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Sustainable sanitation manual and construction guidelines for a waterless composting toilet

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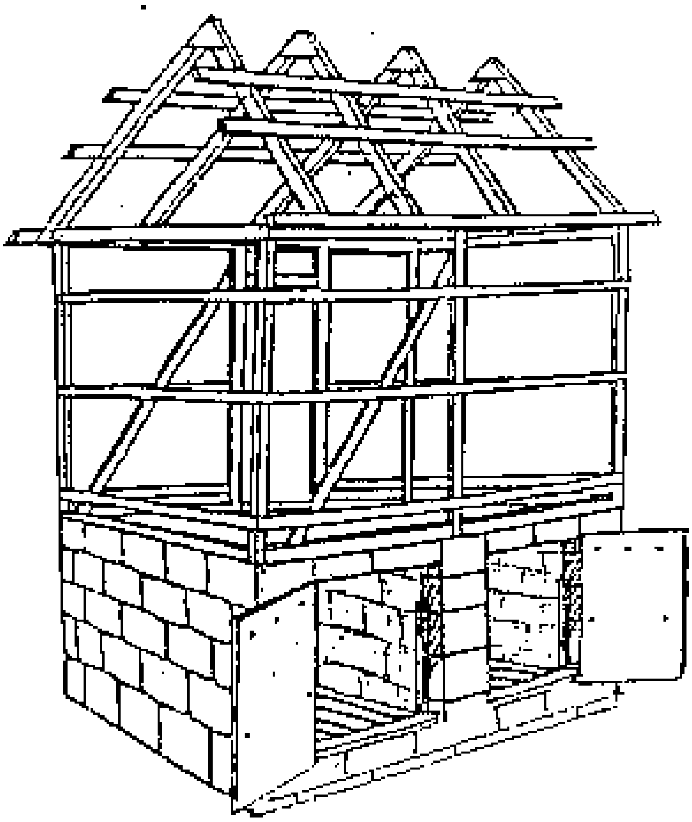
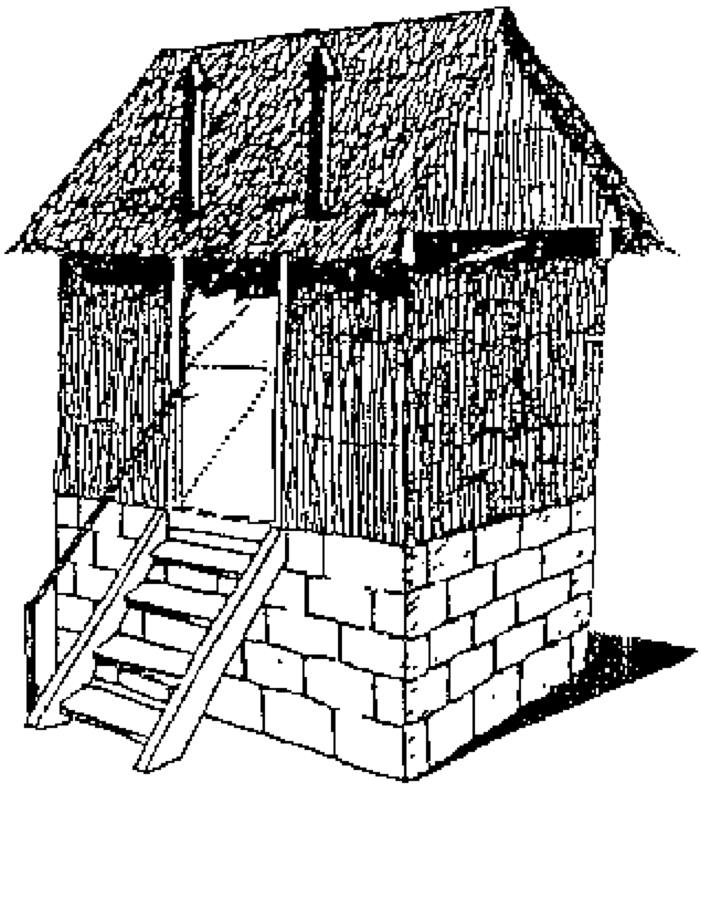




Background information

What is in sewage and how can it be harmful?

Sewage is used water, or the "waste water" that comes from the toilet, or from household cleaning activities such as dishwashing, clothes washing, cleaning the house, or cleaning a boat or motorbike.

Waste water can be harmful to the environment and to your health. It is harmful to the environment because it can contain high levels of nutrients (from faeces, urine, detergents) and other chemicals. It is harmful to your health because it can contain disease-causing organisms called *pathogens*.

Pathogens are invisible to the naked eye so it is hard to believe they are there. There are 4 main types of pathogens and they each cause different kinds of sicknesses and can also cause death.

Pathogen	disease or ???	symptoms
Viruses	hepatitis, polio	yellow skin, cant eat, crippled
Bacteria	salmonella, E-coli	boils, sores, infections in ears and eyes
Protozoa	giardia	vomiting, runny stomach, no energy
Worms	round worms, whip worms	slow growth in children, weakness, hepatitis, anemia, bloody diarrhoea

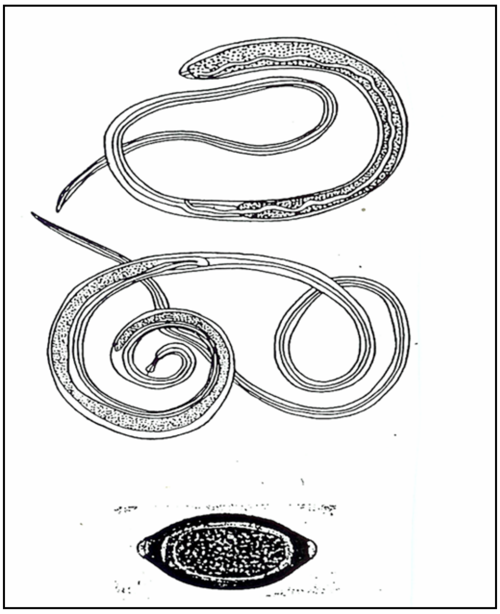
Information on pathogens and worms is provided by Dr Greg Berry from research conducted in the Pacific Islands.

Examples of pathogens

Trichuris worm

An example of a pathogen is the trichuris worm, which is very common in Pacific Island countries, especially among children.

Female worms produce 3,000-20,000 eggs per day. They live in the beginning of the large intestine or gut, called the caecum. The eggs are passed in excreta and can live in the soil for up to 10 years. If they are picked up on the hand of a child or an adult, the eggs can be swallowed when that person touches their mouth, and the eggs then hatch in the lining of the intestine. The adult worms then mate in the person's gut, and lay more eggs. These eggs then get passed in the excreta, and so the cycle continues.

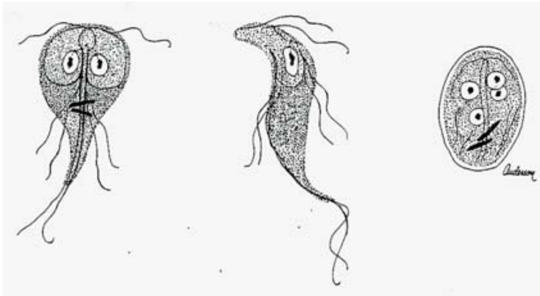


Male and female Trichuris worms and one of their thousands of eggs

These worms can give children bloody diarrhoea and make them lose their appetite. Children with worms are usually thin, anemic, and grow slowly, and may have a collapsed rectum — they find it hard to concentrate at school, cannot think clearly and have no energy to play. Their development can be seriously affected

Giardia

Giardia is another kind of pathogen, called a protozoa. This one does not need a male and female to mate and produce eggs. They just divide and produce cysts.



