Water for the World

Constructing a Household Cistern

Technical Note No. RWS. 5.C.1

Well constructed cisterns play an important role in providing families with an accessible supply of potable water. Cisterns and storage jars constructed of locally available materials offer improved access to water supply in many areas where good supplies are limited. They also provide a means of controlling the water quality.

This technical note describes construction steps for building reinforced concrete cisterns, ferrocement tanks, and medium and large reinforced mortar storage jars. The steps discussed are offered as guidelines and can be changed to fit local needs and situations. Before attempting the construction of any cistern, seek advice and assistance from people experienced in working in concrete and ferrocement construction.

Useful Definitions

FERROCEMENT - An economical and simple-to-use type of reinforced concrete made of wire mesh, sand, water and cement.

VOIDS - Empty spaces; open areas between particles or substances.

Materials Needed

Before beginning the construction process, be sure to have the following items:

1. A plan of the cistern showing the design and dimensions as shown in Figure 1.

2. A list of materials, tools and other supplies needed to complete the job. Similar to the list in Table 1 or 2. All materials should be available before construction begins in order to avoid delays.

Table 1. Sample Materials List for a Reinforced Concrete Cistern

Item	Description	Quantity	Estimated Cost
Labor	Local workers	____	____
Supplies	Portland cement	____	____
	Clean sand and gravel	____	____
	Clean water for mixing cement	____	____
	Reinforcing rods	____	____
	Screened mesh	____	____
	Boards and plywood for forms	____	____
	Nails	____	____
	Old motor oil or lubricant for forms	____	____
	Galvanized pipe for overflow	____	____
	Tap for outlet	____	____
	Guttering	____	____
Tools	Shovels and picks	____	____
	Measuring tape	____	____
	Hammers	____	____
	Saws	____	____
	Carpenter's square	____	____
	Pliers	____	____
	Wire cutters	____	____
	Mixing bin, mortar box	____	____
	Buckets	____	____
	Trowel	____	____
	Adjustable wrench	____	____
	Screw drivers	____	____
	Paint brush	____	____
	Level	____	____

Total Estimated Costs = ____

Table 2. Sample Materials List for a Ferrocement Cistern

Item	Description	Quantity	Estimated Cost
Labor	Local workers	____	____
Supplies	Portland cement	____	____
	Plain wire, 2.5mm	____	____
	Chicken mesh, 1m wide	____	____
	Water pipe	____	____
	Water tap	____	____
	Overflow pipe	____	____
	Galvanized iron sheet and angle iron	____	____
	Sand	____	____
	Gravel	____	____
	Bolts	____	____
	Water	____	____
Tools	Shovels and picks	____	____
	Wire cutters	____	____
	Wrenches, adjustable and open	____	____
	Screw drivers	____	____
	Paint brushes	____	____
	Trowels	____	____
	Mixing bin, mortar box	____	____
	Wheelbarrow	____	____
	Buckets	____	____
	Hacksaw and blades	____	____
	Hammers	____	____

Total Estimated Cost = ____

Construction Steps for a Reinforced Concrete Cistern

Follow the construction steps below. Refer to the appropriate diagrams during the construction process.

