > Once the latrine's type (either dry or wet), shape (circular or square), pit volume, and lining material (e.g. bricks, stone, concrete ring, or wood) are determined, follow the following procedure to dig the pit.

Figure 9: Internal and external dimension of the latrine pit



- Circular shape pit
- Internal Radius = 0.5m (White Color)
- External Radius = 0.7m (12cm bricks thickness and 5 cm sand/gravel back filling)
- Shaded part is top 0.5 m stone/gravel and mortar seal

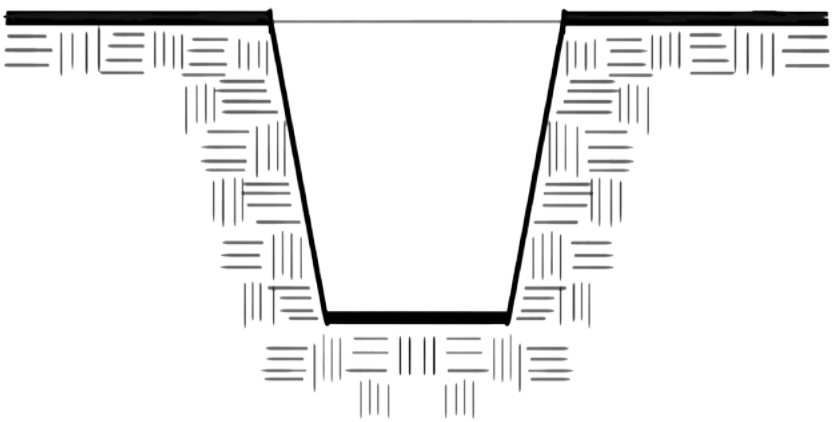
2. Prepare the required quantities of lining materials, such as bricks, sand, cement, gravel, and stone before starting to dig the pit.
3. Select the latrine's building site and level the ground.
4. Mark and post a stick firmly at the center point.
5. Using rope or string, measure a radius and make a circle around the firmly posted stick.

Example:

If the lining material is fired bricks, add 0.12m (brick's thickness) and 0.05m (space for gravel/sand back filling) on the radius of the circular pit. This makes the external radius of the pit equal to 0.7m.

6. First, make a circle for the internal diameter (white color) and then make a circle for the external diameter (shaded portion). The shaded portion is for the pit lining and the space for gravel filling.
7. Sprinkle ash on the external diameter's circle's lines.
8. Start digging the soil into the marked circle area, down up to 500 millimeters, irrespective of pit size.
9. Before continuing to dig, construct the ring beam using stone/bricks (top 500 millimeters seal) by leaving the internal diameter open and adequately curing the ring beam for 7 days.
10. Once the ring beam dries, continue to dig downwards to the desired depth (e.g. the remaining 2500 millimeters).
11. Dig the pit by sloping inward 100 millimeters every 1000 millimeters depth to avoid the caving in of the pit wall (Figure 10).
12. Remove excavated soil away from the working area at least 2 meters away from the pit, and immediately start the lining work.
13. Cure the lining for seven days and allow the mortar to dry completely before backfilling the space between the lining and ground with sand.

Figure 10: Narrow bottom inverted cone shaped latrine pit (sketch)



V-shaped pit

5.3.1.2 Digging hard (rocky) soil formation

Even though a deeper pit is more advantageous as it will allow the latrine to be used for a long time, sometimes it's difficult to dig in places where the water table is high, or the soil formation is rocky. In areas with rocky soil, the surface soil layer (500 millimeters to 1 meter) may be easily excavated but digging deeper manually may prove difficult. Rocky and hard to dig soil is stable (i.e., the pit will not collapse) and does not require lining, but sometimes the soil will not allow for the excreta's liquid contents to seep into the surrounding ground, and raw fecal matter may overflow and contaminate the soil and surface water.

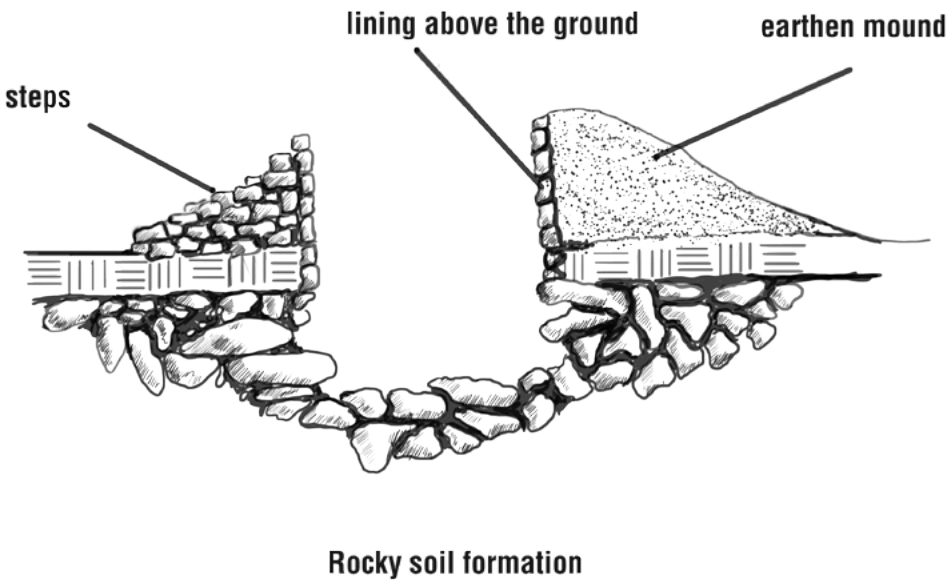
Therefore, in such areas, it is important to consult the local community to get information on:

- How they manage digging the rocky soil (tactics, procedures, type of special digging materials)
- Maximum depth needed to bury a deceased person and how much time it takes to excavate to the required depth, length, and width, and how many persons this undertaking typically involves.

Such information will help determine the pit dimensions, the required height for the soil mound, and the associated costs.

1. If space is not a problem, excavate the pit to the maximum possible depth and increase the pit's width and length dimensions.
2. If space is critical, after excavating the pit to its maximum depth, continue to construct lining (stone, bricks, or concrete ring) up to 1.2 meters above the ground (Figure 11).
3. Bring soil from another place to construct a mound around the pit structure and firmly compact the soil.
4. It is advisable to construct a pit with the same dimensions (i.e., a double vault latrine) to alternately use and avoid reconstruction. Remove the superstructure, slab, and vent from the old vault to install in the new, and seal the old vault with soil and biodegradable materials (up to 500 millimeters depth) for more than 2 years.

Figure 11: Excavation of rocky soil formation and lining of the pit above the ground (sketch)

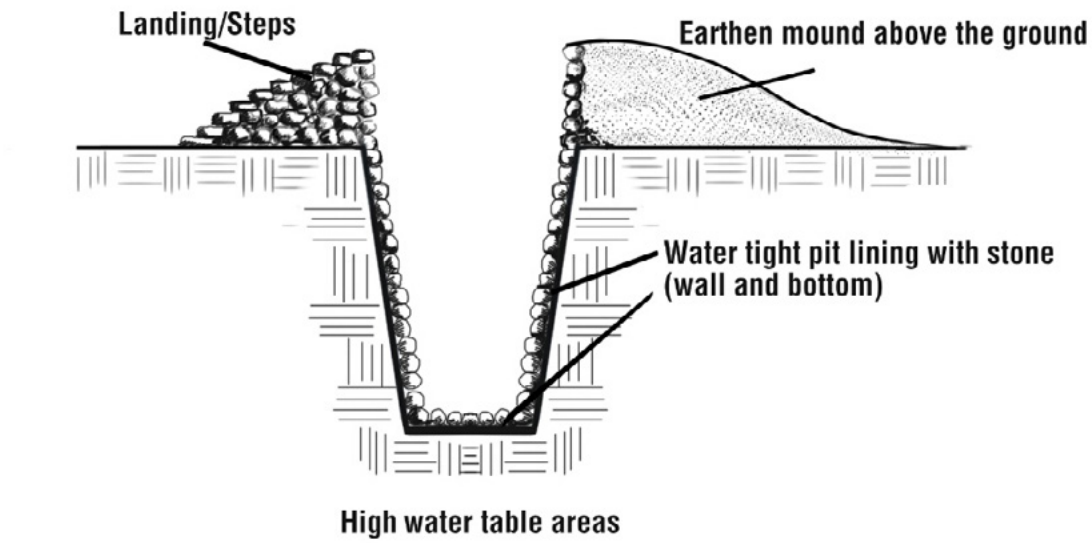


5.3.1.3. Digging a latrine pit in a flood-prone area (or an area with a high water table)

Raised latrines are constructed in flood-prone areas that have a high water table, where the recommended pit depths cannot be attained (Figure 12). In such circumstances, the pit depths are increased by raising the pit walls. In areas with high ground water, the pit is excavated as deep as possible at the end of the dry season, if the water table of the particular area is known.

1. Collect information on the type of soil and static water table during the dry season, as well as the height to which logged water reaches above ground.
2. Dig the pit to the required depth during the dry season when the water table is lowest.
3. Line the bottom of the pit and the whole wall with durable materials (fired bricks, stone, or reinforced blind concrete rings), and make it watertight.
4. Consider the typical height logged water reaches in the area, and extend the lining above the ground level.

Figure 12: Excavation and lining of pit in areas with the highest ground water table (sketch)



5.3.2. Pit lining with different materials

The primary purpose of the lining is to a) prevent the pit wall from collapsing; b) provide support to the slab and superstructure; and c) guarantee safety for the users.

Lining the pit with durable materials makes it easier to remove fecal sludge when the pit becomes full, allowing for its reuse. Durable line materials are resilient and can withstand environmental pressures such as inundation due to flooding and water logging.

- Even though the soil formation is hard and self supporting, the top 50 centimeters of the pit depth should be lined with durable materials and cement mortar joints to a) uphold (support) the slab and superstructure, b) eliminate the pit's chance of caving in, and c) prevent the entrance of runoff and vermin.
- Refill the space between the soil and the lining with gravel and sand. If the liquid part of the fecal sludge is intended to seep into the surrounding soil, the pit lining should not be watertight (space between lining materials should not be closed with mortar).

- Do not forget to cure the lining and allow time (7 days) for the cement mortar to gain full strength.
- In marshy, water logged, and flood prone areas, resilient pre-casted reinforced concrete rings are preferred for lining.
- The latrine's slab must be produced after the pit lining is completed to allow for at least a 100 millimeters overlap of the slab with the pit lining.
- If fecal matter is going to be removed from the pit (as in the case of the pit latrine or pour flush off-set latrine), the cover slab should have a man-hole behind the superstructure through which a hose can be inserted for vacuum emptying, or allow for its complete removal to enable manual desludging.

5.3.2.1 Pit lining with bricks/stone

The decision whether to partially or fully line a pit with bricks or stone depends on the stability of the soil in the area. If the wall of the pit is unstable, it will need to be fully lined. In general, prepare the selected lining materials before digging the pit.

Partial pit lining with bricks and stone

1. Review the pit latrine design (substructure, floor/slab, and superstructure, including its dimensions, shape, and construction materials).
2. Adapt the design on the ground/site and dig 500 millimeters down from the ground level
3. Line the borders of the pit with permanent material (brick or stone).
4. Prepare mortar by mixing 1-part cement in 3 parts clean sand (1:3 ratio). Add water and mix thoroughly.
5. Use mortar to join the bricks/stone, ensuring the bricks/stone are close together. There should not be space between bricks/stones. Use a sprit level to make sure the bricks/stone are even with each other.
6. Line to the top of the pit. The lining should go a little above the pit.
7. Cure adequately and allow the mortar to dry.
8. Dig the rest of the pit within the lining.

Full pit lining with bricks and stone

1. Review the pit latrine design (substructure, floor/slab, and superstructure, including its dimensions, shape, and construction materials).
2. Dig the entire depth of the pit.
3. Level the bottom and clear away loose dirt and rocks.
4. Line the border of the pit with bricks/stone or wooden material (Figure 13).
5. Leave space between bricks/stone (seepage holes) by mortaring every other joint through which the liquid part of the latrine content (sludge) can seep into the surrounding soil. Do not forget to seal the top 500 millimeters with mortar to avoid the entrance of runoff and vermin.
6. If lined with bricks or stone, cure for at least 7 days and allow the mortar to dry completely before backfilling the space between the lining and ground with sand. The top 500 millimeters of the pit should be backfilled with clay or mortar.

Figure 13: Pit lining with bricks

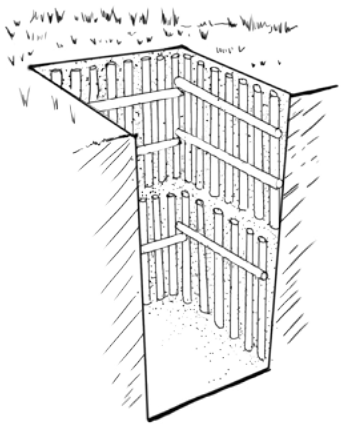
5.3.2.2. Lining with wooden and bamboo materials

1. Cut logs or wooden poles to a length equal to the depth of the pit.
2. Place the logs vertically along the sides of the pit. The space between the logs should be 25 millimeters to 75 millimeters.
3. Cut four poles equal to the length and width of the pit (Figure 9).
4. Nail or tie the poles horizontally across the vertical logs. Do this about 500 millimeters from the top, at the middle and at the bottom of the pit.
5. OR cut and post the bamboo pole at 300 millimeters. Split the bamboo lengthwise into two or three pieces, and weave them inside the pit. If the pit is circular, measure the external diameter and weave the bamboo outside and insert into the pit (Figure 14).
6. Place/use a concrete ring beam on the top of the pit to make it stable (to evenly distribute vertical pressure (load) of the slab on the lining).

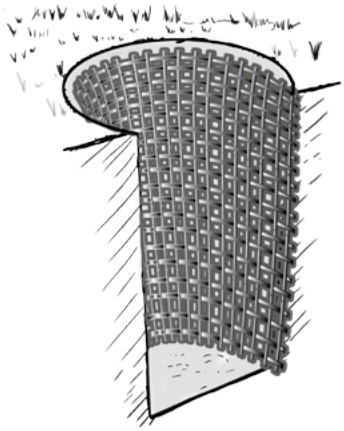
Note:

- **In areas where bamboo trees are available, like in the Benishangul and parts of the Amhara and SNNP regions, woven bamboo can be used to line pits.**
- **Wooden logs usually rot due to damp conditions, or are damaged by termites. Therefore, first treat the logs with used motor oil to minimize rotting and damage by termites.**

Figure 14: Wooden and bamboo materials for pit lining



Lining with Wooden log



Lining with Woven Bamboo

5.3.2.3 Lining with Ferro cement

Whether to fully or partially line the depth of the pit with prepared mortar (mixture of sand and cement) and wire mesh (chicken wire) will depend on the latrine's design.

Procedure for lining with Ferro cement

1. Review the pit latrine design (substructure, floor/slab, and superstructure, including dimensions, shape, and construction materials). Check whether the pit is partially or fully lined.
2. If partially lining the pit, dig 500 millimeters down, or if fully lining the pit, dig the entire depth of the pit.
3. Level the bottom and clear away any loose dirt and rocks.
4. Apply mortar to the walls of the pit; make a layer that is 12 millimeters thick.
5. Apply 2-3 layers of steel wire mesh (chicken wire).
6. You can keep the mesh in place by driving long staples through the mesh and mortar into the soil.
7. Below 500 millimeters, put spacers in the mesh before it is covered with mortar. Insert short pieces of stick (diameter of 20 millimeters each) into the mesh through the first layer of mortar.
8. Apply a second layer of mortar and push firmly into the mesh; the layer should be 10 millimeters thick. The mesh should be completely covered with mortar.

5.3.2.4 Lining with a precast concrete ring

1. Review the pit latrine design (substructure, slab, and superstructure, including dimensions, shape, and construction materials). Check whether the pit is partially or fully lined with a blind or perforated concrete ring, or mixed.
2. If partially lining the pit, dig the top 500 millimeters depth and insert a concrete ring inside the pit, and then dig the rest of the pit inside the border of the ring.
3. If the pit is fully lined, dig the entire depth of the pit.
4. Level the bottom and clear away loose dirt and rocks.