Giadia don't need to mate, they just divide

Sometimes people can have worms and protozoa and viruses all at once. Many children under five in the Pacific suffer from constant diarrhoea. It is a serious threat to the region's number one resource —children.

Stopping the spread of these invisible threats

The spread of pathogens can be stopped by doing a few simple things:

1) using an appropriate toilet;

2) washing your hands; and

3) protecting food from dirty hands and flies.

Toilets

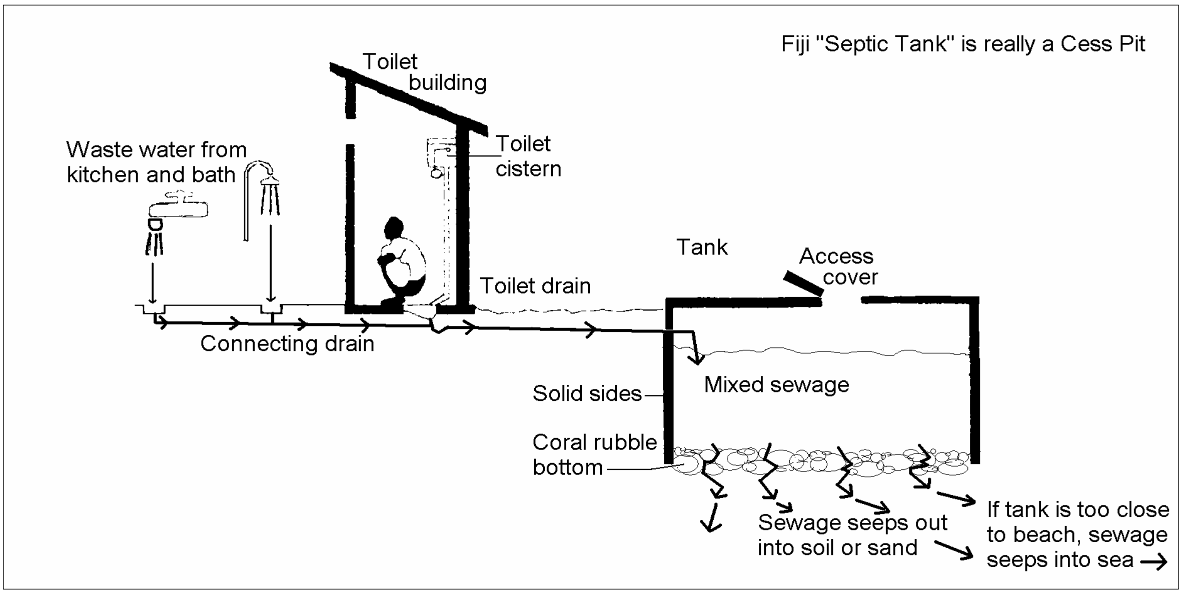
A properly designed toilet contains the human waste in a safe place while the pathogens are destroyed, and it is one of the strongest barriers to the spread of disease.

Common ways of disposing of waste in the Pacific Islands include using the bush or the beach — in which case there is no toilet — or using one of several types of toilet:

- Bush toilet — this is a hole in the ground with a simple cover around the hole.
- Pit toilet — pit toilets are usually covered with a concrete slab and have a "house" on the slab. The house needs to moved when the pit fills up.
- VIP toilet — VIP stands for ventilated improved pit toilet. These are really the same as pit toilets, but have a PVC pipe added to improve airflow and reduce flies and smells.
- Water seal — A pit covered with a concrete slab and a concrete toilet seat. A bucket of water is used to flush the waste into the pit.
- Flush/Septic toilet — A porcelain toilet with a water cistern. These require piped water to flush the waste into a concrete septic tank, where solids settle in the tank. The water collects in the tank and then passes out into a "soak", or straight into the soil and groundwater. The discharged water should be treated in a properly constructed trench to destroy the pathogens.
- Waterless compost toilet — The waterless compost toilet (CT) works just like a compost heap for your garden. In the garden compost heap you mix pig manure with dead leaves and chopped up branches, and leave if for a few months until it decomposes and makes a good fertiliser. In the CT it is human manure instead of pig manure, mixed with leaves and left for at least six months so that all the pathogens are killed by the composting process.

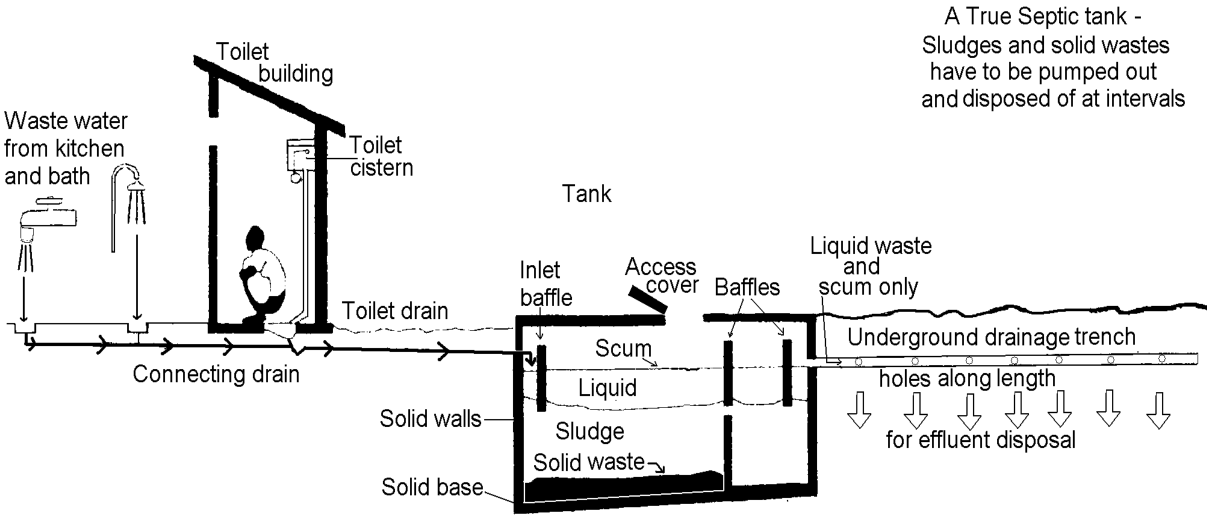
Unfortunately, using a toilet does not guarantee that the pathogens are safely removed and treated, if it is the wrong kind of toilet for your environment and situation.

The wastewater from septic tanks, water seal latrines and pit toilets can easily enter and pollute the groundwater, because generally it is not treated. In areas close to the beach or on small coral islands, wastewater can move underground to the reef, as shown below in the drawing of the Fiji septic tank "cesspit".



Septic tanks in Tuvalu and many other parts of the Pacific are built in the same way as this Fiji "cess pit". This is not a good system, as it allows untreated waste — and the invisible pathogens waste contains — to seep into the environment.

A properly built septic tank (see below) must have solid sealed walls and base. The solids settle in the tank, and the liquid passes across the top and through to a treatment trench. The trench has to be big enough so that the liquid can spread out in the soil, which allows the pathogens to be destroyed over time. This treatment method requires a lot of land, and to be safe the whole trench needs to be at least 50 metres away from groundwater, rivers and the reef.



How to decide which toilet is best for you

All types of toilets are ok **IF** they are properly built, and are the right toilet for your situation. It is important to understand how the toilet system works, so you can make the right decision about which type to use.

For example:

Land — there has to be enough land to allow a pit toilet to be moved around, or to fit a large treatment trench, which must be installed along with a septic tank.

Soil — if you have a flush toilet and septic tank, the soil in the treatment trench has to hold the wastewater long enough for it to be treated. Wastewater will drain through sandy soil too quickly, and won't be treated.