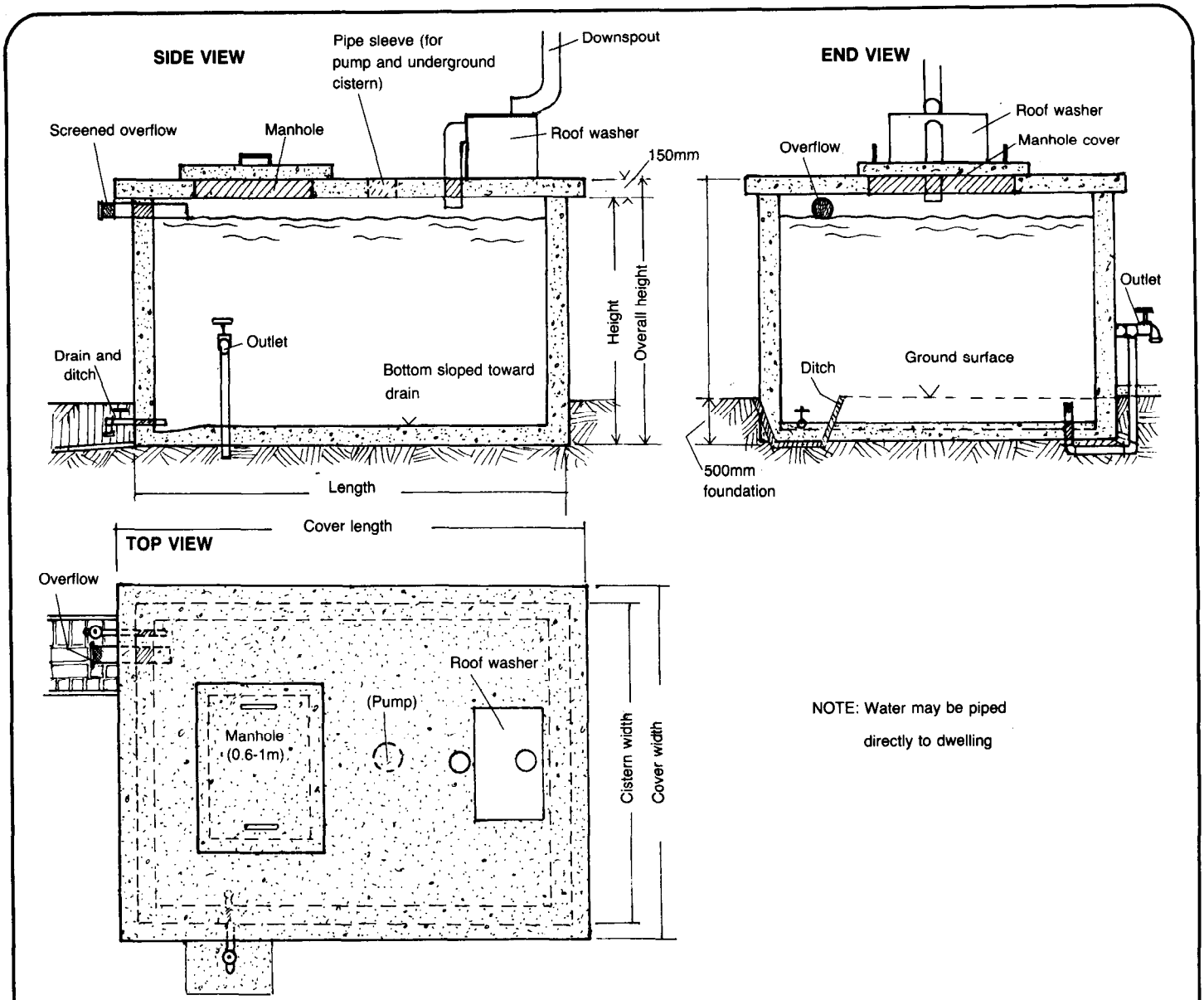


Figure 1. Plan for Household Cistern

1. Find the best location near the house to build the cistern. It should be located on high ground for good drainage and should not be located closer than 15m to the nearest waste disposal site. Once the site is located, mark it out using a measuring tape, wooden stakes and cord, as shown in Figure 2.

2. Dig out a base in the ground to fit the dimensions of the cistern. The hole should be only 50-100mm deep. This will allow installation of an outlet near the bottom of the cistern to take advantage of the entire volume of the cistern. Level the excavated area using flat-nosed shovels and scrapers made from wood.

