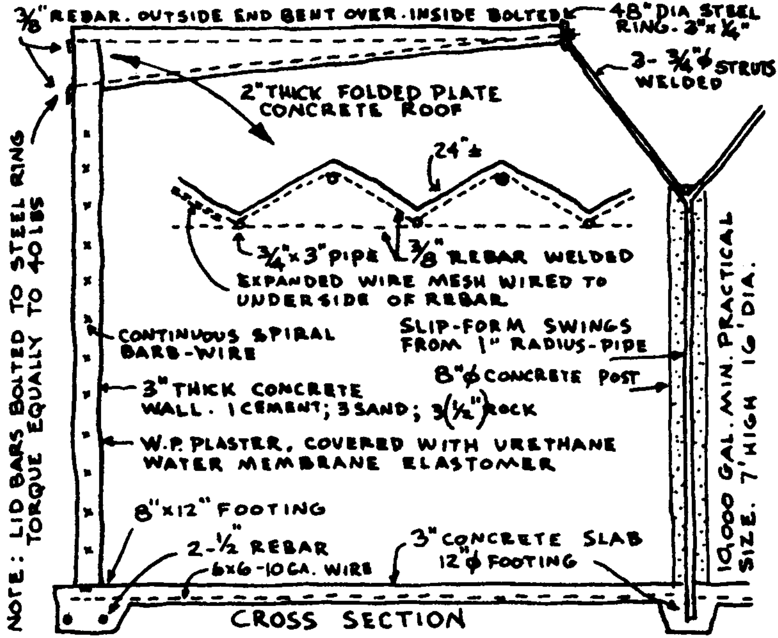
Agricultural Engineer James Waller found that a spring emitting a trickle of water as little as 2 quarts per minute can be harnessed and stored to supply enough water for 35 head of cattle. This same amount is more than sufficient for average homestead requirements.

Traditional water storage facilities have proven to be expensive and inadequate. In a few years a metal tank will rust and a wood tank will deteriorate. Neither can be installed underground—which is essential for the prevention of temperature rise and evaporation. Concrete is the best material to use in building a water storage tank. An underground concrete tank undergoes minimal damage and evaporation.

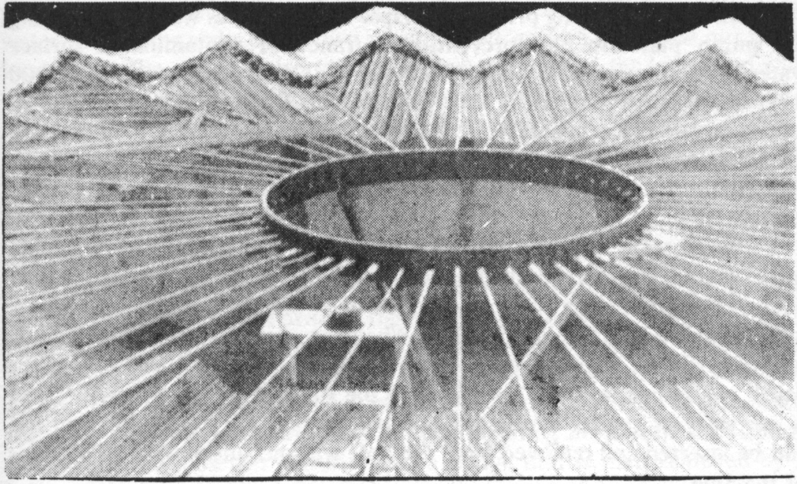
My earliest contribution to the owner-builder homestead technology has been the development of a low-cost, all-concrete circular reservoir. The foundation-floor of this tank consists of a single concrete slab. The roof is a 2-inch thick concrete folded-plate poured on expanded-metal lath, as illustrated in accompanying drawings. An owner-builder can fabricate this tank for about two cents a gallon of water stored.

AUTHOR SHOWING WALL-BUILDING TECHNIQUE USING HORIZONTAL (SPIRAL) SLIDING FORM


3/8" REBAR. OUTSIDE END BENT OVER. INSIDE BOLTED
48" DIA STEEL RING. 2" x 1/4"
3- 3/4" φ STRUTS WELDED
2" THICK FOLDED PLATE CONCRETE ROOF
24" ±
3/4" x 3" PIPE
3/8" REBAR WELDED
EXPANDED WIRE MESH WIRED TO UNDERSIDE OF REBAR
CONTINUOUS SPIRAL BARB-WIRE
SLIP-FORM SWINGS FROM 1" RADIUS-PIPE
8" φ CONCRETE POST
3" THICK CONCRETE WALL. 1 CEMENT; 3 SAND; 3(1/2") ROCK
W.P. PLASTER, COVERED WITH URETHANE WATER MEMBRANE ELASTOMER
8" x 12" FOOTING
2-1/2" REBAR
6x6-10 GA. WIRE
3" CONCRETE SLAB
12" φ FOOTING
CROSS SECTION
NOTE: LID BARS BOLTED TO STEEL RING TORQUE EQUALLY TO 40 LBS
10,000 GAL. MIN. PRACTICAL SIZE. 7' HIGH 16' DIA.