Water — there has to be enough water throughout the year to pour into and flush a flush toilet or a water seal toilet.

Groundwater — it is important that there be no groundwater or reef nearby that will be polluted from the wastewater.

Money — you must have enough money to maintain the toilet, including paying water bills, and repairing pipes and cisterns.

Which toilet is best depends on several things, such as whether you have good access to water, how big your family is, and where you live. The following questions will help in making the right decision:

Deciding on the type of toilet to use

Fresh water

Where does your water supply come from?

Is water supply reliable?

How much water is used by family?

What is the weather like where you live? What is the rainfall?

Your family and home

How many people are there in your family?

How much space and land do you have to build a toilet?

What is the cost to build and maintain a toilet?

The environment

What is your soil type? Sandy, rocky, or clay? Is the soil salty?

Do you have groundwater? (It will need to be protected).

Are you close to beach or reef?

How waterless composting toilets can be useful

Like all types of toilets, composting toilets have advantages and disadvantages, but they can be especially useful in some situations. Consider composting toilets if your fresh water is limited; if groundwater is near the surface, or sensitive environments such as reefs are nearby; the soil is sandy; you have limited land area, making it hard to find space to move a pit toilet, or you can't afford the cost of a septic tank and drainfield.

The composting the takes place in the sealed chambers under the toilet seat. There are two chambers. You use one chamber until it is full, and then close it off. You then begin using the second chamber until it is full. When the second chamber is full, it is time to empty the first chamber. The waste is now a safe fertilizer for your fruit trees.

Advantages of composting toilets

Nutrients — using the toilet compost as a fertiliser returns nutrients to the soil, instead of mixing them with water (which causes problems for the environment). A rich hygienic fertilizer is produced if the waste is left at least 6 months to compost (and this fertilizer costs nothing).

Water savings — CTs don't need water for flushing, which means precious water can be saved for essential needs.

No digging — CTs require no digging of deep pits or holes, since they are built at ground level, except for the shallow trenches for the evapotranspiration (ET) gardens for treating the urine/liquid.

No moving the toilet — CTs don't need to be moved when they are full, just close one chamber and use the other, and the CT can be built anywhere.

More affordable — CTs are cheaper to build and maintain than a septic system.

No smell — CTs don't smell when properly used and maintained.

No sludge — There is no bad-smelling unhygienic waste to remove and dispose of, such as the sludge from a septic tank when these are emptied.

Safe — CTs can destroy all pathogens, including worm eggs and viruses.

Disadvantages of composting toilets

Some work is required — CTs are both more expensive to build than water seal toilets and require more work to take care of, because they have to be emptied wen the compost is ready.

Built above ground — the CT chambers must be constructed above ground, so stairs or a ramp are needed to access the toilet room.

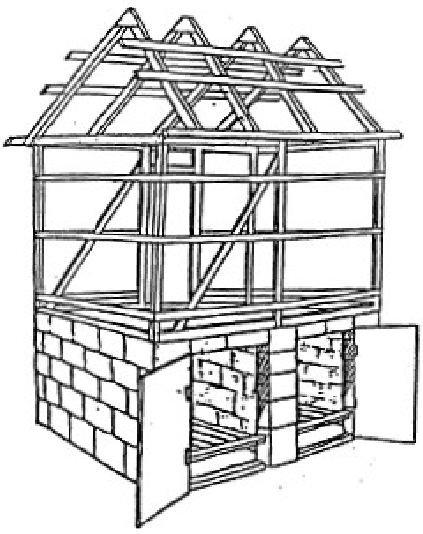
Dry organic matter — you must add dried leaves or woodshavings after use to make the compost.

Building a waterless composting toilet

How the toilet works

Composting toilets have two main treatment parts: the two **composting chambers** and the **evapo-transpiration (ET) trench**. The toilet house is built on top of the composting chambers.

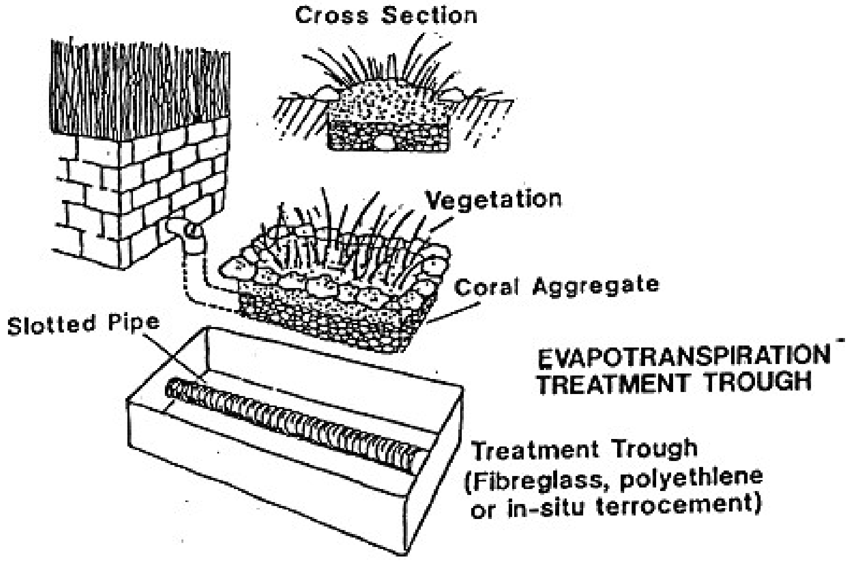
Composting chambers underneath toilet house.



BASIC STRUCTURE
(Concrete blockwork and timber frame)

COMPLETED TOILET
(Clad with local materials)

The waste in the composting chambers breaks down naturally because of the addition of dry organic material, such as leaves. The composting process won't work properly if the compost is too wet, so a pipe is installed to carry extra liquid from the toilet into the ET garden. It treats the extra urine and liquid that passes through the compost pile in the chamber. These gardens prevent any urine or liquid from passing into the soil, so there is no discharge from the CT into the environment.



Urine and liquid are treated and removed using two natural processes — evaporation and transpiration — which convert liquids into vapor. Through evaporation the urine and liquid moves from the surface of the ground into the air. Transpiration is the process of the urine and liquid passing through the leaves of living plants.

As the CT is used, any urine or liquid not absorbed in the compost pile passes through the false floor and drains into the pipe to the ET garden. The roots from plants growing on top of and around the ET garden then "drink" the urine. Small amounts of rainwater will collect in the ET garden, mixing with the nitrogen rich urine, and providing plants with a liquid fertilizer. The ET is lined with concrete blocks, stonework, or thick black plastic.

The evapo-transpiration trench, before it is covered with stones and soil.

Materials and tools list

This list of tools and materials is a combination from CTs built in Fiji, Tuvalu and Vanuatu. There are some ideas contributed by workshop participants and CT owners about using different materials and/or design changes.

Adapt to suit your toilet

This is not an exact list of the materials. Exactly what you will need will depend on what size CT you build, whether you use stone, ferrocement or concrete block walls, and other details. This list is a guideline for suggested materials and quantities. Local materials can be used to replace shop materials, as long as the CT works properly and the design principles are followed. Read the Technical Specifications (page 26) for design principles.

What's not included

You should decide what materials to use for constructing the toilet house on top of the chambers. This will depend on local custom, building styles, and your budget and preference, so a list of materials for the toilet house is not provided here. Please contact your Public Works Department with any questions on this.

Tool List

The Tool List includes the tools you will need for building the CT, whatever materials you choose to use.