5. Use/insert perforated rings at the bottom of the pit, with holes between 25-50 millimeters in diameter, to allow the liquid contents of the latrine to seep into the surrounding soil (Figure 15). If perforated concrete rings are not available, create holes between the joints of the rings by placing pieces of stone.
6. Seal joints together with mortar or cement.
7. Backfill behind the rings with sand.
8. If the highest ground water table reaches the ground surface, use watertight concrete rings and joints. The bottom of the pit should be watertight.

Figure 15: Blind and perforated precast reinforced concrete rings

Precast reinforced concrete ring

5.4 Construction and installation of latrine slab

Once the construction of the latrine's substructure (excavation and lining) is completed, the construction of the pit slab is next. The household can choose and purchase a slab that is compatible with the pit lining from the local market, or produce a slab on site.

- The slab should adequately support the weight of the user and the latrine's superstructure components.
- Slabs have different sizes and shapes (rectangular, square, or circular). Larger slabs are heavier, and could cause damage to pits lined with wooden or bamboo materials.
- The slab's thickness varies depending on the area of the pit.
- There are two types of concrete slabs:
  - Concrete with no reinforcement bar (SanPlat)
  - Reinforced concrete slab
- Slab should have a squat-hole with a tight cover, but if the latrine is VIP it does not need a squat-hole cover.
- The slab should also have a raised seat and hand rails for households with physically disabled family members.
- A VIP latrine has two holes (a squat-hole and a vent hole).
- The top surface of the slab should be intact (no opening) and smooth for easy cleaning and washing.

5.4.1 Slab options

A number of factors determine households' choice of latrine slab, such as the local availability of different slab types; whether or not the slab is easy to install; and its costs. A slab's shape could be circular, rectangular, or square. Slab sizes also vary depending on the size of the pit. Slabs can also be produced from concrete (with or without a reinforcement bar), plastic, or wooden materials.

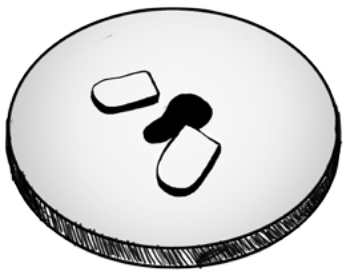
Figures 16 to 21 provide important information on slab types and shapes. Table 9 also provides basic descriptions and outlines the advantages and disadvantages of different slab options to aid households and producers to make informed choices.

Types and shape of slab options

Figure 16: Reinforced square or rectangular concrete slab

Reinforced square or rectangular concrete slab

Figure 17: Reinforced circular concrete slab

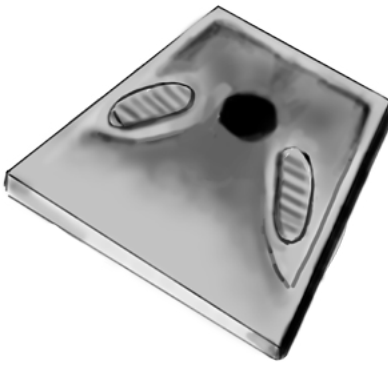


Reinforced circular concrete slab

Figure 18: SanPlat concrete slab

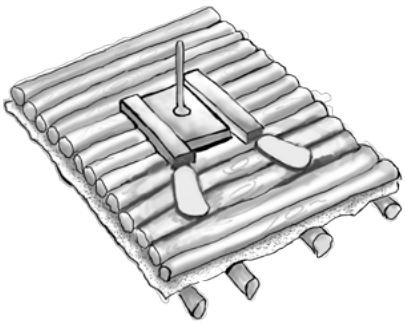
SanPlat concrete slab

Figure 19: Plastic slab



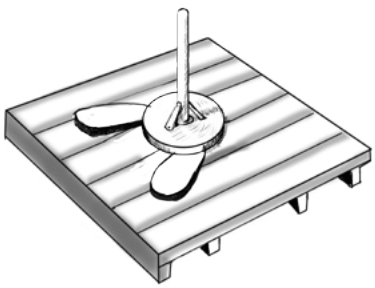
Plastic slab

Figure 20: Wooden Slab (riprap)



Wooden Slab (riprap)

Figure 21: Wooden slab (timber)



Wooden slab (timber)

Table 10: Description of the advantages and disadvantages of latrine slab options

Slab options	Slab size (Example)	Description	Construction skill	Advantage	Limitations
Wooden slab	1100mm x 1100mm x 100mm	Wooden riprap or timber supported by wooden logs placed over the top of the pit. Riprap should be mud plastered to allow for easy cleaning and to fill the opening between the ripraps.	The owner or local carpenters can build the wooden slab.	– Constructed with locally available construction materials – Lighter compared to a concrete slab and can be installed over pit lined by any type of material (either with wood, bamboo, bricks, stone, or Ferro cement) – Low cost compared to all other slabs	– Not washable but cleanable – Can decompose or be damaged by termites if not treated with used motor oil – Not suitable in areas where wooden logs are unavailable – Not environmentally friendly (contributes to deforestation)
SanPlat	600mm x 600mm x 600mm	SanPlat concrete slab is a small-sized concrete slab produced with no reinforcement bar, and supported by a wooden slab (riprap).	– Can be locally produced and installed by the local mason and carpenters with some skills training – Placed on the wooden slab	– Durable, safe, reusable, and washable – Easily transported – Easily cleaned – Lighter compared to reinforced concrete slab and can be installed over pit lined with any type of material (wood, bamboo, bricks, stone, or Ferro cement)	Wooden slab (support) can decompose or be damaged by termites
Rectangular, square, or circular reinforced concrete slab		It is a precast concrete slab reinforced with an iron bar. Thickness of the slab increases as size increases. An iron bar with a diameter is used as the size of the slab increases.	Produced by local masons with adequate skills training.	– Durable, safe, and reusable – Washable and easily cleaned – Suitable to install over the pit lined either with wooden logs, bricks, stone, or Ferro cement – It is also possible to install over pit dug in stable soil with its top 50 cm sealed with gravel and mortar	– It collapses if placed over the pit lined with bamboo – Relatively high cost
Circular dome-shaped concrete slab		A precast concrete slab built without reinforcement.	Produced by local masons with adequate skills training.	– Durable, safe, and reusable – Washable and easily cleaned – Suitable to install over the pit lined either with bricks, or stone – It is also possible to install over a pit dug in stable soil with its top 50 cm sealed with gravel and mortar	– It collapses if installed over the pit lined with bamboo – Relatively high cost
Plastic slab		An industrial product manufactured from polyethylene vinyl chloride (PVC).	Installed by local masons and carpenters with minimum skills training.	– Durable, safe, and reusable – No rusting/corrosion – Washable and easily cleanable – Suitable to install over a pit lined with any type of lining materials – Relatively low cost compared to reinforced concrete slab	Not widely available in the local market and needs promotion

5.4.2 Determining the shape and size of the slab

The latrine's shape and size is determined by the pit's shape and size, as well as the thickness of its lining. The size of slab should be slightly wider to provide an adequate overlap of at least 10 centimeters with the width of the pit lining. Therefore, the slab could be circular, flat, rectangular, dome-shaped, or square-shaped.

Whether produced on site or purchased from the local market, the slab's shape and size should be compatible to the shape and size of the pit lining.

- If the pit is circular, the slab shape should be circular to cover the pit tightly. The same goes for square and rectangular pits.
- The slab's type and size (diameter, length, width, and thickness) should take into consideration the type of lining used for the pit.
- If the pit is not lined with durable material (stone, bricks, or a reinforced concrete ring), do not use a reinforced concrete slab as it may endanger the user by causing the latrine to collapse. Instead, use lighter slabs (like wooden and plastic slabs).
- Wide pit sizes need large, thick slabs that are reinforced by thick iron bars with narrow spaces in between them.
- The slab size should overlap 100 millimeters to 150 millimeters (10-15 centimeters) with the pit's lining on all sides.

Table 11: Linkage between the pit and a slab's shape and size

Pit shape	Lined pit size	Type and shape of slab product	Slab size	Remarks
Circular pit	Internal free space diameter of 1200mm (1.2m)	Reinforced concrete circular slab	Diameter of 1500mm (1.50m)	– 150mm (15 cm) overlap with pit lining – Slab split into three pieces – Re-bar diameter of 12mm and inter-bar space 15cm – Slab thickness of 100mm (10cm)
	Internal free space diameter of 1100mm (1.1m)		Diameter of 1400mm (1.40m)	– 150mm (15 cm) overlap with pit lining – Slab split into three pieces – Re-bar diameter of 12mm and inter-bar space15cmm – Slab thickness of 100mm (10cm)
	Internal free space diameter of 1000mm (1m)		Diameter of 1300mm (1.30m)	– 150mm (15 cm) overlap with pit lining – Slab split into two pieces – Re-bar diameter of 10mm and inter-bar space 10cmm – Slab thickness of 80mm (8cm)
	Internal free space diameter of 900mm (90cm)		Diameter of 1200mm (1.20m)	– 150mm (15 cm) overlap with pit lining – Re-bar diameter of 10mm and inter-bar space 12cm – Slab thickness of 100mm (10cm)
	Internal free space diameter of 800mm (80cm)		Diameter of 1100mm (1.10m)	– 150mm (15 cm) overlap with pit lining – Re-bar diameter of 10mm and inter-bar space 12cm – Slab thickness of 100mm (10cm) – Pit diameter less than 80cm does not allow excavation

Pit shape	Lined pit size	Type and shape of slab product	Slab size	Remarks
Rectangular pit	Internal free space area of 1000mm x 1200mm	Reinforced concrete rectangular slab	1300mm x 1500mm (1.30m x 1.50m)	– 150mm (15 cm) overlap with pit lining – Slab split into three pieces – Re-bar diameter of 12mm and inter-bar space 15cm – Slab thickness of 100mm (10cm)
	Internal free space area of 900mm x 1100mm		1200mm x 1400mm (1.20m x 1.40m)	– 150mm (15 cm) overlap with pit lining – Slab split into three pieces – Re-bar diameter of 12mm and inter-bar space 15cm – Slab thickness of 100mm (10cm)
	Internal free space area of 800mm x 1000mm		1100mm x 1300mm (1.10m x 1.30m)	– 150mm (15 cm) overlap with pit lining – Slab split into two pieces – Re-bar diameter of 10mm and inter-bar space 12cmm – Slab thickness of 100mm (10cm) – Pit with less than 80cm width does not allow excavation
Square pit	Internal free space area of 800mm x 1000mm	SanPlat without reinforcement	700mm x 700mm (0.7m x 0.7m)	– Placed over the wooden log/riprap – Slab thickness 60mm (6cm) – Can be installed on Arborloo latrine
	Internal free space area of 800mm x 1000mm		600mm x 600mm (0.6m x 0.6m)	– Placed over the wooden log/riprap – Slab thickness 60mm (6cm) – Can be installed on Arborloo latrine
Square pit	Internal free space area of 1200mm x 1200mm	Reinforced square concrete slab	1500mm x 1500mm (1.50m x 1.50m)	– 150mm (15 cm) overlap with pit lining – Slab split into three pieces – Re-bar diameter of 12mm and inter-bar space 15cmm – Slab thickness of 100mm (10cm)
	Internal free space area of 1100 mm x 1100 mm		1400mm x 1400mm (1.40m x 1.40m	– 150mm (15 cm) overlap with pit lining – Slab split into three pieces – Re-bar diameter of 12mm and inter-bar space 15cmm – Slab thickness of 100mm (10cm)
	Internal free space area of 1000 mm x 1000 mm		1300mm x 1300mm (1.30m x 1.30m	– 150mm (15 cm) overlap with pit lining – Slab split into two pieces – Re-bar diameter of 12mm and inter-bar space 15cmm – Slab thickness of 100mm (10cm)
	Internal free space area of 900 mm x 900 mm		1200mm x 1200mm (1.20m x 1.20m	– 150mm (15 cm) overlap with pit lining – Slab split into two pieces – Re-bar diameter of 12mm and inter-bar space 15cmm – Slab thickness of 100mm (10cm)
	Internal free space area of 800 mm x 800 mm		1100mm x 1100mm (1.10m x 1.10m	– 150mm (15 cm) overlap with pit lining – Slab split into two pieces – Re-bar diameter of 12mm and inter-bar space 15cmm – Slab thickness of 100mm (10cm)

Pit shape	Lined pit size	Type and shape of slab product	Slab size	Remarks
Rectangular	Internal free space area of 800 mm x 900 mm	Plastic slab	700mm x 800mm	– Placed over the wooden log/riprap – Smooth top surface and ragged bottom – Outer sides of the slab (length and width) are sealed by precast concrete beam and mortar
Square	Internal free space area of 800 mm x 800 mm		700mm x 700mm	– Placed over the wooden log/riprap – Smooth top surface and ragged bottom – Outer sides of the slab (length and width) are sealed by precast concrete beam and mortar
Rectangular or square	Toilet cubicle with floor area of a range of 0.8m2 to 1m2	Plastic/ceramic pan with water seal/trap	588mm x 468mm	– Set up into concrete slab/floor – Can be fitted to an on-set or off-set pour-flush latrine – Height of 291 mm – Connected to water seal/trap and drainage pipe
			520mm x 400mm	– Set up into concrete slab/floor – Can be fitted to an on-set and off-set pour-flush latrine – Height of 190mm – Connected to water seal/trap and drainage pipe

5.4.3 Determining quantities and cost of slab options

The quantities of materials for slab construction and their corresponding costs vary depending on the slab's size and type of construction materials needed. Durable slabs (like reinforced concrete and plastic slabs) are relatively costly compared to wooden slabs. However, although wooden slabs are low cost, they can be damaged by termites or decay, and are not washable or cleanable. The production, purchasing, and installation costs of different slab types vary from region to region and woreda to woreda, depending on the availability of materials and skilled labor in the area.

Access to information about the cost of the slab production materials allows households to decide which slab options are available at an affordable cost. Table 5.4.3 provides information on the specification of quantities of material, purchase of the materials, and labor (unskilled and skilled) required for slab production and installation. Quantities of the materials required for slab production are calculated based on the assumptions set out in the table.