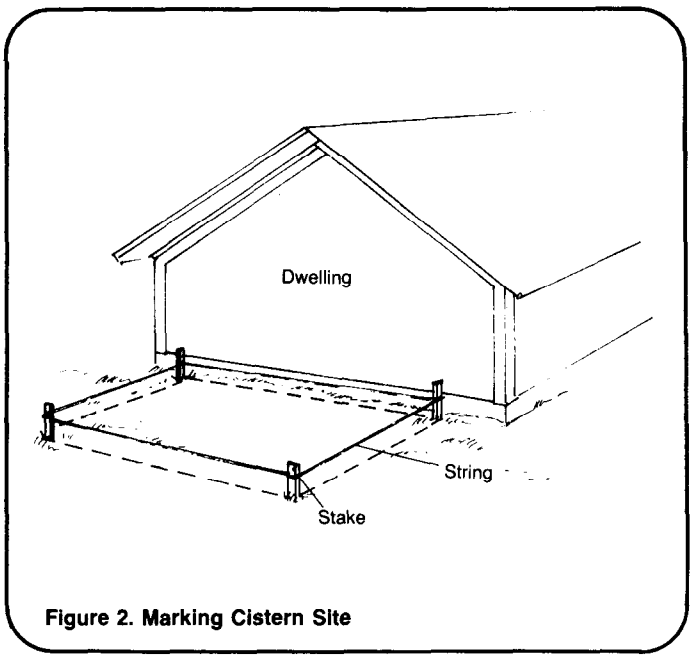


Figure 2. Marking Cistern Site

3. Prepare the forms for the structure. Use plywood sheets, if available, for the faces and small pieces of wood for bracing. All formwork for the cistern should be completed before any concrete is poured.

- Nail all forms together to the design size of the cistern. Walls should be 200mm thick.

- Brace the forms well. Place small holes in the forms and slide wire through them. At the end of each piece of wire, attach a stick to hold the wire in place. Then tighten the wire to create enough pressure to withstand the force of the poured concrete. See Figure 3. Dirt should also be piled up against the outside of the walls to give them support against the weight of the concrete.

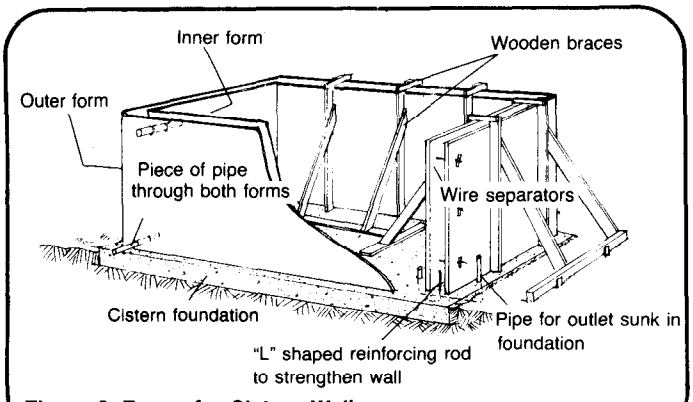


Figure 3. Forms for Cistern Walls

- Place reinforcing rods in the forms. For best results, lay the rod for the floor in a grid pattern as shown in Figure 4. The cross bars should be long enough to cross the entire length of width of the floor and extend at least 300mm into the wall. The reinforcing rods should be bent to fit into the wall forms to a height of 300mm. Other lengths of rod are then tied with these lengths to complete the installation of the reinforcing rod.

This technique is recommended to provide a solid connection between the wall and the floor. Figure 4 demonstrates the placement of reinforcing bars in concrete. The steel bars should be separated 150mm with the first cross bar laid 75mm from the edge of the pour. The bars should be placed one third of the distance from the outside or, as in the example given, about 70mm in from the outside edge.

4. Make holes in the form for placement of the overflow and outlet pipes. The pipes should be placed directly in the forms when pouring the concrete to ensure a good pipe installation.

5. Oil all forms before pouring concrete. Use old motor oil or other available lubricant to prevent the concrete from sticking to the forms.

6. Formwork and steel bar placement for the cover follow the same procedures as outlined above. After forms are complete, mix the cement, sand and gravel in a 1:2:3 ratio adding 23 liters of water for each bag of cement. These proportions will ensure a thick paste.