Tool	Construction Use
Hammers	Nailing wood & using cold chisel
Handsaws	Cutting wood
Trowels	Working concrete
Shovels	Preparing site, mixing concrete
Spirit Level	Leveling blocks and concrete
String Line	Marking out CT dimensions
Measuring Tape	Measuring CT dimensions
Cold Chisel	Breaking concrete blocks
Fly Screen	Separating sand from coral, vent pipe
Chicken Wire w/ 12.5mm holes	Separating small stones from large stones
36 liter bucket	Making toilet pedestal with concrete
No. 10 block mould	Making blocks for chambers
No. 15 block mould	Making blocks for chambers
Bolt cutters	Cutting rebar to size
Pliers	Cutting and fastening tie wire
Carpenter's square	Accurate measurements
Metal Shears	Cutting Flat Galvanized Sheet Iron
Hand Drill w/12mm or ½" bit	Drilling holes in house wood for rebar

False Floor Material List

Material	No.	Use
3 x 5 local hardwood (80 cm)	4	False Floor
3 x 5 local hardwood (115 cm)	24	False Floor
50mm (2”) galvanized nail (1 kg)	1	False Floor

Composting Chamber Material List

Material	No.	Use
Standard concrete block (number depends on size of chamber)	66-106	Chamber Walls
6 mm Rod x 6m	10	Foundation Slab
Cement (40 kg Bags)	9	Foundation & Floor Slab
Galvanised Iron 90cm x 1m, or 19mm marine ply	1.2	Access Doors
Chicken Wire 90cm x 12.5mm x 1m	1	Toilet Stool
20mm galvanized flat nail (kg)	½	Access Doors
100mm steel nail (kg)	1	Toilet House Structure
75mm galvanized nail (kg)	½	Access Door Frames
Sand (cubic meter)	2	Chamber / Slab / Foundation
Small aggregate (cubic meter)	1	Chamber / Slabs / Foundation/ET
Large aggregate (cubic meter)	1	Chamber / Slabs / Foundation/ET
100mm PVC pipe 3m	1	Vent Pipe
100mm Strap Hinges	1	Door to Toilet
100 x 10 mm Galvanized Padbolt	1	Door to Toilet
Tie wire (kg)	¼	Foundation & Floor Slab
3 x 10 local hardwood/treated pine (80cm)	4	Access Door Frames
3 x 10 local hardwood/t.pine (54cm)	4	Access Door Frames
3 x 5 local hardwood/t.pine (74cm)	4	Access Doors
3 x 5 local hardwood/t.pine (44cm)	4	Access Doors
3 x 15 local hardwood/t.pine (74cm)	6	Baffle Boards

Evapotranspiration (ET) Garden Material List

Material	No.	Use
Black Plastic 2m wide (per m)	5	Evapotranspiration Garden
100mm or 75mm PVC pipe 30cm	2	Evapotranspiration Garden
100mm or 75mm PVC pipe 50cm	2	Evapotranspiration Garden
100mm or 75mm PVC 90 Bend w/Inspection Cap	2	Evapotranspiration Garden
And/OR Concrete blocks	10	Evapotranspiration Garden

Construction guidelines

This section will provide the general construction steps for building the CT. There are basic plans attached at the back of this manual but the measurements depend on what size CT you want to build to suit your family's needs (see the Technical Specifications). It is recommended that you check with your Public Works Department for assistance in ensuring you are using the right plans before building.

Choosing the place(site) to build the toilet

Before you start work, choose a site that is:

- Convenient for the family;
- Close to the house but away from the neighbours;
- Has enough room to put the toilet building and the trenches.

Avoid high wind areas, and low wet areas. If you are building a new house the chambers can be built underneath, so the CT is located inside.

Preparing the place (site)

- Level the ground where the CT will be built
- Do not remove any banana or food trees near the site. Trees are good for shade, privacy and will 'drink' the urine and liquid from the ET garden.

Mixing the concrete

- Only use stones that will pass through 25 mm chicken wire mesh, but don't use very small stones. Measure cement, sand and coral in a bucket. The concrete mix is usually 3 buckets coral/aggregate, 2 buckets sand, and half a 40 kg bag of cement. Maybe you have your own special mix for concrete.
- Do not add too much water during mixing. Otherwise the mix will be hard to work. The cement also collects in the bottom of the mix which means it does not bind well with the sand and coral. This can make the concrete weak. Add only enough water to make a "sticky" mix.

Builders in Vanuatu -making sure the stones/coral are the right size

Forming and pouring the foundation slab

- Construct the formwork for the foundation. The foundation is 10 cm longer and wider that the actual size of the compost chambers to provide room for error when laying the blocks. Measurements for the foundation are: 250 cm long by 135 cm wide.
- Dig the foundation 15 cm deep.

- Fill and compact the formwork with a layer of coral/stone;
- Spread a thin layer of sand on top of the small stones; and
- Cover with plastic.
- Cut pieces of 6mm rebar (also called reo or reinforcing rod), and lay around the edges of the foundation slab.
- Cut pieces of 6mm rebar and bend them in an 'L' shape. Tie these to the rebars around the edge of the foundation where they will go through the blockwork.
- Fill the formwork with the concrete mix.
- When finished for the day, always wet the finished concrete before covering it in plastic, or banana leaves. This will prevent the concrete from drying too fast and cracking. The cement should be kept wet for 2 days after pouring.
- Do not forget to wash the concrete off the tools before it dries!

Building the chamber walls

The chamber walls can be built from cement blocks, stones and cement, or concrete poured into formwork with reinforcing. The main requirement is that the walls are properly sealed and can support the weight of the toilet house and the people who use it.

- After leaving the foundation slab to cure for 2 days, remove the plastic or banana leaves that were covering the foundation slab. Remove the formwork and wash the foundation surface with water.

- Cut 8 pieces of 6mm rebar (also called reo or reinforcing rod). These should be 80–100, depending on the height of the chambers (see next page).
- Using tie wire, tie the cut rebar to the 6mm starter bars that were placed in the foundation slab.
- Set blocks 5cm from the edge of the foundation on each chamber corner.
- Lay the first row of blocks, including the middle row between the chambers
- Fill blocks with the same concrete mix used in the foundation slab construction **or** use the mortar mix and any stones, or pieces of cement block.
- Leave a space for the drainage pipes that will connect to the ET garden

- Fill all the hollow spaces inside the blocks to make a solid wall, especially the spaces where there is rebar (see photo at right).
- Make sure the chambers walls are straight and square. Otherwise there may be problems building the toilet house on top.

- The chambers are usually four blocks high, which is about 80–90cm from the top of the foundation to the top of the last block. But you can make it 5 blocks high if you want a bigger toilet.
- Plaster all walls on the inside of the chambers.
- Construct two ledges in each chamber for the false floor to sit on. These should be 10 cm high and 5 cm wide, at the back and front of chambers.
- Frame the access doors to the chamber with hardwood or treated pine painted with 2 coats of primer.
- Slope the chamber floor towards the outlet pipe and connect the pipes to the ET garden.

Making the evapo-transpiration (ET) garden

- There are many ways to make the ET garden. The cheapest and easiest way is to use plastic to line the trench but it is best to use cement blocks or a concrete lining to make sure the trenches last a long time. It is best to have two trenches: if there is a problem in one, you can still use the other side.
- Dig the pit for the garden and the pipe. The garden dimensions are 70 cm wide by 100 cm long by 50 cm deep. The distance from the garden to the chamber is about 20 cm.
- Put a thin layer of sand in the pit before placing black plastic 3 m long and 2 m wide inside the pit bottom and up over the sides.
- Fill the pit with the large coral/stone.
- Connect the pipe from the chambers to the 90 degree bends. PVC glue is not necessary to stick the pipes together since they will not be under pressure. Tapping the pipes into the 90 degree bend is enough to hold them together.
- Using a handsaw, cut holes in the last 10 cm of the pipes for urine/liquid to

drain into the ET garden. Or drill the holes if you have an electric drill. The pipes can be 100 cm or 75 cmm wide.