Table 12: Bill of quantities for construction of different square shape latrine slabs

Slab type	Slab size (example)	Description of items	Unit	Qty	Unit price	Total price
Circular reinforced concrete slab with diameter of 1.3m and thickness 100mm, split into two pieces Concrete aggregate ratio: Cement: Sand: Gravel = 1:2:3, and ratio of cement mortar = 1-part cement :3 parts sand	Diameter 1300mm and Thickness 100mm	Cement	Kg	15		
		Sand	Cub. M	0.09		
		Gravel	Cub. M	0.013		
		Reinforcement bar, diameter of 10mm	Kg	18		
		Wire	G	250		
		Vent pipe, diameter of 75mm or 110mm, 2.5 m long	Each	1		
		Mesh with size less than 20mm holes	Sq. m	0.5		
		Water	L			
		Unskilled labor (construction and installation)	Man-day	2		
		Skilled labor (construction and installation)	Man-day	1		
		Total cost				
Reinforced concrete slab Concrete aggregate ratio: Cement: Sand: Gravel = 1:2:3, and ratio of cement mortar = 1-part cement: 3 parts sand	1000mm x 1000mm x thickness 80mm	Cement	Kg	15		
		Sand	Cub. M	0.09		
		Gravel	Cub. M	0.013		
		Reinforcement bar, diameter of 8mm	Kg	7		
		Wire	G	200		
		Vent pipe, diameter of 75mm or 110mm, 2.5 m long	Each	1		
		Mesh with holes sized less than 20 mm	Sq.m	0.5		
		Used motor oil	L	1		
		Straight, smooth, and clean wooden frame (formwork), 1030mm x 100mm x 20mm thick, to prepare mold (slab, foot rest, and squat-hole)				
		Nails (# 5 and #6)	G	0.5		
		Used oil	L	1		
		Water	L			
		Unskilled labor (construction, curing, and installation)	Man-day	2		
		Skilled labor (construction and installation)	Man-day	2		
		Total cost				

Slab type	Slab size (example)	Description of items	Unit	Qty	Unit price	Total price
Concrete SanPlat slab (with no reinforcement) Concrete aggregate Ratio: Cement: Sand: Gravel = 1:2:3, and ratio of cement mortar = 1-part cement: 3 parts sand	600mm x 600mm x 60mm	Cement	Kg	10		
		Sand	Cub. m	0.06		
		Gravel	Cub. m	0.09		
		Vent pipe, diameter of 75mm or 110mm, 2.5m long	Each	1		
		Mesh with size less than 20mm	Sq.m	0.5		
		Used motor oil	L	1		
		Straight, smooth, and clean wooden frame (formwork), 1030mm x 100mm x 20mm thick, to prepare mold (slab, foot rest, and squat-hole)				
		Nails (# 5 and #6)	G	0.5		
		Used oil	L	1		
		Water	L			
		Unskilled labor (construction, curing, and installation)	Man-day	2		
		Skilled labor (construction and installation)	Man-day	2		
		Total cost				
Wooden slab	1100mm x 1100mm x 100mm	Wooden logs, diameter of 100mm each, 1.3 meter long	Each	6		
		Wooden log, diameter of 6cm each, 1 m long	Each	17		
		Nails # 8 and #9	Kg	1		
		Used oil	L	5		
		PVC vent pipe, diameter of 75mm or 110 mm, 2 m long	Each	1		
		Mesh wire of size less than 20mm	Sq.m	0.5		
		Wire	M	3		
		Unskilled labor (construction and installation)	Man-day	2		
		Skilled labor (construction and installation)	Man-day	2		
		Total cost				

Slab type	Slab size (example)	Description of items	Unit	Qty	Unit price	Total price
Purchase and installation of plastic slab	700mm x 700mm x 80mm	Plastic slab, ridged at its bottom with squat-hole cover, eight openings for nailing or screwing (2 on 4 sides)	Each	1		
		Nails #8, # 9, and #10	Gram	1000		
		Wooden logs 1000mm diameter each 1.2m long	Each	4		
		Reinforcement bar 8mm diameter	M	10		
		Cement	Kg	0.23		
		Sand	Kg	0.05		
		Gravel	Kg	24		
		Unskilled labor (construction and installation)	Man-day	1.5		
		Skilled labor (construction and installation)	Man-day	1.5		
		Total cost				
Purchase of ceramic/plastic pan and installation/ setting of ceramic/ plastic pan into concrete floor/slab	Size 588mm x 468mm x 291mm Size: 520mm x 400mm x 190mm	Plastic pan or ceramic pan with integrated S-trap, seamless finish, smooth surface, back outlet, for floor or slab mounting and easy fitting, with accessories and installation manual		1		
		Drain PVC pipe of 110mm diameter of 6m long	Pcs	1		
		Fired bricks for the construction of diversion chamber, dimensions of 400mm x 400mm x 400mm, and setting of pan into the concrete floor/slab	Each	35		
		Cement for the construction of diversion chamber, dimensions of 400mm x 400mm x 400mm, and setting of pan into the concrete floor/slab	Kg	15		
		Sand for construction of diversion chamber (dimensions of 400mm x 400mm x 400mm), and setting of pan into the concrete floor/slab	Kg	50		
		Unskilled labor (construction and installation)	Man-day	1		
		Skilled labor (construction and installation)	Man-day	1		
		Total cost for purchasing and installation or setting of plastic or ceramic pan into the concrete floor/slab				

5.5 Step-by-step guidance for the construction of concrete slabs

5.5.1 Construction of the reinforced concrete slab

Despite differences in sizes and shapes, the construction of reinforced concrete slabs follows the same procedures and comprises of seven important steps. This section provides the sequential instructions under each step. In addition, some precautionary notes are also provided. The seven steps include:

1. Prepare a work area and materials for slab construction
2. Construct a wooden, metal, or fiber frame (formwork)
3. Placement of reinforcement bar
4. Mix concrete
5. Pour the concrete
6. Finish the concrete slab
7. Cure the concrete slab
8. Add features to a slab for people with disabilities (optional)

To demonstrate the procedure step-by-step, the following example illustrates the construction of a slab with the dimensions of 1000 millimeters X 1000 millimeters X 80 millimeters.

Step 1: Prepare a work area and materials for slab construction

The area where the slab will be constructed should be level and free of organic materials such as leaves, animal feces, and debris. Clean the work area and spread sand over it. The ideal place for slab construction is under the shade to avoid direct heat from the sun and allow the slab to dry slowly.

Step 2: Construct a wooden frame (formwork)

- Level the ground at the work space (site) for the placement of molds, and the preparation of concrete. The work site should be under the shade (i.e., not exposed to direct sunlight or rain).
- First assemble the molds for both the internal and external slabs as well as the squat-hole, and with used motor oil, grease the molds' inner surfaces that will come in contact with concrete.

Step 3: Placement of the reinforcement bars

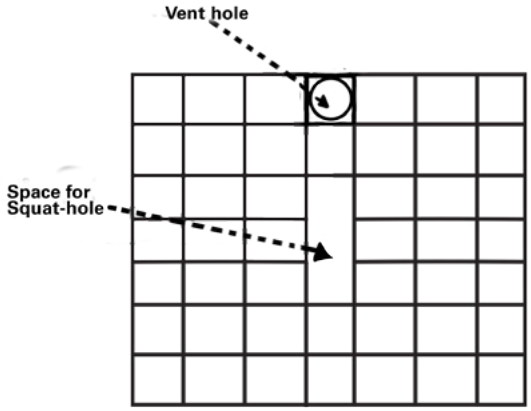
To construct a 1000 millimeters x 1000 millimeters slab, with a thickness of 80 millimeters,

- Use a reinforcement bar with a diameter of 8 millimeters
- Cut the reinforcement bar into 995 millimeters-long pieces
- Arrange the reinforcement bars in vertical and horizontal rows, with a space of 120 millimeters between each bar
- Tie each intersection with wire
- Measure 28 centimeters inwards to the center from all sides and cut two central bars
- Place the reinforced grid bar into the slab frame (Figure 22)
- Place a rock/stone under the four corners of the grid and its center to raise the grid up from the floor
- Paint the squat-hole mold with motor oil and place it on the grid (wider edge should be nearest to the back, 28 centimeters from the slab's edge, and inward and narrow edge should be at the

front).

- Place foot rest mold near the grid's rear edge, at the two-thirds length of the squat-hole mold (235 millimeters). Lay both foot rest molds outwards, left and right, at a 45 degree angle.
- Leave a circular space that has a diameter of 115 millimeters for the vent pipe at the slab's rear.

Figure 22: Reinforcement bar laid in the formwork (mold)



Step 4: Mix the concrete

Concrete is a mixture of cement, sand, gravel, and water.

1. Check that the slab frame (formwork) is properly placed, and that the squat-hole and vent pipe molds are in place before mixing the concrete.
2. Treat the squat-hole mold with motor oil before placing it on the grid.
3. Use the same unit of measure (bucket) to measure cement, sand, and gravel into one pile.
4. Proportion of amount of Cement: Sand: Gravel = 1C : 2S : 3G. This means, using the same bucket, measure:
   - 1 part (bucket) cement
   - 2 parts (bucket) sand (lean and free of silt or soil)
   - 3 parts (bucket) gravel, sized with a diameter of less than 20 millimeters
5. Properly mix the cement, sand, and gravel together on a clean surface until it is completely combined and continue mixing evenly until all of the aggregate (gravel and sand) is covered with cement.
6. Create a hole by opening a space in the middle of the mixed concrete and add water and mix again.
7. Slowly add water, mixing as you go and never letting the water flow outwards.
8. Concrete should have a soft and moist consistency, like dough (i.e., not too stiff or runny).

Note:

- **If concrete mixture is too dry it will cure too quickly and the slab will crack or break. If concrete mixture is too wet, it may form pockets of water, which will also weaken/ crack the slab's structure.**
- **Dirt and organic materials accidentally mixed in the concrete will also weaken the concrete mixture/structure**
- **Use clean sand and gravel (free of dirt, clay, silt, and organic matter)**
- **Take care not to mix concrete with soil**
- **Use good-quality cement**

Step 5: Pour the concrete into the slab formwork (mold)

1. Pour the concrete continuously, starting at one edge of the slab and working it through the rest of the slab. Avoid pouring in separate piles.

Note:

- **Concrete should not be dumped in separate piles and then leveled and worked together; nor should the concrete be deposited in large piles and moved horizontally into final position.**

2. Once the concrete is distributed throughout the slab, vibrate the concrete using a wooden float to get rid air bubbles, and fill the mold until the concrete reaches the slab's top edge.
3. Slowly screed the top surface of the concrete using a wooden board.
4. Move excess concrete and level the area around the squat-hole using a float.

Step-6: Finish the concrete slab

1. Smooth the concrete's top surface with a wooden float.
2. Use the float to work the gravel/stones into the slab and allow the sand and cement to come to the surface. Apply pressure and vibrations to the concrete. This will eliminate air pockets that could reduce the durability/strength of the slab.
3. Test whether the concrete is firm by pushing down your finger up to a depth of 1 centimeter and using a float, smooth the surface and rough edges.
4. Finish the sides of the slab by using a trowel or edging tool.
5. Remove any sharp edges or ridges from the slab's top surface by lightly dragging the edge of a metal trowel along the surface in a sweeping motion.
6. Set the foot rests (align the foot rest molds with the squatting hole, scratch the surface of the concrete slab inside the mold with the edge of a metal trowel where foot rest will be set, and gradually place the concrete into the foot rest molds).
7. Repeat steps 1-3.
8. First allow the concrete to set for about an hour. Then, remove the footrest frames (molds).
9. Continue toweling the surface until the concrete shines.
10. Cast the squat-hole and smooth the edges.

Smooth the edge of the squat-hole to make cleaning easier and to tightly fix the hole-cover.

a. Before the concrete sets, gently hit the squat-hole mold with a hammer to reduce air bubbles.
b. When the concrete is firm to the touch, remove the squat-hole mold.
c. Moisten the cement with water and gently smooth the edges of the squat-hole.
d. Remove any sharp or protruding sand and gravel materials.
e. Continuously repeat this process until the squat-hole's edges are smooth and free of sharp edges.

Step 7: Cure the concrete slab

Curing involves keeping the slab moist and under the shade for at least a week or beyond until it attains full strength. Properly curing the concrete slab for more than seven days ensures its strength and durability. Keeping the slab moist allows the slab to dry slowly. If the slab dries too fast, it may crack and finally break.

1. Water should not be added within the first 8-10 hours (initial setting after the casting) because concrete itself has water.
2. Start to cure (sprinkle water on the slab's exposed surface) after 10 hours, at least twice a day for 10-14 days (final setting).
3. Keep the slab wet /moist by placing wet straw or cloth directly over its surface.
4. Remove the formwork (frame) after seven days and move the slab after 14 days.
5. Keep the slab in the same place and under the shade for 14 days, and do not install before 28 days (after which it should completely harden).

Note:

- **Sprinkle water on the concrete slab at least once per day for seven days.**
- **Keep the slab under the shade for about one month (to ensure its full strength).**
- **Do not use cement from a bag that was previously opened, stored too long, or has formed a hard mass.**

Addressing the needs of family members with physical disabilities

There are households with physically disabled family member(s) who must use a wheel chair or arm support for walking. Thus, the slab must be modified to meet the needs of a person who uses a wheel chair.

Adding features to a slab used by people with disabilities

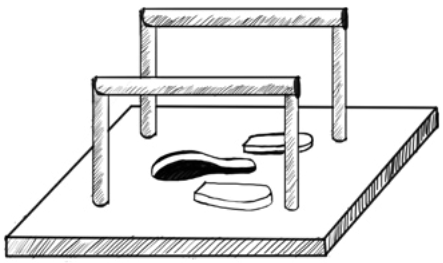
Handrails

Add or embed strong handrails (usually galvanized iron pipe with a diameter of 30mm) into the reinforced concrete slab to support the weight of the user when they are sitting or squatting and when they stand up after defecation) (Figure 23).

Fix or weld the handrails with a reinforcement bar

Consult the user with the disability about the required distance between the handrails and their height before fixing (welding).

Figure 23: Galvanized iron pipe handrails



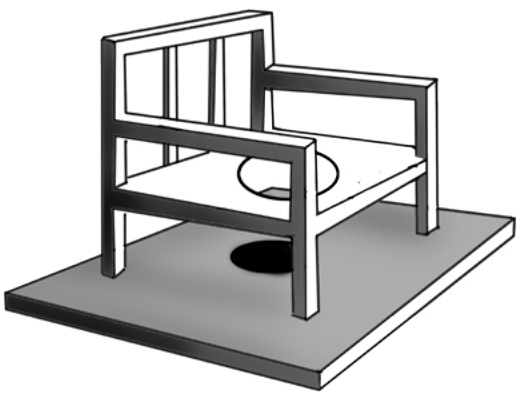
Galvanized iron pipe Handrails

If wooden handrails are used, it should be strongly fixed on the wall

Raised toilet seat and ramp

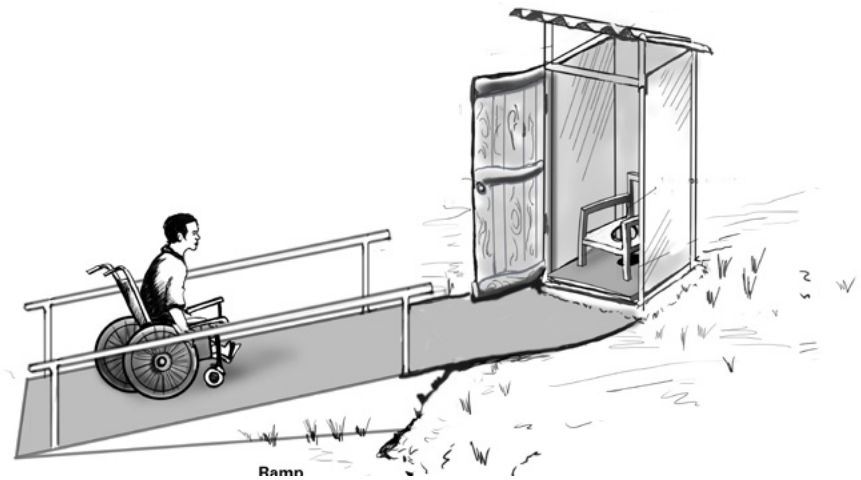
- People whose legs do not function because of paralysis or an accident usually use a wheel chair to move from place to place or crawl using their hands and other body parts.
- For the disabled to easily access a latrine, the latrine seat should be a raised (sitting) type. A sitting type of latrine pan allows people with disabilities to transfer from their wheel chair to the seat, and for elderly people to lower themselves.
- A raised latrine can be easily constructed from wood (like a chair with handrails) (Figure 24a).
- Fix the legs of the chair on the concrete slab.
- Construct a ramp with a slope of 20 percent for family members who use a wheelchair to easily access the latrine (Figure 24b).

Figure 24a: Raised wooden latrine seat



Raised wooden latrine seat

Figure 24b: Ramp



5.5.2. Construction of sanitary platforms (SanPlat)

A SanPlat is a concrete slab with a size of 600 millimeters x 600 millimeters x80 millimeters, without reinforcement bars. This type of slab provides an alternative for households who cannot afford to buy a reinforced concrete slab. Constructing the SanPlat applies the same principles, procedures, and materials as the reinforced concrete slab, with the exception of the reinforcement bar.

Note:

Concrete slabs are heavy to transport from the locations they are produced or sold, to where they will be installed. Households may choose to transport a slab using human labor, the backs of animals, or a cart pulled by animals. Therefore, to carry, load, unload, and transport a concrete slab, it is very important to divide it into two to three pieces during its production.