CONCRETE CYLINDRICAL TANK
USING A REVOLVING SLIP-FORM TO SPIRAL A THIN-WALL MONOLITHIC CONCRETE WALL

DEVELOPED BY AUTHOR 1957



READY
FOR ROOF POUR
30,000 GAL TANK

If a natural spring or artesian well cannot be developed, a homesteader has the choice of *digging, boring, driving, jetting* or *drilling* into the ground for water. Each method, discussed briefly below, has its unique advantages, depending mostly upon the ease of penetration into the earth formation. One's State Geological Survey office will assist in determining what type of earth formation one is likely to encounter: just submit a legal description of your property.

Where the water table is fairly close to the ground surface, a well can be advantageously dug. Depths of from 10 to 40 feet are common. A circular hole, about 40-inches in diameter is usual: being round it is less apt to cave in. Except in cases of solid rock, dug wells require some form of permanent lining. Lining prevents collapse of the hole as well as supporting the pump platform and preventing entrance of contaminated surface water. One unique and practical method of digging deep wells (up to 200 feet) has been developed by the World Health Organization. The first 45 feet is cast-in-place concrete. A system of pre-cast concrete cylinders are then lowered into the well and assembled together. They act as caissons: as earth is removed, the caissons drop lower, guided by upper-level cast-in-place lining.

Bored wells can also be constructed by hand labor, using a simple earth auger. The maximum practical depth is 50 feet, using a 6-8 inch diameter auger. Boring with an auger involves simply forcing auger blades into the soil while turning the tool. When the space between the blades is full of earth the auger is removed from the hole and emptied. As greater depth is attained sections are added to the auger. A pully-equipped tripod is necessary as greater depths are reached, so that the extended auger rod can be inserted and removed from the hole without unscrewing all sections of the pipe.

11.2.5 Ferrocement water tanks

Ferrocement water tanks are constructed from cement-rich mortar, plastered onto chicken wire reinforced with weld mesh or standard small diameter reinforcement bar. Tanks can be built with basic skills using commonly available equipment in a relatively short period. These are all advantages over reinforced concrete and masonry tanks.

Typically, they may be used to replace Oxfam tanks which can either be dismantled and stored for use elsewhere or used to develop water supplies rapidly in response to changing circumstances.

Table 11.7 gives comparative dimensions, material requirements and

Table 11.7 Dimensions, materials and construction time for ferrocement tanks

Dimensions					
Tank volume, m^3	10	20	30	40	50
Base diameter, m	3.02	4.10	4.95	5.70	6.30
Mesh radius, m	1.36	1.91	2.33	2.70	3.01
Inside radius, m	1.33	1.88	2.30	2.67	2.98
Wall height, m	1.80	1.80	1.80	1.80	1.80
Materials					
Bags of cement, tank	11	18	27	41	51
roof	3	5	7	9	12
Weld mesh: rolls of 2m × 45m, mesh size 150 × 150mm	20	30	40	50	66
Chicken wire: rolls of 1m × 30m, 25mm mesh chicken wire	1	2	2.5	3	4
Binding wire, 16 gauge, kg	6	10	13	16	20
Clean sand, m^3	1.5	2.5	3	4	5
Gravel (< 25mm) m^3	0.8	1.3	2.0	2.5	3
200 litre drums of water	13	20	25	30	35
Construction time, days	8	9	13	14	17

Source: UNICEF, undated

estimated construction time for tanks up to 50 000 litres ($50m^3$). Tanks over 40 000 litres ($40m^3$) require a central column to support the roof.

Box 11.2 outlines the construction procedure for ferrocement tanks based on a technique developed and successfully used in Kenya. A key aspect of the approach is that rigid shuttering is not required. Adapt the procedure for tank sizes up to 50 000 litres ($50m^3$). This particular design is not suitable for tanks above this size. All concrete and mortar mix ratios are by volume. Use well graded clean sand

Box 11.2 Construction procedure for a $20m^3$ ferrocement tank

Day 1 Refer to Figure 11.10.