- After cutting or drilling the holes, clean the plastic shavings out of the pipes.
- The pipe from the inside of the chamber should slope down to the edge of the ET garden so that any excess urine/liquid will easily drain into the ET garden.
- Cover the stones in the trench with plastic or old rice bags to help the water run off the trench when there is heavy rain. Cover the bags with soil and pile into a mound so rain will flow away from the trench
- Put stones around the ET garden with stones or coral and plant flowers inside to identify its boundaries.

Forming/pouring the floor of CT house

There are two ways of constructing the toilet floor slab: you can make the floor slab in two parts on the ground, and then set them on the chambers after they have cured, or construct a formwork to pour the floor slab in place on the chambers.

Option 1: Make the floor slab in two parts on the ground, then put them on the chambers after they have cured for 3 days

- Using 25 x 50 mm timber construct two sets of formworks. Leave 5cm of space between the edge of the outer chamber walls and the floor slab after placing them on the chambers.
- Leave a space for the vent pipe and the toilet seat.
- Cut a small (5 cm long) section of the 100 mm vent pipe to be set in the slabs where you want to put the vent pipe. The best place is behind the seat to support the lid when it is up.

Option 2: Construct a formwork and pour the floor slab in place on the chambers

- Construct the formwork.
- Using the fiberglass toilet seat, mark out where the hole will be located for both chambers and cut the arc mesh.
- Place the arc mesh wire on formwork making sure it is about 2cm above the formwork.
- Place a piece of pipe in the slab to allow for vent pipe installation.
- Pour the concrete.
- Install 50mm long bolts around both holes for the toilet seats so they can be screwed to the concrete.
- Install bolts around edge of slab to attach the frame of the toilet building

- Cover the slab with plastic or banana leaves and let it cure for a few days.

Building the false floors

The compost pile sits on a “false floor” which is 10 cm above the floor of the chamber. This allows air to move under the pile and any excess liquid to drain out of the pile and into the ET garden. The floor should be made of durable timber to prevent rot. It must last at least the full period of use plus the period when the chamber is closed for composting, meaning about 12 months in all. The floor can be replaced when the compost is emptied if it is starting to rot, but it is better if it lasts for many years, as then it won’t need to be replaced.

- Measure the inner dimensions of each chamber and build the floor.
- Both treated pine and local hardwood should be painted with 2 coats of primer, so that they last a long time.
- The slats should be 50 mm wide and 25 mm thick. The spacing between the timber pieces should be about 15 mm.
- After nailing all of the pieces together and ensuring the fit is good, cut the floor in half to allow for easier removal during cleaning.

In Vanuatu they have used another idea for constructing a false floor, which is to build two small frames and nail ¼" copra mesh wire to the frames. This false floor design requires less treated timber to construct, but costs the same as the first option because of the cost of the copra wire. You will have to make sure the wire doesn't rust.

Building the access doors

- The material used for constructing every part of the access doors should be constructed from treated timber, or from a local hardwood timber, that will not rot.
- The size for door frames will vary depending on the size of your CT. The doorframes are nailed to the concrete blocks using concrete nails. Then fill in any spaces between the doorframe and the chamber walls with mortar
- Nail runners on the inside of the frame to hold the baffle boards.

- Cut the baffle boards out of marine plywood or treated pine and paint them with primer. The baffles boards hold the composting pile inside the chamber when you open the door to check if it has fully composted. If the pile is fully composted and ready to remove you can slide out the baffle boards and empty the chamber.
- The doors of the chambers can be made with marine ply or flat tin on a frame.
- They can be attached to the frame with hinges or wingnuts or bolts.

Baffle boards

Toilet pedestal construction

It is possible to make a toilet pedestal and seat out of timber or out of concrete. You can also buy a toilet pedestal and seat made for CTs, but these are expensive.

In Vanuatu they made a concrete pedestal and moulded it on to the slab, using a bucket as the form for the toilet pedestal. The following pictures show the pedestal being built.

- Turn the bucket over and wrap it in 12.5mm chicken wire.

- Cut rebar to a length of 35 cm and place it over the chicken wire.
- Cut pieces of rebar and place these at the back of the toilet. They will support the toilet seat.

- After placing the rebar, fold the chicken wire back over the rebar. The wire may need to be cut in places to better fit the bucket and also to fold around the longer rebar supporting the toilet seat.
- Fit the toilet seat on the stool and find where the two bolts for the seat will be located. Remove the seat and place two sticks where the bolts were.

- Using the mortar mix, completely cover the rebar and chicken wire.
- Leave it to sit for one day with this rough plaster.
- After a day, remove the toilet seat from the bucket.
- Remove the sticks and place the toilet seat on the stool.
- Turn the stool over and add the second coat of mortar to form well with the toilet seat. Leave to cure for another day.

Building the house on top of the composting chambers

The house on top of the composting chambers can be constructed using methods and materials that suit your budget. What matters is that the toilet room is strong, comfortable, dry, and attractive.

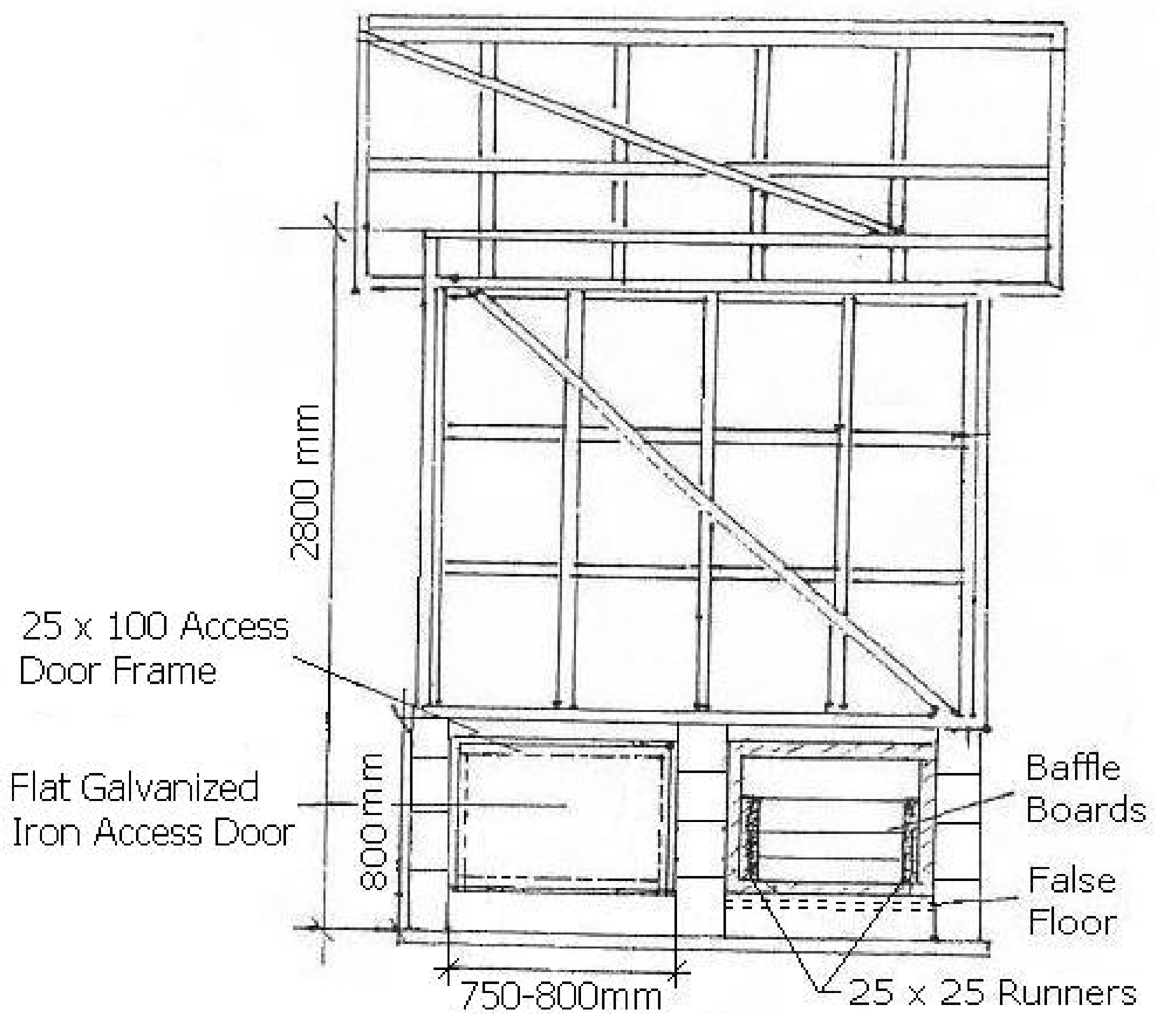
There are many choices for materials as well as design. It is up to you to decide