- **Prepare wooden timber splints that are straight, smooth, and of different lengths.**
- **Paint the timber with used motor oil.**
- **Place the timber splint at equal distance from one end to the other end in the formwork (mold) before pouring the concrete - Section 5.5.1 –step 2.**
- **If you want to divide the slab into two equal pieces, measure and place the splint at center; but if you want to divide the slab into three pieces, measure and place two splints at equal distances.**
- **Measure and cut (length and width wise) for each piece and place the reinforcement bar in the formwork (mold) – section 5.5.1- step 5.**
- **Pour concrete into the formwork (mold)- section 5.5.1 -step 5.**
- **Do the same activities under section 5.5.1 step 6.**
- **Smooth the top surfaces of each piece of slab and the edges of the squat-hole, but scratch and leave rough the slab's top surface where the foot rest will be set during installation.**
- **Allow the concrete to set for one hour and then remove the splint (s) slowly. Do not smooth the edges.**
- **Adjoin pieces of one slab together during installation using cement mortar.**
- **Set the foot rest on the slab's scratched surface.**

Figure 25: Concrete slab divided in to two pieces

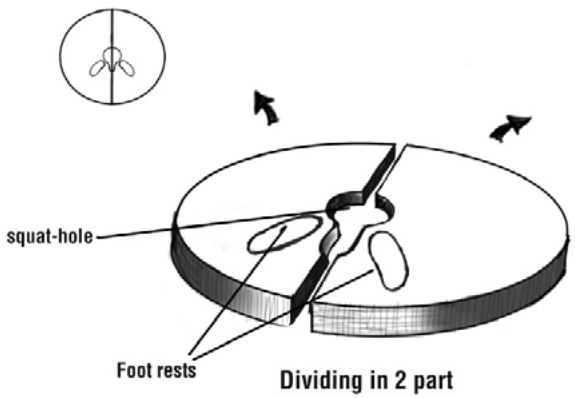
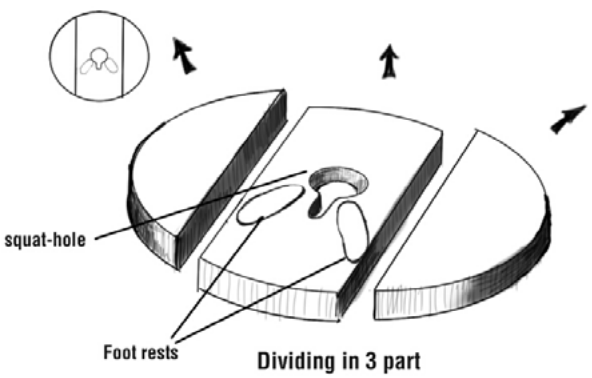


Figure 26: Concrete slab divided in to three pieces



5.5.3. Construction of wooden slabs

The top part of the wooden slab can be plastered with mud to create a flat surface for easy cleaning. A SanPlat or plastic slab can be placed on the wooden slab.

The construction of wooden slabs follows four steps:

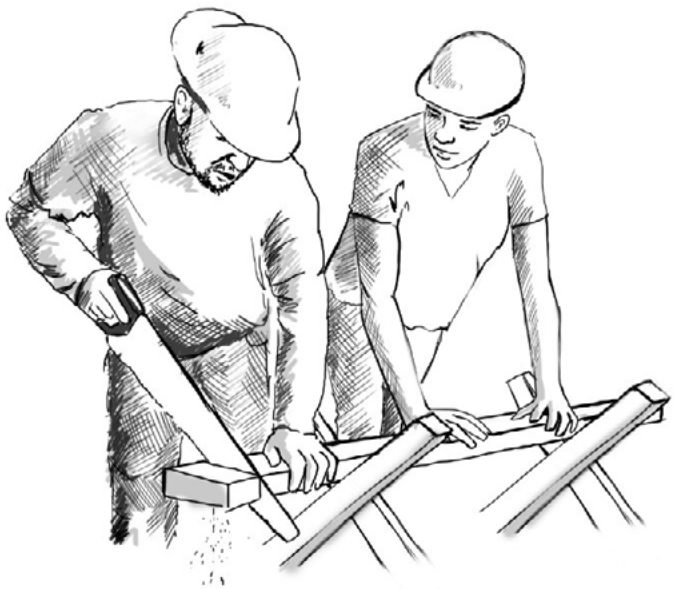
1. Measure and cut wood
2. Treat wood
3. Construct slab
4. Plaster the floor with mud mixed with cement
5. Construct four reinforced concrete ring beams (to place two along its length and two for its width) to prevent termites from accessing the wooden riprap

Step 1: Measure and cut the wood

For example, to construct a wooden slab with an internal size of a 1000 millimeters x 1000 millimeters:

1. Measure pieces of strong wood to fit over the latrine pit, with an overhang of 400 millimeters on each side. (Length of the overhang should be 400 millimeters on one end and 400 millimeters on the other to eliminate the chance of collapse and ensure the user's safety). Then, the total length of the wood will be 1000 millimeters + 400 millimeters + 400 millimeters = 1800 millimeters. A flat wooden slab is easier to construct and clean than a round wooden slab.
2. Measure 300 millimeters from the back wall and create a rectangular squat-hole with length 330 millimeters X width 180 millimeters in the middle of the front wall (90 millimeters from the left and 90 millimeters from the right side). Measure and cut pieces of the riprap wood to fit to the dimensions of the squat-hole and place/fix on the supporting wood.
3. Measure six pieces of wood for lateral support (four for lateral support and two for middle support, each with a length of 1800 millimeters, to be laid out to support the shortened pieces of woods cut to create the squat-hole).
4. Cut the pieces of wood at the appropriate lengths.

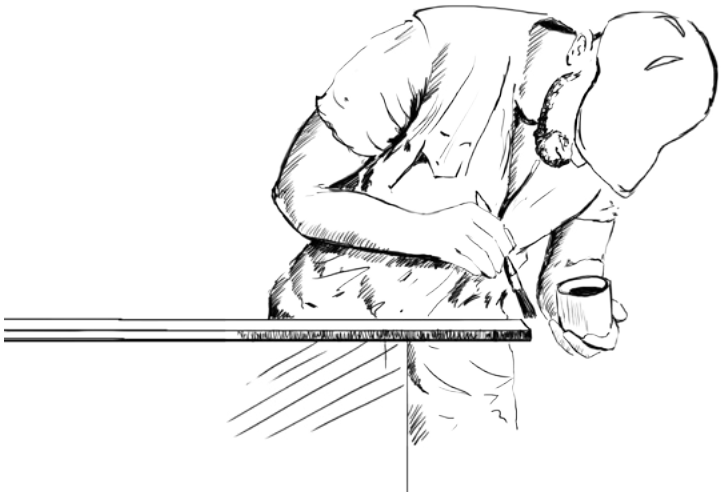
Figure 27: Picture of a carpenter measuring and cutting the wood



Step 2: Treat the wood

1. To prevent termites and rotting, treat wood with used motor oil or paint. Spread ash or lime where the wood will rest before setting down the lateral and middle wooden support, or wrap the wood with plastic materials.
2. Before installing the slab, allow the oil used to dry.

Figure 28: Picture of a person painting (treating) wood



Step 3: Lay the wooden slab

1. Lay pieces of wood, approximately one meter long, parallel to each other. This will create the top of the slab.
2. The shorter pieces of wood should be placed in the middle of the slab to create a squatting hole.
3. Place the four lateral supports horizontally across the slab, two on each side of the squatting hole in the opposite direction to the wooden slab (riprap). Fix firmly the lateral and middle support wood to the concrete beam.
4. Nail firmly each riprap wood to the lateral and middle supporting wood.

Figure 29: Picture of a carpenter nailing riprap to the lateral supporting pieces of wood

Step 4: Plastering the wooden slab with mud

1. Mix mud and grass or straw and spread on slab to create a thick, flat layer. Plastering helps to close openings between the riprap, prevent fly egress, make cleaning easy, and contribute to stability during use.
2. Do not step on the plastered slab before the mud dries and becomes hard.
3. Add cement to mud to harden the floor surface. If cement is not available, use soil from the termite mound that is hard and waterproof.

Figure 30: Picture of a person plastering the wooden slab

Note:

- **Termites are a common challenge in the Rift Valley, low lands, and western parts of Ethiopia.**
- **Termites cause damage to structures built using wooden materials (such as houses, latrines, fences, and food stores) and have a direct and indirect economic and environmental impact.**
- **Wooden slabs are susceptible to and easily damaged by termites. Wooden slabs are not preferred to other slab options, unless households cannot afford other options or they are unavailable in the area.**
- **If no other option exists, treat (paint) the wooden materials used for the construction of the slab and superstructure with used motor oil and/or wrap with plastic materials.**
- **Mobilize the community to destruct termite mounds (nests) by excavation, flooding, and/or suffocation.**

5.6 Installation of slabs

5.6.1. Installation of concrete slabs

- Installation of the SanPlat and reinforced concrete slab is done after the slab is fully dried and has attained its full strength (i.e. after 28 days).
- The top 500 millimeters depth around the top of the pit should be constructed by a strong material (stone or brick with concrete mortar) to support the slab's weight. Otherwise, as the slab is heavier (it should weigh above 80 Kg), it may damage the pit's lining.
- Therefore, do not install a reinforced concrete slab on a substructure lined with weak materials (such as wood and bamboo).

1. Place the slab on the top surface of the pit lining.
2. The slab surface should overlap with the pit lining at least 100 millimeters on all sides.
3. Using concrete mortar, seal the openings between the slab's bottom surface and the lining,

Figures 31 and 32 show a foundation constructed from bricks to support the circular and rectangular reinforced concrete slab.

Slab Foundation (top 500mm depth)

Figure 31: Circular Foundation

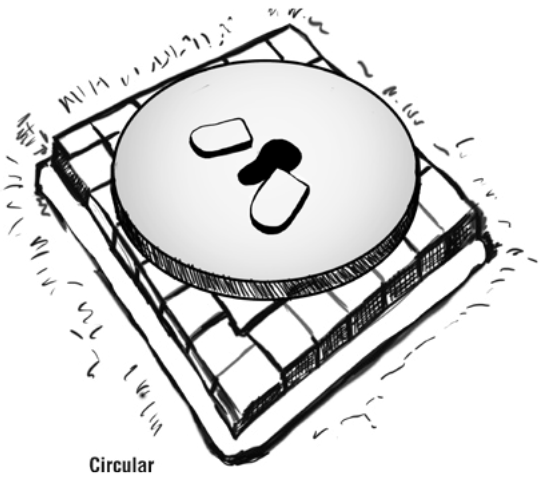
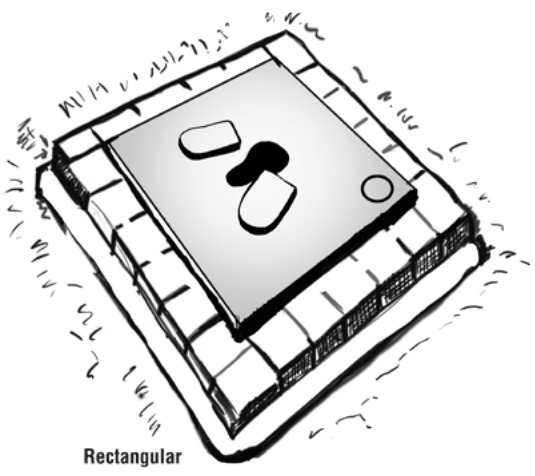


Figure 32: Rectangular Foundation



1. Construct the superstructure (see section 5.7).
2. Seal any opening with concrete mortar at the juncture of the slab, wall, and top surface of the pit lining.
3. Smooth the slab's top surface to remove any hard materials for easy cleaning and washing.

5.6.2. Installation of plastic slabs

Once the pit lining is completed and ready for the installation of the plastic slab, follow the next steps, which use the example of a pit with an internal size of 1000 millimeters x 1000 millimeters.

1. While constructing the pit lining, leave spaces for two wooden logs (each with a diameter of 120 millimeters) to be placed on all four sides for slab support.
2. Prepare the four wooden logs, each 1200 millimeters long and treated with used motor oil to prevent rotting.
3. Measure, cut, and place the wooden logs (two along the width and two along the length) on the designated space on top of the pit lining. Measuring is important so that the points where the plastic slab is screwed or nailed on the top side of the wooden logs fit on each of the four sides.
4. If the size of the plastic slab does not fit with the pit's internal size, prepare four pieces of a reinforced concrete beam, with the dimensions of 1200 millimeters x 100 millimeters x 80 millimeters (thickness), to cover the outer opening surrounding the plastic slabs.
5. Place and fix the wooden logs together at each crossing point with nails.
6. Place and fix the precast concrete beams with concrete mortar.
7. Remove the uneven top surface of the pit lining (all surfaces and edges where the plastic slab rests) or make smooth by using cement mortar.

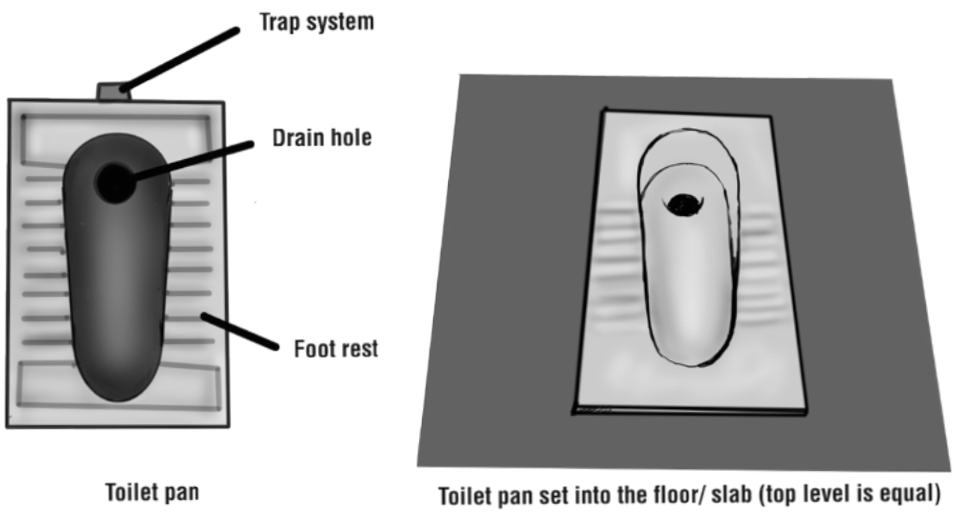
8. Place and fix the plastic slab to the wooden logs on each side, using nails or screws.
9. Build the superstructure (see section 5.7)
10. Seal any opening between the plastic slab and concrete beams with cement mortar.
11. Level the top surface of the concrete beam and plastic slab so that they are at equal height and make smooth with cement mortar.
12. Finally, clean the top surface of the slab to get rid of any rough materials.

5.6.3. Installation or setting of plastic or ceramic pan into a concrete slab

Most of the time, toilet pan suppliers sell the pan with an installation manual. In addition, the finished top of the slab and the top of the toilet pan should be on an equal level (Figures 33 and 34). Therefore, sufficient space must be arranged ahead of time while constructing the concrete slab by measuring the dimensions (length, width, and depth) of the squatting pan and leaving additional space for the installation of the S-trap or P-Trap and slab.

1. Remove stone or cement stone from the open space where the pan is to be set.
2. Place bricks under the trap to hold the pan and place the pan on the bricks at the level of the slab.
3. Connect the S-Trap or P-Trap to the pan's drain hole on one end and to the drain pipe on the other end.
4. Check the water seal by adding water and checking whether the water gently flows through the drainage pipe (slope) to the soak away pit.
5. Check whether the top of the pan is equal to the level of the finished slab (by using a sprit level).
6. Fill any void space beneath the pan with concrete cement (mortar), as well as space between the slab, pan (on all sides), and beneath and around the S-Trap.
7. Check the level again and correct any deviations.
8. Immobilize the pan and S-trap until it becomes stable.
9. Using a sponge or wet cloth, gently smooth or remove any rough objects (like remnants of mortar), sand, or cement powder on the surface of the squatting pan and in the hole before it dries.
10. Cure the mortar for at least seven days.

Figure 33 and 34: Toilet pan set in to the floor or slab



Different types of materials for walling and roofing of household latrines

Figure 35: Stone-mud wall (movable wall)

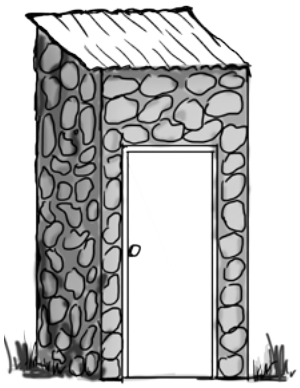


Figure 36: Brick wall (permanent wall)

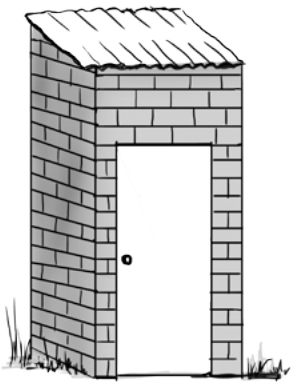


Figure 37: CIS wall and roof (movable wall)

Figure 38: Wooden wall with CIS roof

Figure 39: Mud plastered wooden wall/thatched roof

Figure 40: Grass/leaf wall and roofing

5.7 Construction of latrine superstructure

- The latrine's superstructure is comprised of components located above the ground. These include walls, a door, and roofing.
- The superstructure prevents the pit from filling with runoff water, and wooden slabs from decaying.
- It also protects the user from sun and rain, and provides privacy during defecation. A good superstructure also provides security for women.
- The latrine's cubicle should have enough space to provide comfort to the user (not less than 0.9m2) and adequate walling and roofing.