Pour the floor and about 200mm up the side of the wall in the first pour. Tamp down the cement with steel rods and shovels to make sure that all voids are filled. Once all reinforcing rods are attached, finish the pour, tamp the mixture well and smooth all surfaces.

Cover the concrete with canvas, burlap, empty cement bags, plastic or other protective material to prevent loss of moisture. Keep the covering wet so the concrete does not become dry and crack. When pouring the cover, be sure to leave an opening for access to the cistern. The opening should be fitted with a cover which either can be locked or is difficult to remove.

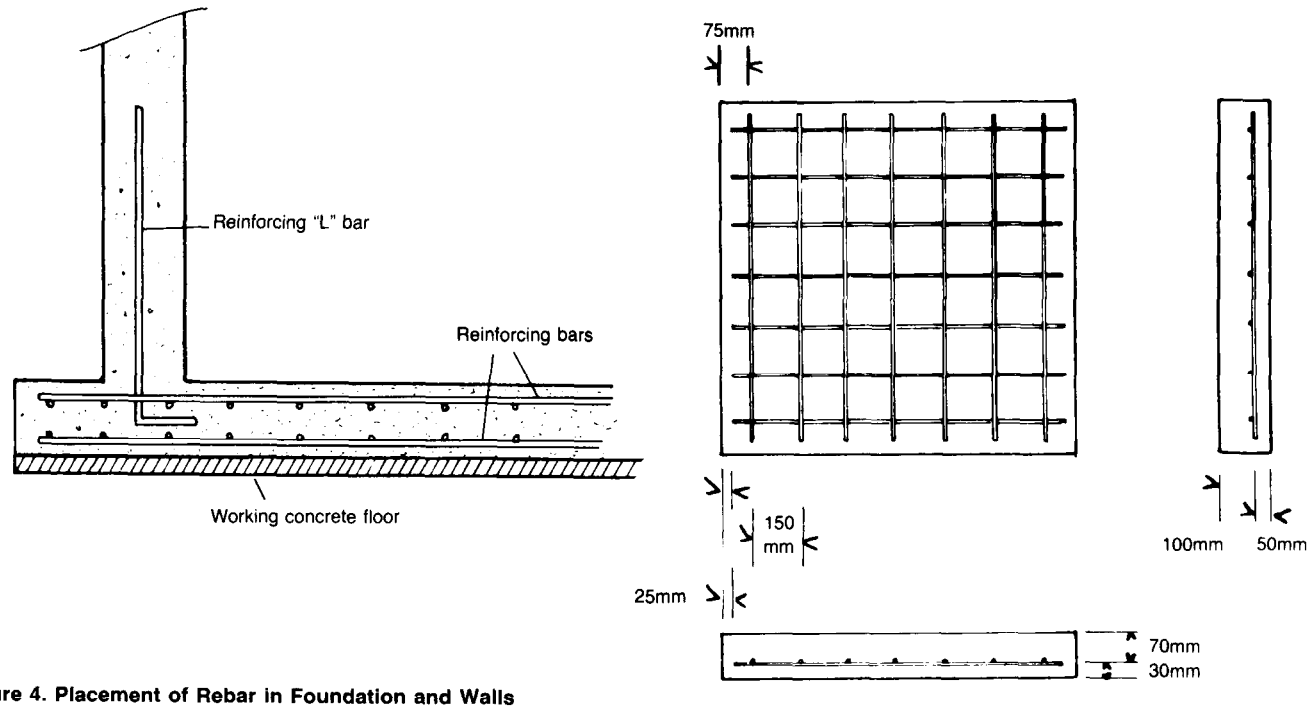


Figure 4. Placement of Rebar in Foundation and Walls

Reinforced concrete cisterns can be built underground. They are usually equipped with hand pumps for extraction of the stored water. To build an underground cistern, follow the same basic construction steps for above-ground cisterns. Make sure that the walls extend at least 300mm above the ground surface. A tight fitting cover with an access opening and a small base for a hand pump should be cast.