CT in Vanuatu 3 blocks high

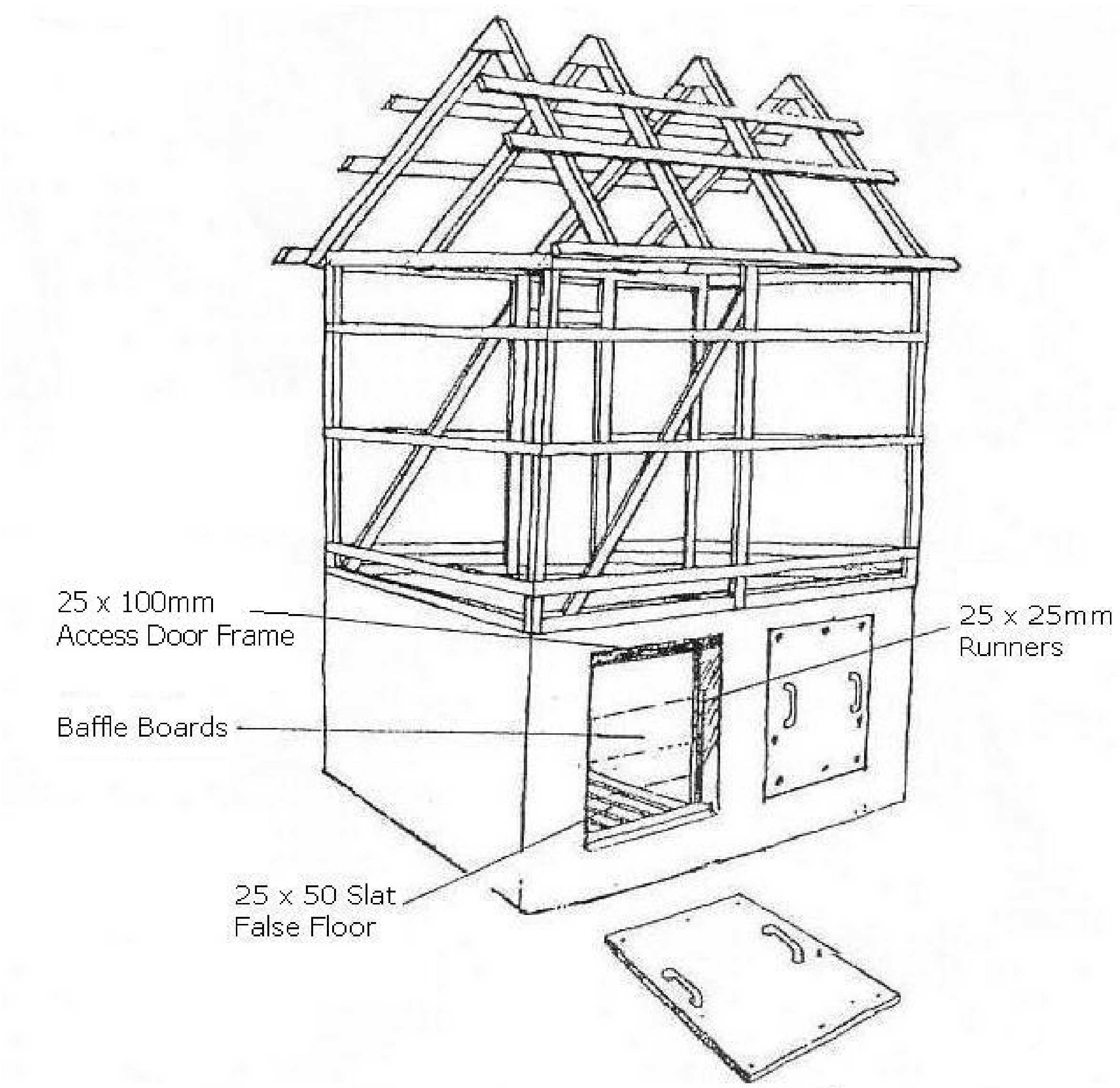
CT in Tuvalu 5 blocks high

Technical drawings

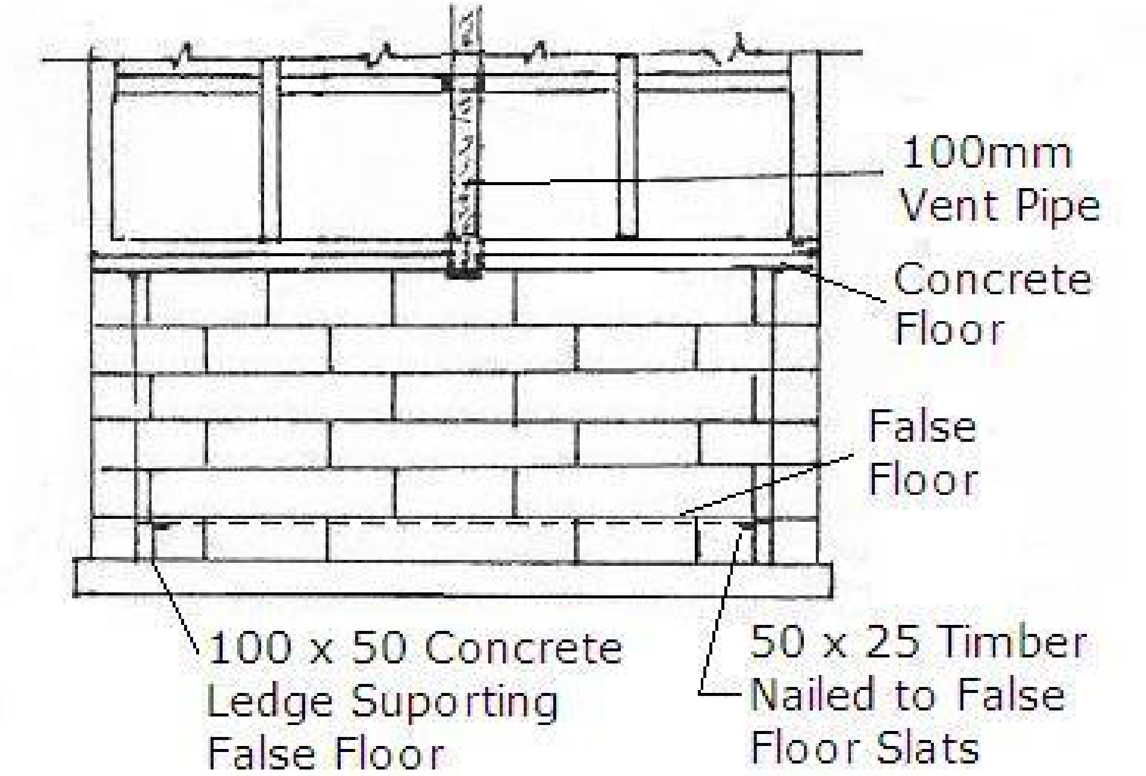
In this first sketch the size of the CT composting chambers are smaller than the demonstration model built in Funafuti in October 2006. This shows that the CT can be changed and built to suit the size of the family who will be using it. Before building a CT discuss your needs with your Public Works Department so you can decide which size CT is best for you and the land where it will be built.