5.7.1. Latrine walling and roofing options

- The design of the latrine's superstructure and materials used for its construction vary from place to place depending on the area's culture, household's livelihood, and availability of construction materials in the locality.
- The selection of walling and roofing materials should consider the strength of the pit lining materials and the prevalence of termites. Lighter materials like wood, bamboo, CIS, canvas, and grass are advisable.
- In areas where lighter materials are not available or affordable, heavy materials like mud blocks, bricks, and stone can be used, but the wall structure must not rest on the slab or pit lining.
- Construction materials for the superstructure (walling and roofing) could be permanent or transferable, and depend on the preference of the household, availability of the materials and skills to construct the latrine, and other associated costs.
- Similar to a dwelling house, wood, stone, grass, leaves, mud bricks, corrugated iron sheets, and polyethylene plastic sheets are commonly used materials for the construction of a latrine's wall and roofing (Figures 35-40).

5.7.2 Determining quantities and costs of latrine walling and roofing materials

- Bricks and Corrugated Iron Sheets (CIS) walling materials are relatively costly compared to other walling material options. Materials like stone may not be available in some communities and polyethylene plastic sheets may also not be available in the market in some remote rural areas. However, households can use the same materials they used for the walling and roofing of their dwelling house.
- Similar to materials used for the construction of pit lining and slabs, costs for walling and roofing materials vary from region to region, woreda to woreda, and season to season, depending on the availability of materials and skilled labor in the area.
- Tables 12A and 12B provide information for households and entrepreneurs on options for walling material and their corresponding advantages and disadvantages so that they can consider their associated costs. Similarly, Tables 12C and 12D provide the same information for roofing material options.

Table 13A: Material options for latrine walls, and their corresponding advantages and disadvantages

Walling materials	Description	Advantage	Disadvantage
Woven bamboo	Prepared by vertically splitting bamboo into two or three parts and weaving them in between firmly planted and equally spaced bamboo poles.	– Provides privacy – More tolerant to termites than wood – Owner can build it (construction does not require specialized skills) – Does not need mud plastering – Can be built on wooden and concrete slabs and the pit can be lined by any type of material	– Not widely available all over the country – Affected by termites – Households may prioritize bamboo for the production of marketable materials like basket, chair, and floor mats.
Wooden logs	Can be harvested from the forest or grown on land plots. Commonly used for the construction of the walls of dwelling homes.	– Widely available – Provides privacy and protection from wind – Relatively low cost – If mud plastered, it provides privacy – Owner can build it (construction does not require specialized skills) – Can be built on any type of slab and the pit can be lined by any type of material	– Rots easily and can be damaged by termites if not treated with used oil (not durable) – Deforestation – Wood is scarce and costly in some parts of the country
Mud blocks	Made from a mixture of soil and hay, and dried under the sun. Used to build the walls of a house in areas where wood is scarce or unaffordable.	– Provides privacy and protection from wind – Tolerates termite damage and relatively more durable than wood – Can be produced with minimum skills training – Low cost compared to bricks, stone, and concrete blocks – Can be used for the construction of off-set latrines – Can be built on a concrete slab reinforced by a bar (diameter of 12mm), and a pit lined with stone, fired bricks, or precast reinforced concrete rings	– Heavy weight can cause wooden and plastic slabs to collapse, as well as pits lined with wood and Ferro cement – Easily damaged by vermin (rodents) – If no proper roofing, it is easily damaged by rain and can collapse

Walling materials	Description	Advantage	Disadvantage
Bricks (fired or sun dried)	– Prepared from soil and made dry by the sun's heat or by fire to make it strong – Usually produced for household use and commercial purposes	– Provides privacy and protection from wind – Raw material (soil) is widely available – Households can produce bricks with some skills training – Termite resistant and will not decompose like wooden materials – Not damaged by rodents/vermin – Bricks can be reused in another pit once the first pit fills	– Heavy weight can cause wooden and plastic slabs to collapse, as well as pits lined with wood and Ferro cement – Bricks require concrete mortar – Mortar needs 7 days to cure and is less feasible in areas where water is scarce – Requires skilled labor – Relatively costly
Masonry stone	Stone is locally used for the construction of fences and dwelling houses. Some households use a stone dike around the wooden wall for flood prevention. Produced and manually crushed for household use and small businesses.	– Provides privacy and protection from wind – Stone is not damaged by termites and rodents/vermin – Structure can be built using mud mortar and locally available skilled labor – Stone is widely available in most parts of the country – Widely used for the construction of houses and latrines in highland areas where it's hard to obtain wood – Can be used for the construction of walls for the off-set latrine	– Heavy weight can cause all types of slabs and pit lining to collapse – If mortar is used, it needs 7 days to cure (mortar is less feasible in areas where water is scarce) – Relatively costly
Concrete hollow blocks	Can be locally produced but is not commonly used by most rural households.	– Provides privacy and protection from wind – Durable, and not damaged by moisture, termites, and rodents – Can be built on reinforced concrete slab and pits lined with bricks, stone, or reinforced concrete ring	– Not reusable once the pit is full – Requires skilled labor – Needs mortar and curing for 7 days – Cost is very high compared to other alternatives
Corrugated iron sheets (CIS)	CIS is a commercial product mainly used for roofing in rural areas.	– Provides privacy and protection from wind – Durable, and not damaged by termites and rodents – Material is reusable (transferrable to another new latrine) – Can be constructed by local carpenters	– Damaged by corrosion (rusting) – Heats up under the sun and increases the temperature inside the pit, producing an offensive odor – Difficult to construct in the absence of a wooden frame

Table 13B: Material options for walling and their cost estimation

Walling material options	Wall Size (Example: length 1200mm x with 1200mm and rear height 1700mm)	Description of items	Unit	Qty	Unit price	Total Price
Thatched wall	1200mm x 1200mm x 1700mm	Wooden logs (diameter of 100mm each, 2.5m long)	Each	6		
		Wooden logs (diameter of 50mm, each 1.30m long)	Each	16		
		Wooden logs (diameter of 5mm, each 1.65m for rafter)	Each	4		
		Nails #6 and #7	Gram	1000		
		Grass for wall cover	Bundle	4		
		Unskilled labor	Man-day	1		
		Skilled labor	Man-day	1		
		Total cost of thatched wall				
Woven bamboo or mesh supported by bamboo/ wooden pole	1200mm x 1200mm x 1700mm	Wooden logs (diameter of 100mm, each 2.5m long)	Each	6		
		Bamboo (diameter of 30mm, each 2m long)	Each	80		
		Bamboo mesh for wall cover (area of 2m x 4.8m)	Each	1		
		Wood for wall frame (diameter of 5mm, each 1.25m)	Each	6		
		Nails #6 and #7	Gram	500		
		Unskilled labor	Man-day	1		
		Skilled labor	Man-day	1		
		Total cost				
Polyethylene plastic sheet/ canvas supported by wooden pole	1200mm x 1200mm x 1700mm	Wooden logs (diameter of 100mm each 2.5m long)	Each	6		
		Wood (diameter of 5mm, each 1.25m for wall frame)	Each	6		
		Polyethylene plastic sheets (canvas) for wall cover (area of 2m x 4.8m)	Each	1		
		Nails #6 and #7	Gram	500		
		Unskilled labor	Man day	½		
		Skilled labor	Man day	½		
		Total cost				

Walling material options	Wall Size (Example: length 1200mm x with 1200mm and rear height 1700mm)	Description of items	Unit	Qty	Unit price	Total Price
Corrugated iron sheet (CIS) wall, supported by wooden poles	1200mm x 1200mm x 1700mm	Wooden logs (diameter of 100mm, each 2.5m long)	Each	6		
		Wood (diameter of 50mm, each 1.3m long)	Each	6		
		Wood for wall frame (diameter of 5mm, each 1.25m)	Each	6		
		Nails #6 and #7	Gram	500		
		Corrugated iron sheets (CIS), 35-G for walling	Each	6		
		Unskilled labor	Man-day	1 ½		
		Skilled labor (carpenter)	Man-day	1 ½		
		Total cost				
Wooden logs	1200mm x 1200mm x 1700mm	Wooden logs (diameter of 100mm, each 2.5m long)	Each	6		
		Wood (diameter of 50mm, each 2.30m long)	Each	30		
		For walling, wood for rafters (diameter of 5mm, each 1.65m)	Each	4		
		Nails #6 and #7	Gram	2000		
		Teff-hay for mud plastering walls	Bundle	4		
		Mesh wire with less than 2mm opening	Sq. m	0.25		
		Unskilled labor	Man-day	3		
		Skilled labor	Man-day	3		
		Total cost				
Dry masonry stone wall with mud mortar	1200mm x 1200mm x 1700mm	Masonry stone mortared by mud	Cub. M	4.5		
		Unskilled labor for the preparation of mud mortar and to assist skilled builder	Man-day	6		
		Skilled labor (stone building)	Man-day	6		
		Total cost				

Table 13C: Latrine roofing material options, and their corresponding advantages and disadvantages

Roofing materials	Description	Advantage	Disadvantage
Thatched grass/ leaves	– Commonly used for the roofs of dwelling houses, crop storage facilities, and latrines. – In some areas, used for the construction of walls for houses and latrines	– Provides protection from rain, wind, and sun – Widely available roofing material – Very low cost (affordable) – Can be constructed using locally available skills and/or by the household – Keeps the inside of the latrine at a cool temperature, to allow for less odor emission	– Damaged by termites, earth worms, and rodents – Prone to fire accidents – Requires wooden materials to support (impossible to use in areas where wood is scarce) – Weight of the thatched roof increases during the rainy season – Not fully able to shield from rainfall, which can sometimes damage it
Bamboo strips (mesh)	– Produced by splitting bamboo into tiny parts and weaving them across each other. Meshed bamboo is commonly used for roofing, floor mats, and bedding, in areas where bamboo is available	– Can be crafted locally and is available in the local market – Bamboo grass can easily grow in the family compound if the ecology is conducive – Can serve for three to five years – Can be built by local carpenters and/ or by the household – Reduces the sun's heat, shelters from wind – Relatively low cost	– Easily damaged due to decomposition (because of rain), and by termites and rodents – Does not fully shield from rain (may drip)
Polyethylene plastic sheet	– A commercial material commonly used for roofing in pastoral areas and households in lowland communities	– Provides protection from rain, wind, and sun – Lighter than CIS and thatched roofing materials – Easy to construct, does not require special skills – Relatively low cost compared to CIS	– Heats up under the sun and increases the temperature inside the pit, to produce an offensive odor – Easily damaged by the sun's heat and rodents
Corrugated Iron Sheets (CIS)	– CIS is a commercial product mainly used for roofing in rural areas.	– Provides protection from rain, wind, and sun – Durable and reusable (can be transferred to a new latrine) – Relatively costly initially, but its durability results in savings over the long term	– Heats up under the sun and increases the temperature inside the pit, to produce an offensive odor – High initial cost, but affordable for well-to-do households

Table 13D: Roofing material options and their cost estimation

Roofing material options	Roofing size (Example: length x width)	Description of items	Unit	Quantity	Unit price	Total price
Thatched (grass)	1500mm x 2000mm	Wood (diameter of 50mm, length 2.2m each)	Each	6		
		Wood (diameter of 30mm, length 5m each)	Each	5		
		Grass for roof cover	Bundle	5		
		Rope (0.5mm thick)	meter	50		
		Unskilled labor	Man-day	1		
		Skilled labor	Man-day	1		
		Total				
Bamboo mesh	1500mm x 2000mm	Bamboo mesh (1.5m x 2m)	Each	1		
		Wood (diameter of 50mm, length 2.2m)	Each	6		
		Wood (diameter of 30mm, length 5m)	Each	5		
		Rope (0.5mm thick)	meter	50		
		Unskilled labor	Man-day	1		
		Skilled labor	Man-day	1		
		Total cost				
Polyethylene plastic sheets/ canvas	1500mm x 2000mm	Polyethylene plastic sheet /canvas (1.5m x 2m)	Each	1		
		Wood (diameter of 50mm, length 2.2m)	Each	6		
		Wood (diameter of 30mm, length 5m)	Each	5		
		Rope (0.5mm thick)	meter	50		
		Unskilled labor	Man-day	1		
		Skilled labor	Man-day	1		
		Total cost of polyethylene plastic sheet/canvas roofing				
Corrugated Iron Sheets (CIS)	1500mm x 2000mm	Corrugated Iron Sheet (CIS), 35-G	Each	2		
		Wood (diameter of 50mm, length 2.2m)	Each	3		
		Wood (diameter of 30mm, length 5m)	Meter	500		
		Nails #7	Grams	50		
		Unskilled labor	Man-day	1		
		Skilled labor	Man-day	1		
		Total cost				

5.7.3 Construction of the latrine's wall and roof, and installation of the vent pipe

Prepare the required walling and roofing materials, and if not built by the household,

- Communicate and agree with laborers
- The overall weight of the latrine superstructure (wall and roofing) should rest directly on the slab and pit lining or outside of the slab.
- The superstructure's shape could be similar to the shape of the slab (circular, rectangular, or square).
- The front height of the wall should not be less than 2 meters.
- The door should have an inside lock for security and a screen made of woven wire mesh, with a weave size of less than 2 millimeters.
- Install the wire mesh screen, with an area of 500 millimeters x 250 millimeters, on one side of the latrine wall, between the door and roofing.

5.7.3.1 Construction of the latrine's wall and roof

To construct a wall around a slab with an area of 1000 millimeters x 1000 millimeters, the external length and width of the wall will be 1200 millimeters x 1200 millimeters, including the thickness of the wall built using wood. Wall thickness increases if built with durable materials (like stone and bricks), and wall thickness decreases if it is built by polyethylene and bamboo materials.

- Measure and cut two wooden logs equally to a length of 2.2 meters (1.7 meters above the ground and 50 centimeters posted in the ground).
- Measure and cut another two wooden logs equally to a length of 2.7 meters (2.2 meters above the ground and 50 centimeters posted in the ground)
- Measure the wall's length and width (1.2 meters x 1.2 meters) around the slab and mark the four corners
- Dig the pit to a depth of 50 centimeters
- Post the wooden poles side by side at the four corners (shorter poles at the back and longer at the front) and fix to the ground by compacting the soil (to immobilize)
- Cut 12 wooden logs of with a diameter of 5 centimeters each at 1.25 meters length, and connect the four poles with nails at equal lengths (at the bottom, middle (1.33 meters) and top (1.7 meters), and similarly connect the two long poles at the top (2.2 meters). On the side with the door, poles are connected at the bottom and top.
- Cover the wall by using the selected material (either CIS, grass, bamboo, or polyethylene plastic sheets)
- Prepare door from CIS, woven bamboo, or polyethylene plastic sheet and attach to the wall.