Other Types of Cisterns

Brick and masonry tanks can be used for rainwater storage. Skilled workers should construct them. Keep the following points in mind when constructing a masonry or brick tank:

- Make all walls at least 300mm thick.

- For shallow tanks, the walls can be built on the floor. For deep tanks, over 1.5m, a concrete footing or foundation built below the base should be constructed.

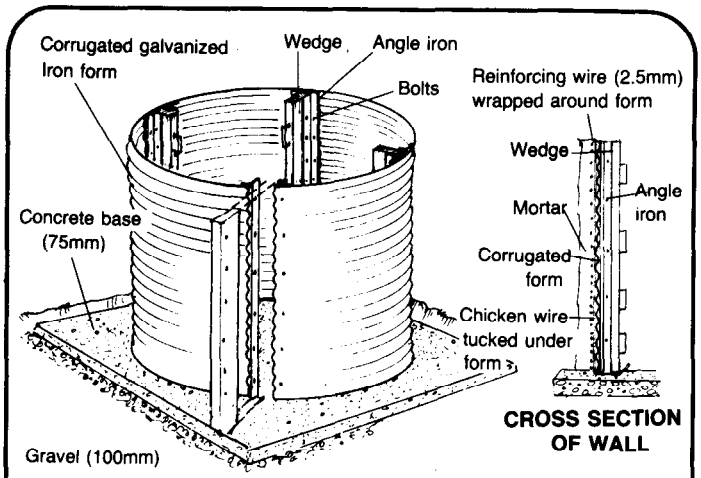
- Line the inside of the cistern with two layers of mortar each 10mm thick to prevent leaks. The mortar, and all mortar used in the construction process, should contain cement and sand in the proportion 1:3.

Ferrocement cisterns are generally circular in shape and made with locally available materials. Some experience and skill are needed. The construction steps described below are for relatively large capacity cisterns, about $10m^3$. Both smaller and larger cisterns can be constructed following the general construction guidelines.

1. Measure and stake out a circular area 2.8m in diameter. A easy way is to drive a stake into the ground at the center and attach to it a length of rope 1.4m, the radius. Tie a stick or pointed object to the other end and trace the circle on the ground. Dig out a base 300mm in the ground.

2. Place a 100mm layer of sand and gravel over the excavated area, and then a 75mm layer of concrete on top of this. Use a concrete mix of 1:2:4, cement: sand: gravel.

3. Before the concrete sets, cast a 1m length of 20mm steel pipe into the foundation, as shown in Figure 5. This will be the outlet. The pipe should extend 80-100mm above the tank floor, high enough above the ground on the outside of the tank to allow a bucket or ceramic container to sit underneath. A tap will be placed on the pipe when construction is completed.



SIDE VIEW of COMPLETED TANK

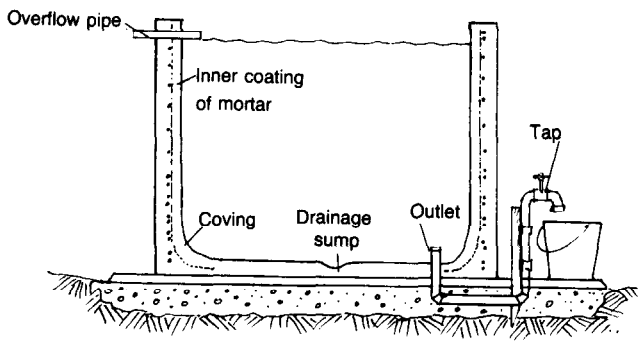


Figure 5. Ferrocement Cistern Construction

4. When the floor hardens, build the formwork for the tank. See Figure 5 for details on formwork preparation. Use 16 sheets of galvanized roofing iron 0.6mm thick. Place four sheets together to form four sections. Bolt the sections to angle iron verticals to form a circle. The steel angle iron, 40mm x 40mm x 5m, is bolted vertically on the inside face at the ends of each set of sheets. Place a wedge between the ends of each section. The wedge can be pulled out to dismantle the forms. Wood can be used for forms. A design similar to that shown in Figure 6 is useful in many areas. This design is especially good where materials such as roofing metal is not available.