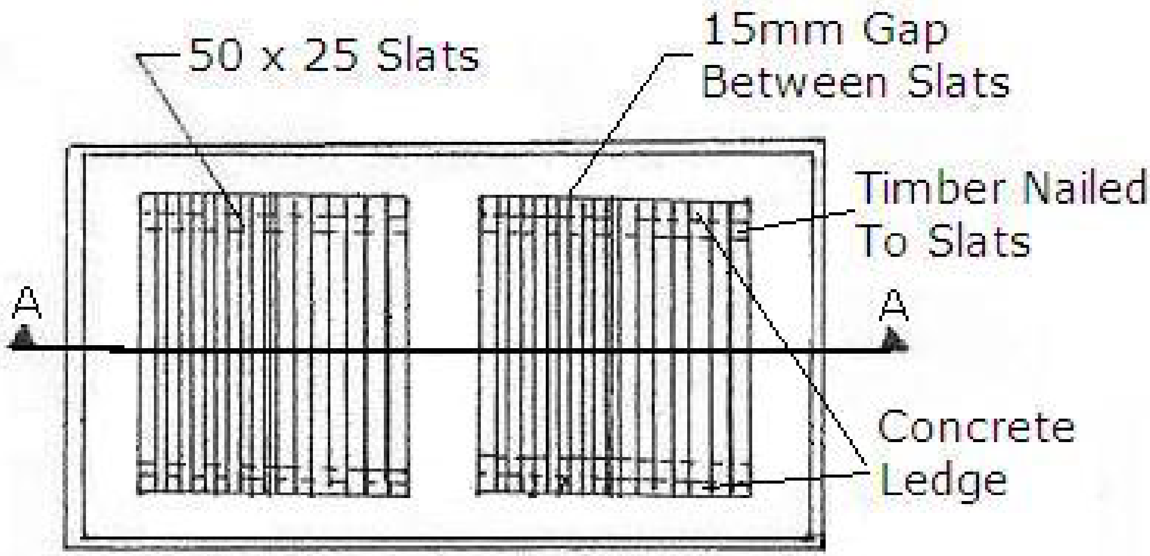
Chambers - Back



The access doors to the composting chamber can be attached with wingnuts or bolts or they can be attached with hinges and a padlock

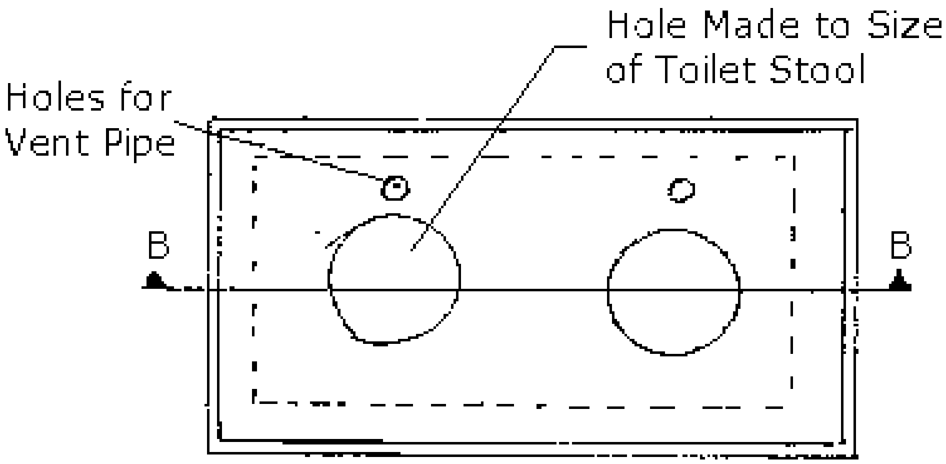


Section A-A

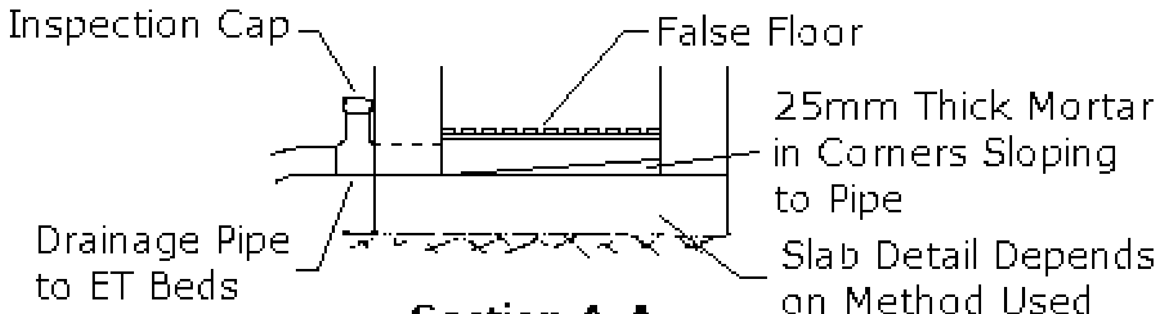


False Floor - Plan View

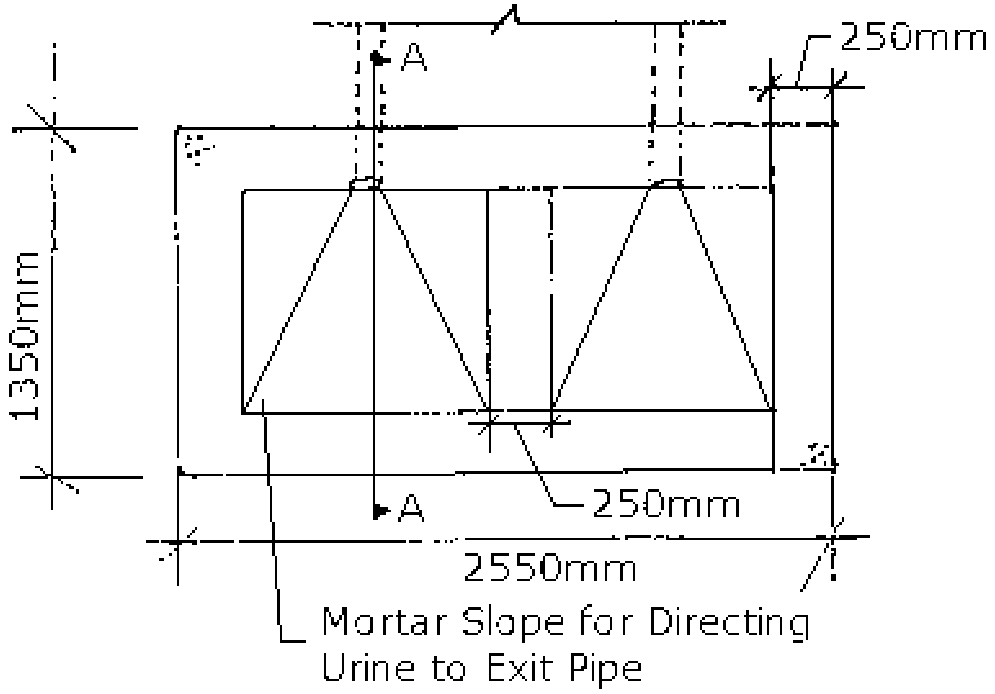
Section B-B



Concrete Floor - Plan View



Section A-A



Concrete Slab - Plan View

Full plans of the CT are available from the Public Works Department in Tuvalu

Technical specifications

Given below are specifications for installation as a separate toilet house (as shown in this manual), built within a new house, or retrofitted into an existing house

The design includes the composting system and a superstructure for a freestanding toilet building. The composting chambers described herre, including ventilation and drainage system, can also be installed beneath a bathroom or toilet room, within a house or amenities block. The design of the superstructure or toilet house can be adapted to local requirements, but should be durable.