5.7.3.2 Installation of the vent pipe

- Cut a piece of bamboo or PVC vent pipe at a length of 50 centimeters above the roof's highest peak
- Vertically insert the vent pipe into the slab's hole that leads down the pipe into the pit
- Seal opening around vent and attach to slab by concrete mortar
- If the vent pipe is erected outside of the wall, attach the vent pipe to the wall using a wire or rope, and if it is erected inside the wall, the vent should pass through the roof
- Using cement mortar, seal the openings around the juncture of the vent pipe, slab, and roof opening through which the vent pipe is passed
- Tie a wire mesh screen on the top of the vent pipe

Note:

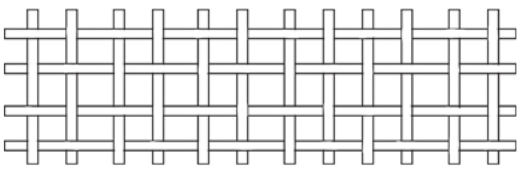
- **The bad odor or smell produced inside the pit can escape through the vent pipe's top opening that is covered with a wire mesh cape.**
- **Length of the vent pipe should extend 500 millimeters above the roof's highest peak.**
- **Vent pipe can be produced locally from hollow bamboo, or by connecting plastic bottles or PVC vent pipes of different diameters (75mm and 110mm) that are also available in local markets.**

5.7.3.3 Preparation and installation of the wire mesh screen on the latrine wall

If the wall is built from mud-plastered wood, bricks, or blocks, prepare and set a screen made from wire mesh on the wall to illuminate the inside of the latrine (Figure 41)

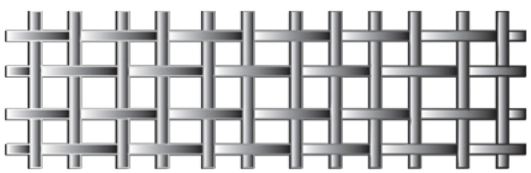
1. Cut the wire mesh at a length of 500 millimeters and width of 250 millimeters (area = 500 millimeters x 250 millimeters)
2. Prepare a wooden frame and then set the screen on the frame with # 4 nails
3. Set the screen on the wooden wall with nails
4. If the wall is made of bricks, blocks, or stone, the mesh screen does not need a wooden frame, and can be set on the wall with concrete mortar before plastering the wall
5. After finishing the plastering work, paint the wire mesh with anti-rust

Figure 41: Wall screen (made of wire mesh)



Wire Mesh Screen Opening: 2mm x 2mm (without wooden frame)

- Mesh Screen Area = 500mm x 250mm



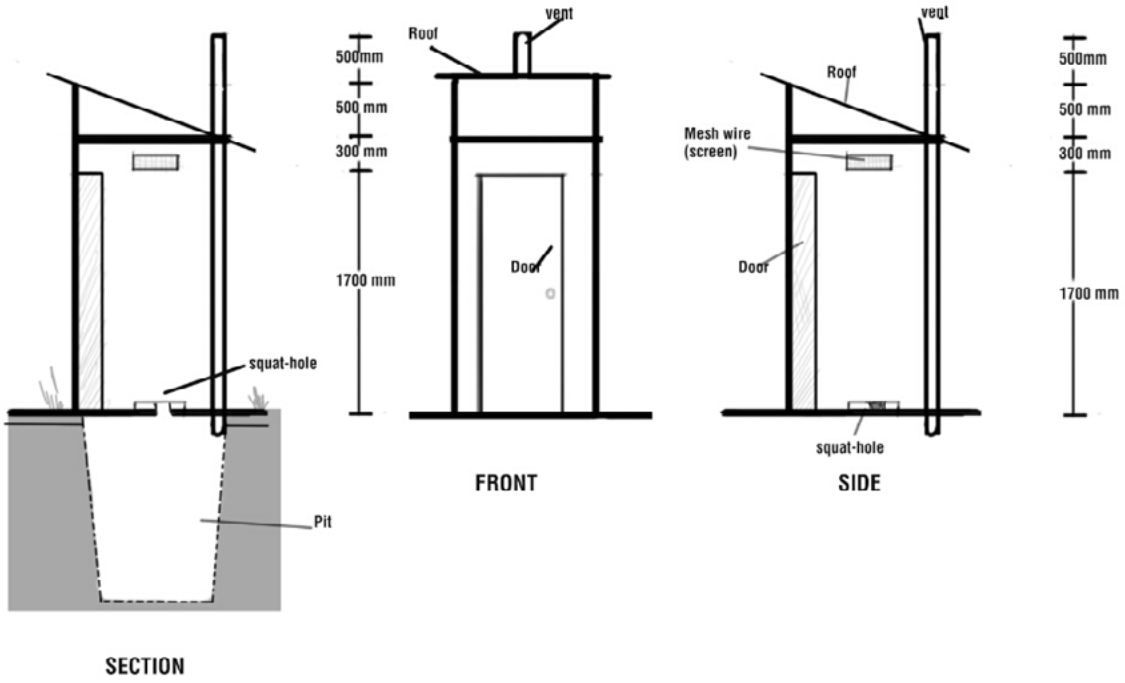
Wire Mesh Screen Opening: 2mm x 2mm (with wooden frame)

- Mesh Screen Area = 500mm x 250mm
- Wooden Frame Length Wide = 500mm x 30mm x 20mm
- Wooden Frame Width Wide = 250mm x 30mm x 20mm

5.7.3.2 Construction of a rectangular or square roof

- Cut three wooden logs with a diameter of 7 centimeters at a length of 1.9 meters (rafter), and fix on horizontal top ties between the long and short poles at equal distance
- Cut three wooden logs with diameter of 5 centimeters at a length of 1.7meters (purlin), and fix on the rafter at equal distances
- Cover the roof using the selected material (either CIS, grass, or polyethylene plastic sheets)

Figure 42: Sketch of latrine wall, roofing, and vent pipe



6 Latrine Construction for Pastoral Communities

Pastoral communities in Ethiopia seasonally migrate from their usual place of residence to commonly known places in search of pasture and water for their cattle. Usually, not all family members move. While some of the family remain in their home village, others move with cattle herds for three to six months and then go back to their home village when the rains return. Even though each family member constructs a small temporary shelter for their dwelling, they also construct a small cluster of houses, similar to a camp. Pastoral communities need two types of latrine options—permanent, like that of agrarian/sedentary communities; and temporary, like those that serve a group of households (from the same clan) for the season they are away from their village.

Household members usually migrate with construction materials for temporary housing (mainly materials for walling and roofing) to the places where they can get water and pasture for their cattle. Right after they reach their destination, they start to build the temporary shelter. The areas where they stay temporarily are typically marshy areas, where the ground water table is shallow, or around big riverbanks.

Construction of a latrine for a temporary household in a pastoral community

Latrine construction is important for those family members who remain at home and those who temporarily move to other places. Household members moving with their cattle also carry materials for the construction of a temporary latrine. These materials may include a plastic slab with a squat-hole cover, a wooden frame, plastic sheets (polyethylene) for the superstructure (wall and roofing), and an old barrel (plastic or metal) for the substructure.

6.1 For family members remaining in the home village

– Refer to this manual's sections 2 and 5, which recommend procedures to be followed for choosing the appropriate materials for the construction of superstructures and substructures (pit digging and lining), as well as slab types and their installation. These procedures apply to all sedentary (agrarian) households.

6.2 For family members moving to other places

– Use the procedures described under section 5.2.2, to determine the required size for a dry pit to be used for a period of three to six months, by a family of five persons.

6.2.1 Construction of the substructure, slab, and superstructure

– If the soil is stable, follow the same procedures for the excavation and construction of slabs and superstructures as for households living in sedentary communities.

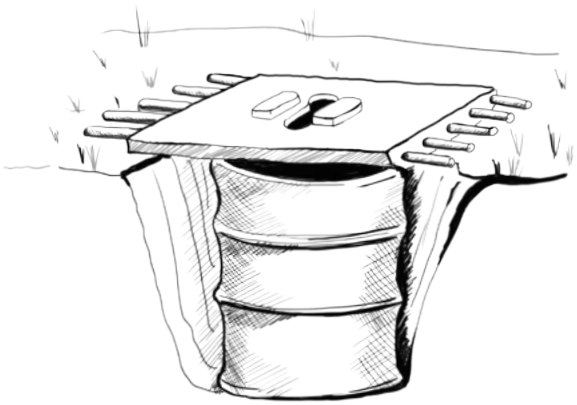
6.2.2 Construction of substructure in places with unstable soil formation

– Excavate a circular pit to a depth of 1000 millimeters and a diameter of 1000 millimeters (follow the same procedure under section 5.3.1above).
– Insert an old metal or fiber barrel with a diameter of 800 millimeters and a height of 900 millimeters (this barrel size can serve five persons for six months as they migrate to other areas).
– Excavate a pit with a diameter of 1000 millimeters to a depth of 1200 millimeters.

6.2.4 Installation of plastic slab

– Follow the same procedures stated under section 5.6.2 above for the installation of a plastic slab.

Figure 43: Temporary latrine pit lined with an old barrel



Temporary latrine pit lined with old barrel

6.2.5 Construction of superstructure

– Construct a moveable superstructure using the same materials used for the construction of the temporary house (follow the same procedure stated under section 5.7.3 above).

Abandoning the temporary latrine:

- **Remove the construction materials used for the superstructure and slab, and disinfect with chlorine solution (bleach). Bind the materials in the same manner as those materials used for the temporary house to take back home.**
- **Cover the pit with soil before returning to the family's usual place of residence.**
- **If the migrating family members return to the same place next year, they should excavate a new pit, and construct and use a temporary latrine, following the same procedures stated above.**

7

Soil Type and Choice of **Suitable Materials for the Construction of Latrine's Substructure, Slab and Superstructure**

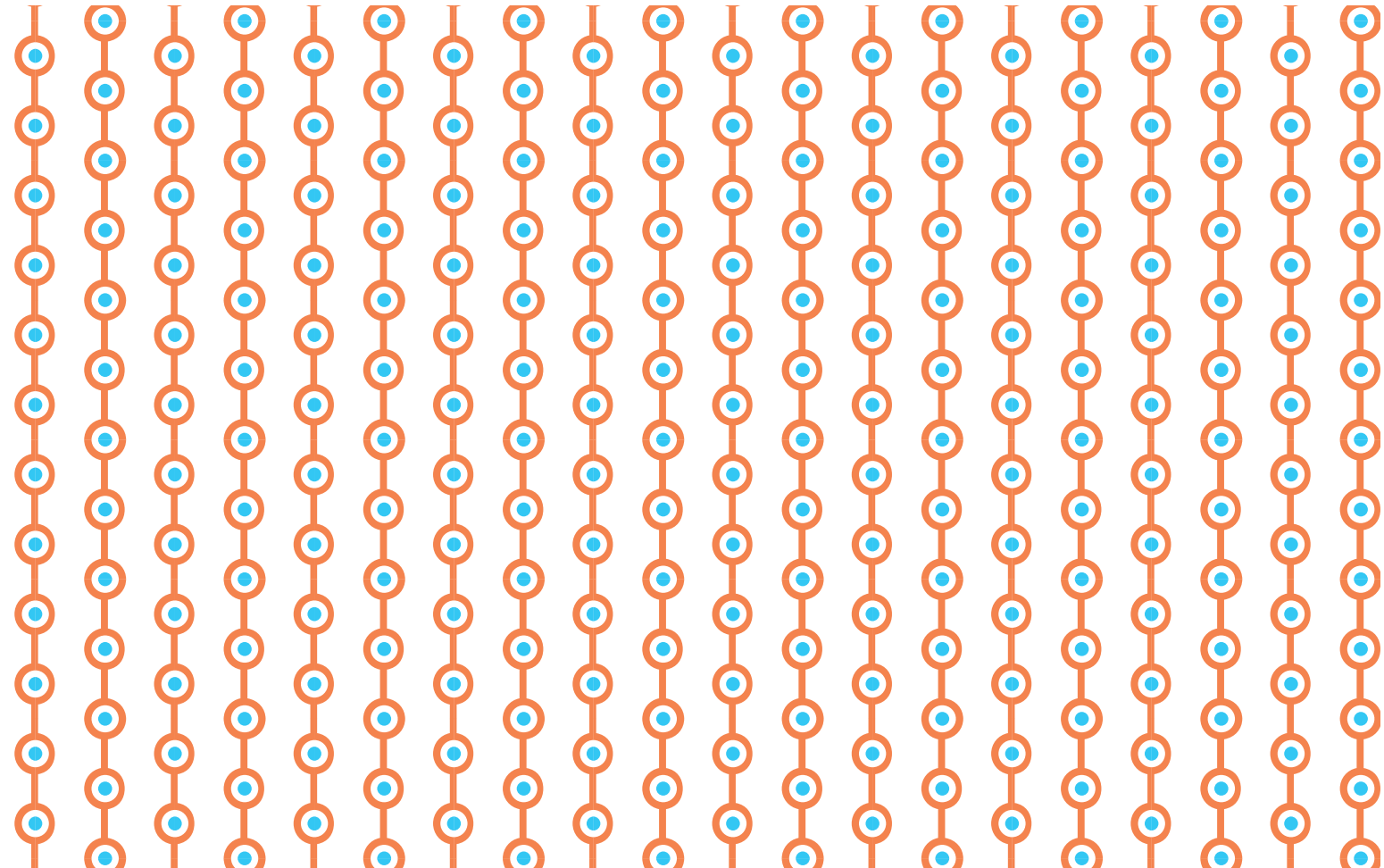


Table 14: Soil type and choice of suitable construction materials

Soil type	Substructure type	Floor/slab type	Superstructure type		Type of latrine option
			Walling materials	Roofing materials	
Stable soil	– Circular, rectangular, or square-shaped pit. – Top 500mm depth of the pit lined with durable material (stone or bricks)	– SanPlat concrete slab with the same shape as the pit fitted in the wooden mud-plastered floor – Reinforced concrete slab or plastic slab with the same shape as the pit and with a tightly fitted squat-hole cover and a bamboo or PVC vent pipe – Reinforced concrete slab split into two or more pieces depending on the diameter /size of the pit (rejoined with mortar during installation) for the easy transportation and transfer to a new latrine – At least 150mm overlap between the slab and lining material on all sides – Ceramic or plastic pan with water seal fitted into the slab (if water is available)	– Wall that provides adequate privacy made of bricks or stone (wall built off the slab) – Wood, bamboo, Corrugated Iron Sheet (CIS), grass, or plastic sheets supported by wooden poles (fitted on the slab). – Door that can be locked from the inside	Roof that protects users from direct sunlight and rain, does not leak, and is made from CIS, grass, plastic sheets, or leaves	– Improved Pit Latrine (IPL) – Ventilated Improved Pit Latrine (VIP) – Single vault compost latrine – Pour-flush latrine
Rocky soil (hard to dig)	– A 900mm x 900mm x 1000mm square pit dug to its deepest possible depth (at least one meter) in the rocky soil and lined with cement mortar – A 2400mm x 1000mm x 1000mm pit dug to its deepest possible depth (at least one meter) in the rocky soil – Walls are lined with cement mortar along its length and width – A pit with a length of 2400mm is divided into two by a stone wall (double vault) – Top 500mm above the ground level of the pit, lined with durable materials (stone or bricks) and cement mortar	– Removable SanPlat concrete slab with the same shape as the concrete ring (Arborloo) – Removable reinforced concrete slab with the same shape/external size of the dug pit and with a tightly fitted squat-hole cover – The reinforced concrete slab can be split into two or more pieces depending on the diameter /size of the concrete ring (rejoined with mortar during installation) for easy transportation and transfer to new latrine – Slab should overlap 150mm with the thickness of the pit's lining on all sides	Removable Wall that provide adequate privacy made up of wood, bamboo, Corrugated Iron Sheet (CIS), grass, or plastic sheet supported by wooden pole (wall fitted on or off the slab)	Removable roof that protects users from direct sunlight and rain, does not leak, and is made from CIS, grass, plastic sheets, or leaves	– Arborloo – Double vault compost latrine

Soil type	Substructure type	Floor/slab type	Superstructure type		Type of latrine option
			Walling materials	Roofing materials	
Loose soil (silt/ clay)	– Circular, rectangular, or square-shaped pit – The whole pit depth should be lined with stone or bricks; or the pit's depth, up to 500mm, should be lined with wood or bamboo – Top 500mm depth of the pit is lined with durable materials (stone or bricks), if the depth below the top 500mm is lined with wood or bamboo	– Removable SanPlat concrete slab with the same shape as the pit – Reinforced concrete slab or plastic slab with the same shape as the pit and with a tightly fitted squat-hole cover or with a bamboo or PVC vent pipe – Reinforced concrete slab split into two or more pieces depending on the diameter/size of the pit (rejoined with mortar during installation) for easy transportation and transfer to new latrine – At least 150mm overlap between slab and lining material on all sides – Ceramic or plastic pan with water seal fitted into the slab	Removable Wall that provide adequate privacy made up of bricks or stone (built off the slab), wood, bamboo, Corrugated Iron Sheet (CIS), grass, or plastic sheet supported by wooden pole (fitted on the slab)	Removable roof that protects users from direct sunlight and rain, does not leak, and is made from CIS, grass, plastic sheets, or leaves, and supported by wooden poles	– Ventilated Improved Pit Latrine (VIP) – Double vault compost latrine – Pour-flush latrine (on site or off site)
Loose soil (sandy)	– Circular, rectangular, or square-shaped pit – The whole pit depth below the top 500mm is lined with a precast reinforced perforated concrete ring – Top 500mm depth of the pit is lined with a precast reinforced blinded concrete ring, and durable materials and mortar are mounded/ compacted around the concrete ring	– Removable SanPlat concrete slab with the same shape with the concrete ring – Removable reinforced concrete slab or plastic slab with the same shape as the concrete ring and with a tightly fitted squat-hole cover or with a bamboo or PVC vent pipe – The reinforced concrete slab can be split into two or more pieces depending on the diameter /size of the concrete ring (and rejoined with mortar during installation) for easy transportation and transfer to new latrine – Slab should fully overlap with the thickness of the concrete ring (lining material) on all sides – Ceramic or plastic pan with water seal fitted into the slab	Removable Wall that provide adequate privacy made up of wood, bamboo, Corrugated Iron Sheet (CIS), grass, or plastic sheet supported by wooden pole (wall fitted on or off the slab)	Removable roof that protects users from direct sunlight and rain, does not leak, and is made from CIS, grass, plastic sheets, or leaves	– Ventilated Improved Pit Latrine (VIP) – Double vault compost latrine – Direct or off-set pour-flush latrine