5. Clean the forms, removing any dirt, and oil them. Then wrap 50mm wire mesh, chicken wire, around the forms. The netting should be wound around to a single thickness and tucked underneath the forms to hold it in place. The mesh provides vertical reinforcement and keeps the straight wire out of the corrugation.

6. Wrap 2.5mm straight galvanized iron wire tightly around the formwork starting at the base. Use the following spacings:

- two wires in each of the first eight corrugations from the bottom,
- one wire in each remaining corrugation except for the top one,
- two wires in the top currugation.

7. Plaster the outside of the forms with a layer of mortar that covers the wire. The mortar mix should be 1:3, cement:sand. When this layer begins to harden, trowel on mortar to cover the wire with a layer 15mm thick. Give the mortar a smooth finish.

8. Take apart the forms after the mortar has set for two or three days. Remove the holding bolts and wedges so that the forms are easily removed.

9. Place an overflow pipe 200mm long and about 80mm in diameter at the top of the tank. Then to finish the cistern, plaster the inside to fill in the corrugations. When this mortar dries, trowel on a final coat.

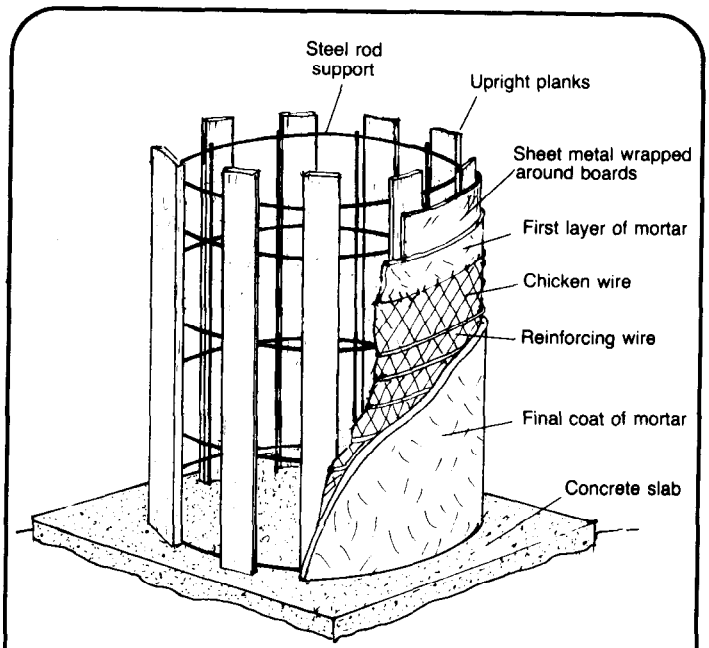


Figure 6. Ferrocement Tank Using Wooden Forms

10. Finally, place a 50mm thick layer of mortar on the floor of the tank. Before the mortar stiffens, make a shallow depression in the middle of the floor to act as a sediment trap for tank cleaning. Sediment can be swept into the sump and removed with a cup.

Roof Structures

Install a roof on the cistern to prevent the evaporation of water, the growth of algae and contamination by rubbbish, insects or rodents. A choice of two roof structures is possible as shown in Figure 7. Figure 7a shows a shell roof built of wire-reinforced mortar between 3-5mm thick. The structure is cast continiously with the walls. After the tank has dried for two days, lay mortar onto shaped formwork made with two layers of wire mesh supported from below by boards. Tie the wire mesh onto the mesh extending from the walls. Install an iron frame to form an access opening in the roof. Remove the frame after construction is completed. Trowel in a layer of mortar and allow three days for curing. After three days, or when the roof is strong enough, take off the formwork and trowel a layer of mortar onto the underside of the tank. Figure 7b shows a completed roof of this type. Let the roof cure for at least seven days. Keep the surfaces moist during the curing process.