The composting chambers

Two concrete composting chambers

Each chamber should be approximately ¾ cubic meters of internal volume, (the demonstration model in Funafuti is 1 cubic meter internal volume), in a side by side configuration on a 100 mm concrete slab. Dimensions of the chambers can be reduced but height should not be less than 800 mm and width of a chamber should not be less than 650 mm. Walls can be made with concrete blocks, or constructed on site using formwork. Chambers must be insect and vermin proof and water-resistant. <u>Foundations of chambers should comply with local specifications for weather conditions and site soils</u>. All timber inside the chambers should be rot resistant local hardwood timber, or treated pine, unless otherwise stated. The internal walls of the chambers should be well sealed with a 1:1 mortar mix. All nails and screws should be galvanized or corrosion proof.

Drainage floor

Under the false floor in the chambers, the drainage floor drops 25 mm to a 75–100 mm drainage outlet, one from each chamber (see evapo-transpiration trench and garden, below).

False floor

50 × 25mm hardwood timber slats provide a removable false floor to support the compost pile. The false floor rests on 50 mm wide concrete block work, 100 mm above the drainage floor of the concrete chambers. A 50 × 25 mm frame is screwed to the underneath of the slats 80 mm from side edge of the false floor. A 15 to 20 mm gap is required between the slats. The access door to the chambers is framed by 100 × 25 mm timber. The top of the false floor is 100 mm below the base of the 100 × 25mm timber frame to which access doors are fastened.

Access door

The access door should be of sufficient depth and width to allow removal of the false floor from the chamber, for maintenance. This can be achieved by building the false floor in two sections. The doors can be from flat galvanized sheet metal, or marine plywood, and are fixed to the 25 × 100 mm timber access doorframe that is recessed into concrete walls of each chamber. The access doors can be secured onto the frame in different ways: using wing-nuts, turn locks made from locally carved pieces of wood, or plastic electric cord C-clips nailed to the access doorframe. It is essential that the chamber doors are easy to open by an adult but are well secured against access by children. The chamber doors should be black (or a dark color) to absorb heat.

Baffle boards

Three 20 × 150mm marine plywood or local hardwood baffle boards are supported by 25 x 25 mm runners at the chamber openings. The runners are nailed to the inside of the 25 x 100 mm access doorframe, allowing a gap of 25 mm for the baffle boards to slide out of the runners and to allow for expansion when wet. The baffle boards prevent the compost pile from falling out of the chamber when the door is removed. The gap at the top of the boards permits inspection of the pile and easy removal of the three baffle boards.

The top of the chambers

A 50 mm ferrocement slab forms the ceiling of the concrete chambers and the floor of the toilet room. This slab can be constructed in place on top of the chambers using formwork, or constructed off the chambers in two parts (one for each chamber) and set on the chambers after curing for two days.

The toilet pedestal

A ferrocement or fiberglass pedestal is set over a hole in the floor of the toilet room above the chamber that is being used. A fiberglass plate, or ferrocement or timber lid is placed over the hole above the chamber that is not being used. The seat and the plate or lid should be easy for householders or maintenance staff to exchange. The pedestal can also be made from timber or moulded in concrete. The walls of the pedestal or toilet seat should be splayed so faecal matter doesn't adhere to the sides, to reduce necessity for cleaning.

Evapo-transpiration trench and garden

75 or 100 mm PVC pipe from each composting chamber drains to the ET trench, which is 500 ×1400 × 750 mm, and lined with plastic (HDPE) or concrete. The trench contains large and small aggregate, sand and soil, and is fed by a 100 mm slotted pipe. Screw capped inspection points in 908 bend between building and trench in 100 mm (or 75 mm) drainage pipe to allow for cleaning. The trenches can be sited at any side of the chamber as long as the drainage floor falls in that direction.

Plant appropriate vegetation or trees — such as banana trees, laplap, or pawpaw trees — on or adjacent to the trench to assist evapo-transpiration of the liquid that drains into the lined trench. Completed trenches should be mounded to assist surface runoff.

The toilet room

A toilet room isn't needed if the composting chambers are installed under a house. If the CT is to be built away from the house then a toilet room must be built. The frame of the toilet room, or superstructure, should be storm resistant and suitable for covering with natural materials such as pandanus thatch or permanent materials such as fibro, plywood, or corrugated iron. Plywood walls should be painted for waterproofing. The hinged door of the toilet room is secured on the outside with a sliding bolt that will allow a padlock to be attached if required. A sliding bolt or similar should also be attached to the inside of the toilet room door.

The toilet room should be well ventilated and allow for natural light.

The roof can be in zincalume, corrugated iron, or thatched with local materials. The materials and design of the superstructure toilet room can be varied to suit local building regulations and the practicalities and aesthetics of the site, as long as it does not compromise the function of the composting chamber and the drainage system.

Two 100mm PVC vent pipes are inserted into the partition between both chambers through the toilet room floor to allow air passage through both chambers, and extending 1 m above the roof. The ventilation pipes are painted black to help the air flow.

Stairs with 200 × 50 mm treads and 200 × 500 mm stringers and handrail would provide stable and safe entry to toilet room for adults and children. Alternatively a ramp can be installed across the front of the building to provide wheelchair access. Concrete blocks can also be used to build the steps. If the site includes an appropriate raised area, the building can be set into the bank so that access to the toilet room is level. The back of the composting chambers and access doors must be above ground level to enable easy maintenance and ensure the drainage system does not threaten groundwater.

Operation and maintenance

Here is a sign that could be placed in the CT telling users about the toilet and how to use it.

> This is an environmentally friendly composting toilet. No pollution goes into the environment
>
> - Please add a handful of leaves from the basket after use
> - Close the lid after you throw in the leaves
> - Wash your hands with soap and water after you leave the toilet
> - No water, chemicals or rubbish should go into the toilet

Changing chamber when one is full

- Before moving the toilet stool to the other chamber open the access door and check the compost by looking over the baffle boards. If it is fully composted and looks and smells OK, remove the compost using a shovel.
- After removing the compost, check under the false floor to see if any compost or leaves fell through the false floor, in case these have blocked the ET pipe. If there is any rubbish, remove the false floor, remove the rubbish and then replace the false floor.
- Start the new composting chamber by adding a thick layer (about 100 mm deep) of dry brown leaves onto the false floor. Then put the baffle boards back and close the access door.
- Now move the toilet stool to the hole over the new chamber.
- Before closing off the chamber that is full, fill it up with dry leaves up to the bottom of the floor slab.

Maintaining/Cleaning the toilet

- After using the toilet, throw one handful of dry leaves into the chamber and then shut the lid. Toilet paper and sanitary pads can be put in the toilet.
- Keep the area inside the toilet house clean and a basket of leaves always near the toilet.
- If the toilet has a bad smell it means that it is not working properly. Try throwing in a large pile of leaves over a few days. If the smell is still there, the pipe to the ET may be blocked.
- Clean the toilet seat with a small amount of water and rag or leaves or toilet paper (and soap if necessary, not bleach) and drop the rag or leaves into the toilet.

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