Soil type	Substructure type	Floor/slab type	Superstructure type		Type of latrine option
			Walling materials	Roofing materials	
Water logged (marshy)	– The whole pit's depth is lined with a watertight precast reinforced blinded concrete ring – Bottom of the pit is made from watertight/proof concrete bedding – Depending on the height of water logging above ground level, the concrete ring is installed above the ground. – Space around the concrete ring above the ground level is mounded/compacted by selected soil materials	– Removable SanPlat concrete slab with the same shape with the concrete ring – Removable reinforced Concrete slab or plastic slab with the same shape as the concrete ring and with a tightly fitted squat-hole cover or with a bamboo or PVC vent pipe – The reinforced concrete slab can be split into two or more pieces depending on the diameter/size of the concrete ring (and rejoined with mortar during installation) for easy transportation and transfer to a new latrine – Slab should fully overlap with the thickness of the concrete ring (lining material) on all sides – Ceramic or plastic pan with water seal fitted into the slab	Removable Wall that provide adequate privacy made up of wood, bamboo, Corrugated Iron Sheet (CIS), grass, or plastic sheet supported by Wooden pole (wall fitted on or off the slab)	Removable roof that protects users from direct sunlight and rain, does not leak, and is made from CIS, grass, plastic sheets, or leaves	– Ventilated Improved Pit Latrine (VIP) – Direct pour-flush latrine

8 Operation and Maintenance of Household Latrines

8.1 Routine operation and maintenance

Routine and periodic operation and maintenance allows a toilet to remain functional and in a condition that makes family members comfortable to use it consistently. The poor operation and maintenance of latrines constrains households' continuous use of sanitation facilities.

This section outlines maintenance procedures for the operation and maintenance of household latrines that are common to all technology options as well as specific to a particular type of latrine technology.

Table 15: Operation and maintenance by latrine type

Type of latrine facility	Operation and maintenance activities	Repair and maintenance activities
Common to all latrine types	**Use and day-to-day operation and maintenance** – Urinate or defecate directly into the squat-hole to avoid the smearing of feces and splash of urine on the slab (to avoid unsightly appearance and bad smell) – Cover feces after each defecation to discourage access to flies and avoid bad smell – Regular cleaning and washing of slab to remove any feces and urine – Clean the slab and edge of squat-hole immediately after use to prevent bad smell, unsightly appearance, and discourage flies – Replace squat-hole cover after each latrine use – Place appropriate anal cleansing material (water, paper, soft paper, or leaf) inside the latrine, to be disposed into the pit after use. – Do not use non-decomposable materials like stone, plastic, and rags for anal cleansing (to prevent the clogging of the latrine) – Scoop the feces of small children and dispose of it in the latrine – Do not dispose of soiled sanitary pads in the latrine pit (burn and dispose together with solid wastes) – Properly wash your hands (and the hands of your children) with soap and water after each latrine use – Raise community awareness on the use of latrines and their operation and maintenance (for all latrine types), as well as on the importance, health, and safety of using compost produced from human feces	– Check for any cracks in the slab, or damage to the latrine's walls, door, roof, and flood diversion ditch, and take immediate action to repair any problems – Check if the pit is full and dig a new pit if the pit only has 750mm left to fill. Transfer the slab and superstructure to the new latrine. – Cover and seal the contents of the old latrine (sludge) with soil (top 500mm) – If the pit's lining is constructed with durable materials (stone, bricks, or a concrete ring) manually excavate the pit content (compost) after two years and make the area ready for re-use when the second latrine becomes full and is sealed – Use personal protection devices while emptying the pit and take care to avoid poisoning

Type of latrine facility	Operation and maintenance activities	Repair and maintenance activities
Specific to Ventilated improved pit latrines (VIP latrines)	– Do not cover, as squat hole should allow air entrance – Keep the inside of the superstructure dark by closing the door and keeping the roof well covered to discourage flies from coming out through squat hole	– Check for damage to the fly screen and odors coming through the squat- hole
Specific to compost latrines (double vault dry compost and Arborloo latrines)	– After each use, cover the feces with ash, saw dust, or leaves to soak up excessive moisture, and improve the carbon-nitrogen ratio. – When the first pit is about 75% full, fill completely with dry earth and seal.	– Transfer the slab and superstructure to the second vault and continue to use the second vault – Close the vault for at least two years to facilitate anaerobic decomposition and the killing of disease pathogens, and then manually empty the decomposed contents of the pit to use for fertilizer – Use personal protection equipment when you excavate compost, to prevent contamination; poisoning by ammonia, methane, and hydrogen sulfide gases; and cuts by broken sharp metals or glass
Specific to Arborloo latrines	– Dig another pit of the same shape and dimension before pit becomes 75% full	– Transfer the slab, and superstructure to the second pit and use the latrine – Close the pit for at least two years and plant fruits and vegetables over it. Remember, if fruits and vegetables are planted in the pit with fresh excreta, pathogens (bacteria, protozoan, and worm eggs) will remain infectious, particularly in humid areas
Pour flush latrines (direct or offset)	– Put the container in the latrine and fill with sufficient water and cover the container – Fill hand washing container and avail soap or ash to encourage hand washing after each latrine use – Splash water on latrine after each use and sweep the slab or pan – Do not dispose soiled sanitary pads into the latrine (it easily clogs water seal) – Do not use hard materials for anal cleansing	– Check for clogging of the drainage pipe and remove clogging if any – Check for over flow and level of sludge in the collect ion pit – Close sewage flow when the pit in use has filled to a depth of 50 centimeters, and divert the flow to next chamber/pit

8.2 Emptying the pit

On-site dry pit latrines are common household sanitation facilities in rural and small towns in Ethiopia. Properly constructed and well-managed pit latrines contain fecal sludge and can provide a safe and adequate barrier to the spread of pathogens. Fecal sludge in dry pit latrines is usually dry and comprised of thick, solid materials that must be emptied manually, with a spade.

In the majority of rural areas, space is not an issue and households can dig new latrines when the old pit becomes full. If that is the case, move the slab and superstructure and install them over the new pit. Then cover the old pit with earth for a period of about two years, until the pit's contents (fecal sludge) is fully or partially treated, through the process of decomposition, and becomes safe to handle. The pit should then be emptied and its contents used as a soil conditioner. The household can then re-use the pit.

In densely populated areas where space is in short supply, or where the cost of constructing a new latrine or double-vault latrine (twin pits) is viewed to be prohibitive, emptying the fecal sludge is a necessity. The task must be carried out with care to avoid human and environmental contamination, as well as to prevent households from abandoning the full latrine and reverting to open defecation.

Therefore, the design and construction of the pit latrine should allow for the emptying of its contents and re-use of the pit. For example, a latrine pit lined with locally available durable materials such as bricks, stone, or a reinforced concrete ring makes emptying easier compared to an unlined pit. A pit lined with durable materials does not collapse during emptying and poses no danger to the emptier.

In general, the old or alternate pit should be kept covered with earth for about two years before its contents are emptied.

Steps to pit emptying

- The latrine pit's size should accommodate the accumulation of sludge for at least 3 years and allow for its top depth of 50 centimeters to be covered with earth.
- Excavate the new pit when the old pit fills to the depth of 1000 millimeters, and line the pit with durable materials (follow the same steps stated under Sections 5.3.1 and 5.3.2 above).
- When the old pit fills to just below the top 50-centimeter mark, move the slab and superstructure to install on the new pit.
- If the latrine is a compost latrine with a twin pit, cover the pit when the pit fills to a depth of 50 centimeters, move the slab and superstructure, and install them on the new pit.
- Immediately cover the fecal sludge in the old pit or alternate pit (vault) with earth and keep covered for about two years.
- When the second pit, or the vault in use, is about to fill the top pit's depth of 1000 millimeters, manually empty the treated (decomposed) contents of the previous pit (vault) and make the pit ready for reuse.

9 Health and Safety Measures

Work frequently exposes workers to various types of work-related hazards and associated health problems. Entrepreneurs or household members who work on a latrine's pit excavation, construction, operation, and maintenance may suffer a work-related accident that results in acute injury, chronic illness, temporary or permanent disability, including the loss of body parts or death.

Therefore, it is important to take special precautions during the different construction phases that include site clearing; pit excavation and lining; construction and installation of latrine slabs, superstructure, and finishing; as well as during the latrine's routine operation and maintenance. The following table (Table 13) provides information on possible hazards and the precautionary measures to be taken to prevent associated health problems. Table 14 lists important personal protective devices that workers should use when engaged in latrine construction.

9.1 Safe working procedures and precautions

The implementation of safe working processes and the procedures and use of personal protective equipment are important to prevent the occurrence of acute and chronic work-related health hazards. Therefore, the following precautionary measures are recommended for entrepreneurs and household members.

9.1.1 Precautions to take during pit excavation, masonry, and lining

- During site preparation, construct temporary fencing around the pit to avoid accidents (animals and children may fall into the pit).
- Entrepreneurs, household members, or daily laborers can prepare stepping holes along the wall of the dug pit, to be used for getting in and out. This is possible if the soil formation is hard. In case of loose soil formation, use a wooden or metal ladder while excavating the pit and lining its walls.
- Check the inside of the excavated pit using a torch light before entering. Dangerous animals like snakes may have fallen in during the night. Remove such animals if this has happened.
- Remove soil, hand tools, and sharp objects from the work space, at least 2 meters away from the pit's edge to avoid back falling.
- Workers (masons/carpenters) should use helmets and eye goggles during excavation and pit lining to prevent head and eye injuries.
- Do not throw stones while the mason is inside the pit, and use a strong rope to convey mortar using a bucket.
- Use rubber gloves and safety shoes to avoid abrasions, cuts, and irritation during pit excavation and lining.

9.1.2 Precautionary measures during the production, lifting, transportation, and installation of concrete slabs

Accidents and permanent damage to body parts may happen during the placement of molds; cutting of reinforcement bars; mixing and pouring of concrete; and lifting, transporting, and installation of slabs. Therefore,

- Use rubber gloves, and wear long sleeves and safety boots to avoid direct contact with body parts and minimize the possibility of cuts, abrasions, and burning.
- Use masks to avoid the inhalation of cement dust, as well as eye goggles, to prevent the irritation of the eye.

9.1.3 Precautions during the routine cleaning of latrines and emptying of compost latrines

Households are likely to come into direct contact with human excreta during the day-to-day cleaning of latrines and emptying of the compost latrines, and will consequently be exposed to different disease-causing microorganisms that may contaminate household utensils. To avoid or minimize possible exposure, family members are expected to consistently:

- Use personal protective devices such as long sleeves, rubber gloves, rubber boots, and hair caps while doing the day-to-day cleaning of the latrines and emptying of compost latrines.
- Keep latrine cleaning and pit emptying equipment in good condition.
- Maintain proper personal hygiene practices, including daily bathing and hand washing; and after cleaning the latrine, wash and disinfect protective devices after each use.

Table 16: Summary of work-related health hazards, and their preventive measures

Hazardous exposure/event	Health hazards	Preventive/control measures
Caving in of pit wall in areas of loose soil formation; sliding back of excavated soil/stone; misplaced hand tools on the edge of the pit	Suffocation, fracture, death, head injury	Clean around the edge of the pit and other work areas; use helmets, gloves, and boots during excavation; build a fence around the pit.
Sliding due to an improperly built ladder, and the caving in of the pit's wall	Abrasion, strain, sprain and/or fracture	Make surfaces rough; build a proper work ladder using strong wood; seek treatment for injuries early. In areas with sandy and loose soil, excavate the pit by inserting a concrete ring into the ground that workers can dig inside.
Injury due to the falling of sharp equipment on exposed body parts; improper handling and use of sharp materials; nail pricking; injury due to falling wood, stone, or other construction materials during pit excavation and lining, as well as slab installation	Bleeding, fracture, death	Use heavy-duty gloves and boots/shoes, helmets, and overwear. Remove any slippery objects from the work areas. Build a temporary fence around the pit. Apply first aid to stop bleeding, and seek treatment early.
Injury to the body parts of small children and animals (fracture, abrasion, cuts) due to their fall into the open pit	Damage to body parts, death	Build a temporary fence around the pit until the installation of the slab is completed. Apply first aid to stop bleeding, and seek treatment early.
Poisoning. Poisonous animals (snakes or scorpions) may fall into the pit during the night and workers may enter the pit without noticing them and be bitten.	Poisoning and death	Check inside the pit for the presence of any strange animals before continuing pit excavation and lining.
Exposure to infectious agents (pathogens) during the day-to-day cleaning of the latrines	Diarrhea and parasitic infection	Always wear protective garments, like heavy-duty gloves, and wash your hands after cleaning the latrine.

Important personal protection equipment for entrepreneurs and family members

Personal protective devices are illustrated to prevent the most frequently exposed body parts from accidents, such as the head, eyes, face, feet, and hands.

Table 17: Protective equipment

Body parts to be protected	Protective equipment	When to use	Figures of the personal protection equipment
Head	Plastic helmet	Pit excavation and lining	**Figure 45:** Figure of plastic helmet 
Eyes and face	Eye goggles	Excavation, masonry work, cutting stones, and cement-sand mixing	**Figure 46:** Figure of eye goggle 
Feet	Leather and Rubber shoes	Lifting of heavy loads, excavation, masonry, concrete work, and concrete slab installation	**Figure 47:** Figure of leather and rubber shoes 
Hands, fingers, and arms	Rubber or heavy-duty gloves	Pit excavation, masonry, concrete work, cutting of reinforcement bars, installation of slabs, daily cleaning and operation of latrines	**Figure 48:** Figure of heavy duty gloves 