Figure 7c shows a more traditional roof structure made from wood. Attach lightweight roofing such as a sheet aluminum or galvanized iron with wire. Screen any open areas between the tank and the roof to prevent the entrance of insects and debris.

Unreinforced Mortar Storage Jars

Unreinforced mortar storage jars can be constructed by people with little or no previous experience. The jars are an inexpensive and relatively easy way to store rainfall for drinking water. Small, 25m^3 capacity, as well as larger 4m^3 jars can be built following the basic construction steps given below. This example is for a 4m^3, 4000-liter, storage jar like the one shown in Figure 8.

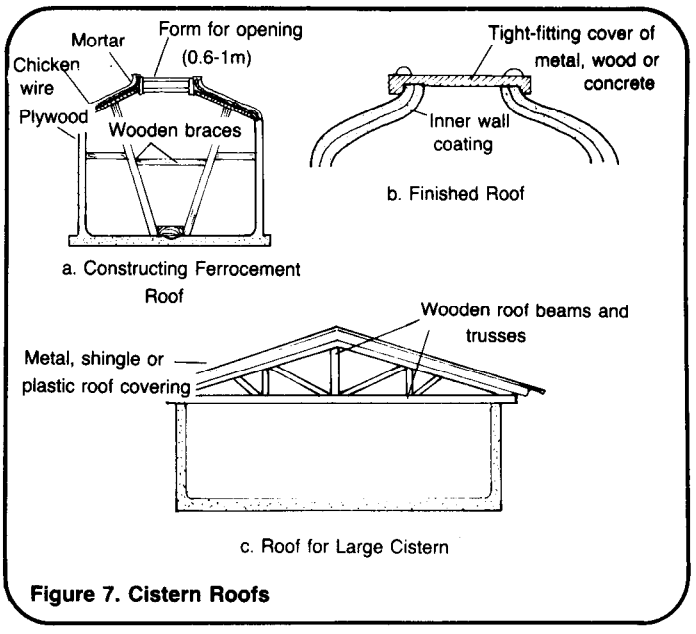


Figure 7. Cistern Roofs

1. The first step in the construction process involves preparation of the mold. Place two pieces of gunny cloth together and mark them out as shown in Figure 8. The bottom width should be marked at 1.2m and the top width at 2.0m. Draw a curved line along the sides connecting the top and the bottom and sew the sack together with heavy tread or twine. The sack height should be 1.7m.

2. Make a precast mortar bottom plate 1m in diameter and 15mm thick. To make forms for the plate, mark out a circle on the ground using a nail as a midpoint and a piece of twine 0.5m long. Trace the circle and lay half bricks or other suitable material around the outside of the circle to act as a form. Place paper, an empty cement bag or other material on the ground within the circle so the mortar does not stick to the ground. Make a mortar mixture of 1:2, cement:sand.

3. Once the bottom plate dries, place the sack narrow end down on the plate and begin filling it with sand, sawdust or rice husks. The weight of the filling material will hold the sack on the plate. Make sure the mortar base sticks out from under the sack, as shown in Figure 8.

4. Completely fill the sack, then fold the top and tie it into the desired shape. With a piece of wood, smooth and round out the jar. When the jar is in the final form spray it with water to completely dampen it.

5. Place a circular ring on the top of the sack to make an opening for the jar. The ring can be made from wood, precast mortar or other suitable material.

6. Begin placing a layer of mortar on the jar. The mortar should be about 5mm thick. Apply another 5mm layer of mortar, checking the thickness by pushing a sharp object like a nail into the side. Be sure to build up any thin spots and add mortar to weak places. Finally, build up the jar thickness and shape as shown in Figure 8. Place a small tap near the bottom of the jar.

7. Twenty-four hours after the jar is constructed, remove the contents of the sack. This operation is easier for small jars. When the jar is empty, check for defects and make any necessary repairs. Paint the inside with a wet mortar mix and then cure the jar outside for two weeks. For best results, cover the jar with damp sacks or plastic sheeting during the curing process.

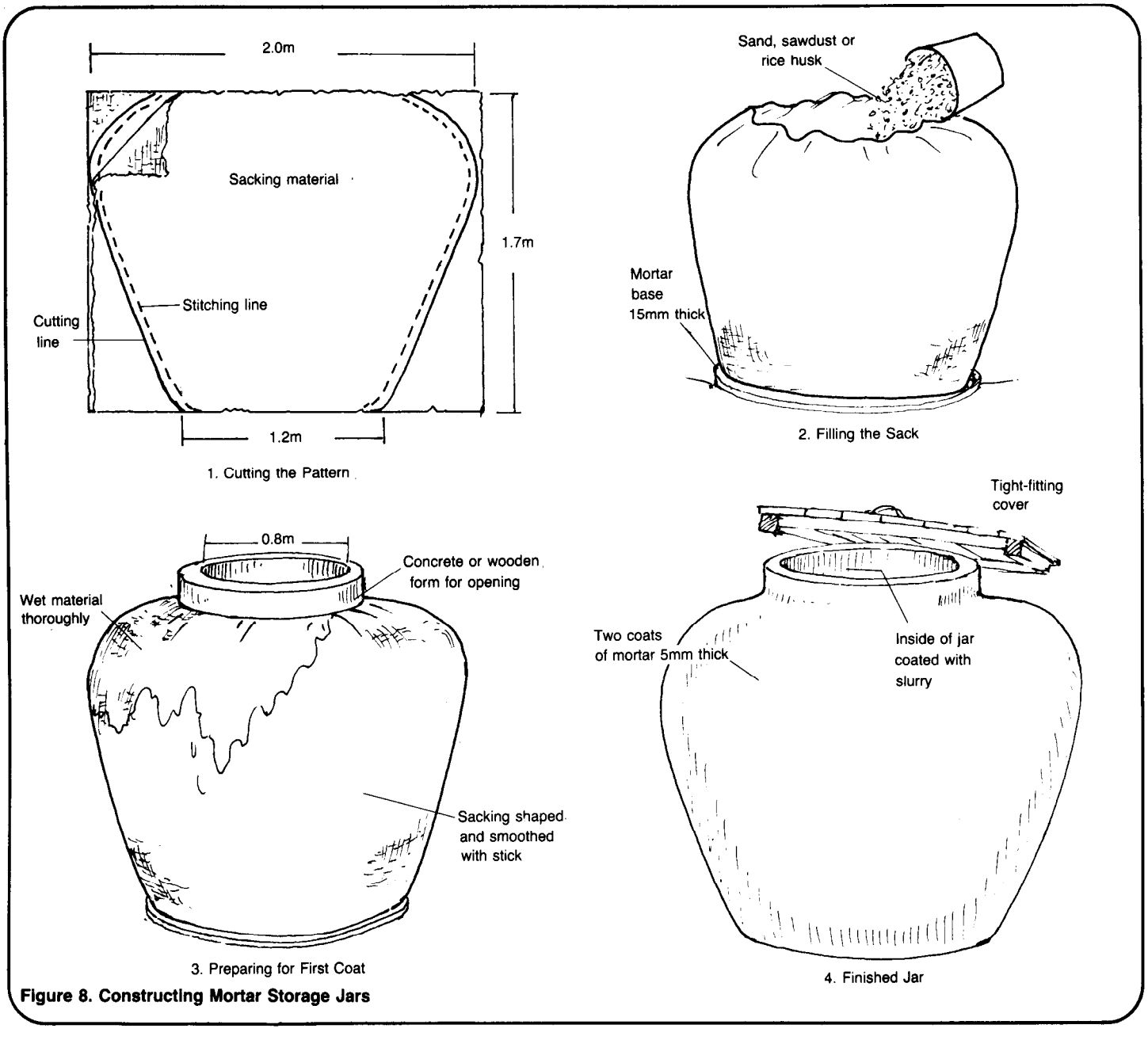


Figure 8. Constructing Mortar Storage Jars