10

Design, Drawings and Cross-sectional view of different

Household Latrine Technology Options

Figure 49: Improved Pit Latrine – with plastic slab and squat hole cover

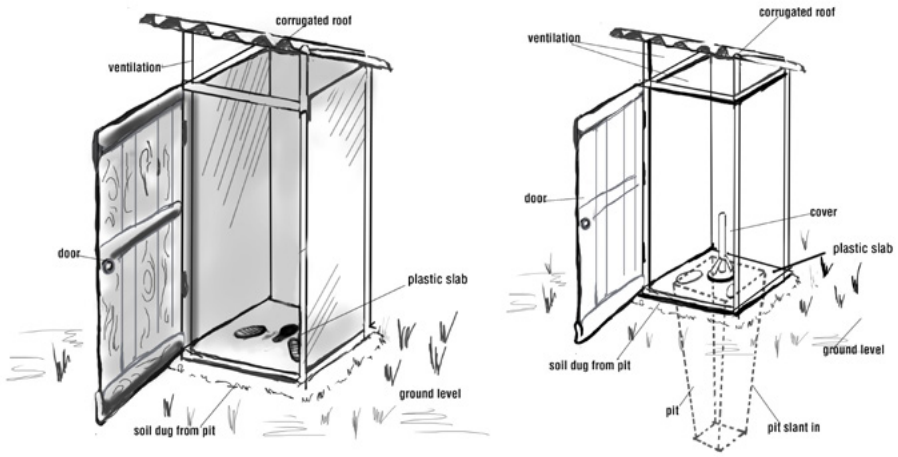


Figure 50: Ventilated Pit Latrine – concrete slab

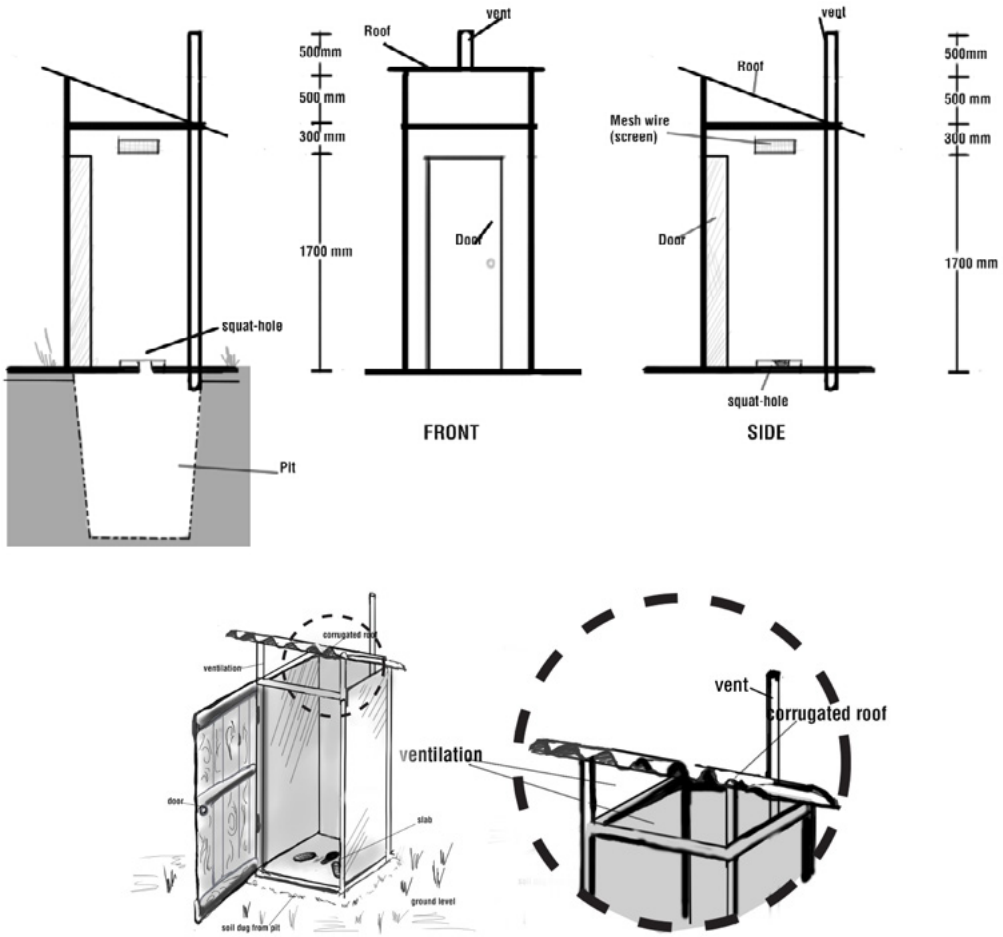


Figure 51: Improved Off-set Single Pit Pour Flush Latrine – ceramic, concrete or plastic slab

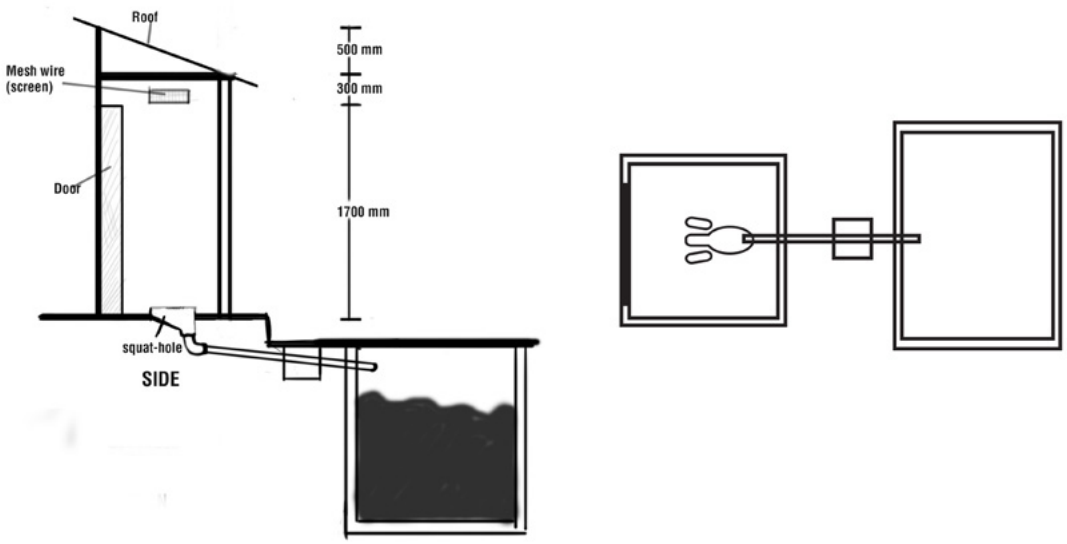


Figure 52: Improved Off-set Twin Pit Pour Flush Latrine – ceramic, concrete or plastic slab

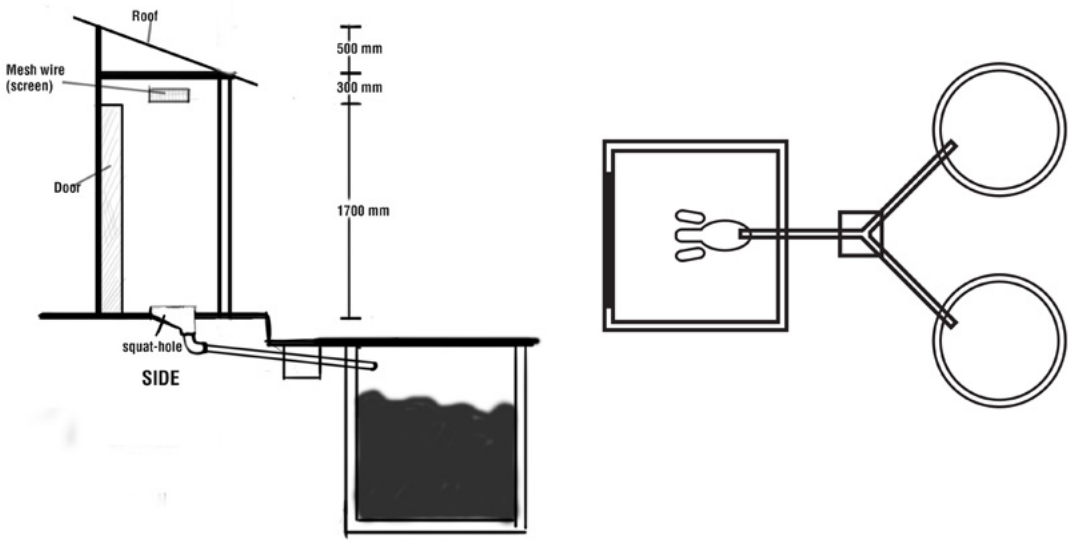


Figure 53: Improved Pit Latrine – with seat for people living with a disability

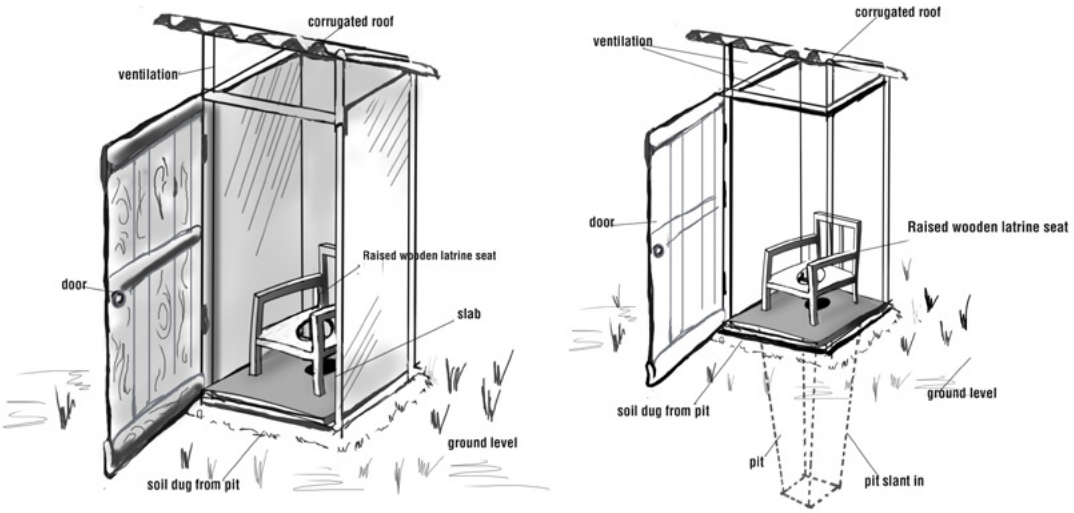


Figure 54: Improved Pit Latrine – with raised seat and hand rails for people living with a disability

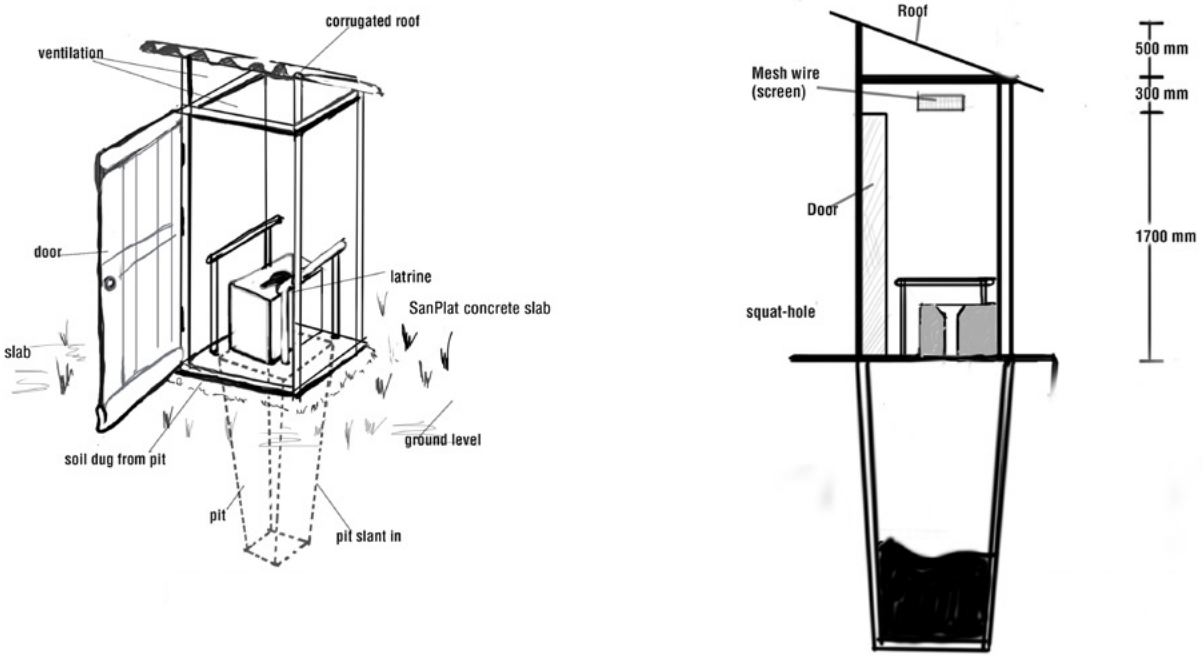
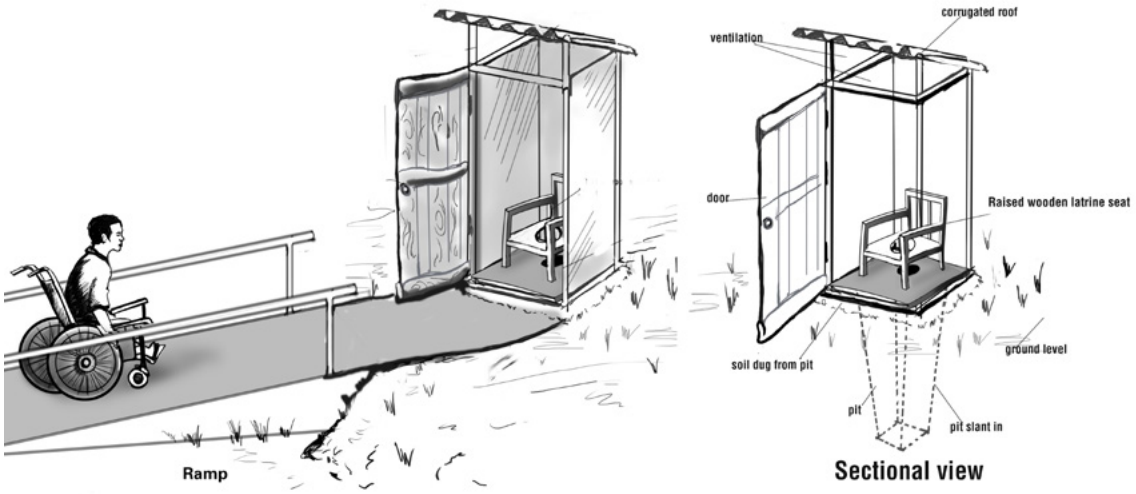


Figure 55: Improved Pit Latrine – with ramp access and seat for people living with a disability



Annexes

Annex 1: Concrete Mortar Preparation

Mortar is a mixture of cement, sand, and water, and is used to attach bricks, blocks, and stone together. The sticking property of the mortar depends on the quality of cement and sand used. Therefore, it is important to use high-grade cement and sand, and clean water for mixing. Screen sand if it is mixed with silt and debris. The common ratio of cement and sand is 1-part cement and 3 parts sand.

Steps for mixing concrete mortar

1. First calculate /determine amount of mortar you need.
2. Measure 1-part cement and 3 parts sand using material that has the same volume (bucket).
3. First, properly mix the dry components before adding water.
4. Add water slowly, constantly mixing using a trowel or shovel until all parts are damp.
5. Apply mortar with a trowel to the desired area (bricks, stone, or block works)
6. Cure the mortared area by keeping it moist for 7 days. Cover the mortared parts of the structure with moist cloth, plastic materials, or cement bags.

Annex 2: Conversion factors for quantifying construction materials

	Construction materials	In kilograms	Remarks
1	1 cubic meter of cement	350	
2	1 meter rebar of 6mm thickness	0.222	
3	1 meter rebar of 8mm thickness	0.395	
4	1 meter rebar of 10mm thickness	0.62	
5	1 meter rebar of 12mm thickness	0.89	
6	1 meter rebar of 14mm thickness	1.21	
7	1 meter rebar of 16mm thickness	1.56	
8	1 meter rebar of 18mm thickness	2.0	
9	1 meter rebar of 20mm thickness	2.47	
10	1 meter rebar of 22mm thickness	2.98	
11	1 meter rebar of 26mm thickness	3.85	
12	1 meter rebar of 28mm thickness	4.83	
13	1 meter rebar of 32mm thickness	6.31	
14	1 meter rebar of 40mm thickness	9.80	

Annex 3: Summary of household latrine substructure, floor/slab, and superstructure construction material options and estimated costs

Substructure (Lining) Material Options	Estimated cost by type of lining material including excavation and labor (ETB)	Floor/Slab Product/Material Options	Estimated cost by type of slab material including installation and labor (ETB)	Walling Material Options	Estimated cost by type of walling material including installation and labor (ETB)	Roofing Material Options	
Stone Lining (3.4m depth)		Concrete SanPlat slab 600mm x 600mm x 80mm		Thatched/ Grass		Thatched/ Grass	
Bricks Lining (3.4m depth)		Reinforced concrete slab 1000mm x 1000mm x 80mm		Polyethylene Plastic Sheet		Polyethylene Plastic Sheet	
Precast reinforced concrete ring of internal diameter 1000mm, thickness 100mm and height 500mm (3.4m depth)		Reinforced concrete slab 1200mm x 1200m x 100mm		Woven Bamboo		Corrugated Iron Sheet (CIS)	
Wood (2m depth)		Plastic Slab 700mm x 700mm x 50mm		Wood			
Bamboo (2m depth)		Plastic Slab 700mm x 800mm x 50mm		Mud Block			
No lining but Top 500mm depth stone/bricks		Plastic Slab 700mm x 1000mm x 50mm		Bricks			
		Reinforced concrete slab 1000mm x 1000mm x 80mm with plastic/ceramic pan/water seal trap		Stone (Mud Mortar)			
				Concrete Hollow Block			
				Corrugated Iron Sheet (CIS)			

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Notes