- Excavate a shallow circular level foundation, 100mm deep and 2.05m radius. Prepare weld mesh of 2.05m radius for floor reinforcement.
- Prepare the wall reinforcement by forming a 12.30m length of weld mesh into an upright cylinder, with overlap, to give a diameter of 3.82m. Bend the bottom wires of the mesh at 90°. Bend the top wires inwards at an angle of 45°.
- Prepare the roof reinforcement by forming cut sections of weld mesh into a 1.90m radius circle with a 450mm high support at the centre.

Day 2

- Position any outlet or drain pipe in a narrow trench in the earth foundation under the floor and protruding through it as shown in Figure 11.10. Backfill the trench with concrete.
- Cast the concrete floor by laying a 50mm thick concrete base (1:2:4 mix) in the prepared foundation. Place the floor reinforcement on the concrete. Cast another layer of concrete (1:2:4 mix) without delay on top of the reinforcement, working from the centre up to 400mm from the perimeter.
- Position the wall reinforcement without disturbing the reinforcement already concreted. Pull into shape and bind. Place the remaining concrete and tamp firmly around the wall. Cover the concrete.
- Continue preparation of the roof reinforcement by cutting and placing chicken wire on the prepared roof weld mesh.

Day 3

- Keep the concrete wet throughout the day.
- Prepare the wall for plastering:
  - – Tightly wrap the weld mesh from the top to the floor with chicken wire. Overlap the ends. Tie the chicken wire to the weld mesh in several places.
  - – Tightly wrap 16 gauge binding wire around the wall as follows (see Figure 11.11)

    4 times around the top weld mesh wire;
    every 100mm for the top 600mm;
    every 80mm for the next 600mm;
    every 50mm for the next 700mm;
    4 times around the bottom and tie to the mesh.
  - – Tie sacking to the outside wall. Firmly tie two ladders together to straddle the wall. Inspect the tank and pull it into a cylindrical shape using staked ropes or binding wire (Figure 11.12).
- If it is windy, postpone further work until the wind calms.
- Plaster the inside wall. Add water to a cement/sand mortar (1:3 mix) until it is just workable. The consistency of the mortar is critical. Experiment on a trial section first and note the water required for a successful mix. Start plastering at the bottom and push the plaster into the wire walls from the inside of the tank. Leave a space in the weld mesh for an overflow and any inlet pipe.
- Protect the walls with plastic sheeting.
- Splash the floor with water.

Day 4

- Remove the sheeting and wet the floor and walls. Keep the concrete wet throughout the day.
- Plaster a second layer of slightly wetter mortar on the inside wall. Remove the sacking and plaster a thin layer of mortar (< 10mm thick) over the outside wall.

(Continued over)

Box 11.2 (continued)

- Cover both the inside and outside walls with plastic sheeting.
- Wet the floor.

Day 5

- Remove the sheeting and wet the floor and walls. Keep the concrete wet throughout the day.
- Cut the top overflow section of the weld mesh, bend outwards at 90° and wrap in chicken wire. Support and plaster the top of the overflow.
- Smooth a 10mm thick layer of plaster on the outside wall and cover.
- Prepare the roof for plastering by sewing sacking to the underside of the roof mesh. This may be supported by poles as in a traditional hut.

Day 6

- Wet the floor and walls.
- Complete the inside wall: Plaster and smooth the inside wall to a total wall thickness of 50mm. Make a mix of equal parts of cement and water. Smooth evenly onto the new plaster to within 150mm of the floor.
- Complete the floor: Plaster the floor with cement mortar (1:3 mix) to create a slope towards the outlet. Finish the floor and remaining 150mm of wall with a mix of equal parts of cement and water, and cover.

Day 7

- Position and plaster the roof: Place the roof reinforcement on the tank wall and bind it to the vertical wall wires. Cut an access hole (450mm × 450mm) in the roof wires. Support the roof on poles. Plaster the roof with cement mortar (1:3 mix) and cover. (See Figure 11.13).
- Cast an access cover in a shallow pit, reinforcing with weld mesh and chicken wire. Cure for a week.

Day 8

- Remove the roof sheeting and wet the roof, floor and walls.
- Plaster the roof (10mm thick) and cover with plastic sheeting.
- The tank should now be strong enough to hold water.

Day 9

- Remove the roof poles and sacking. Plaster the underside of the roof. Plaster a piece of galvanized gauze over the overflow.

Afterwards

Keep the tank covered in plastic sheeting and/or fill it with water to cure for at least two weeks.

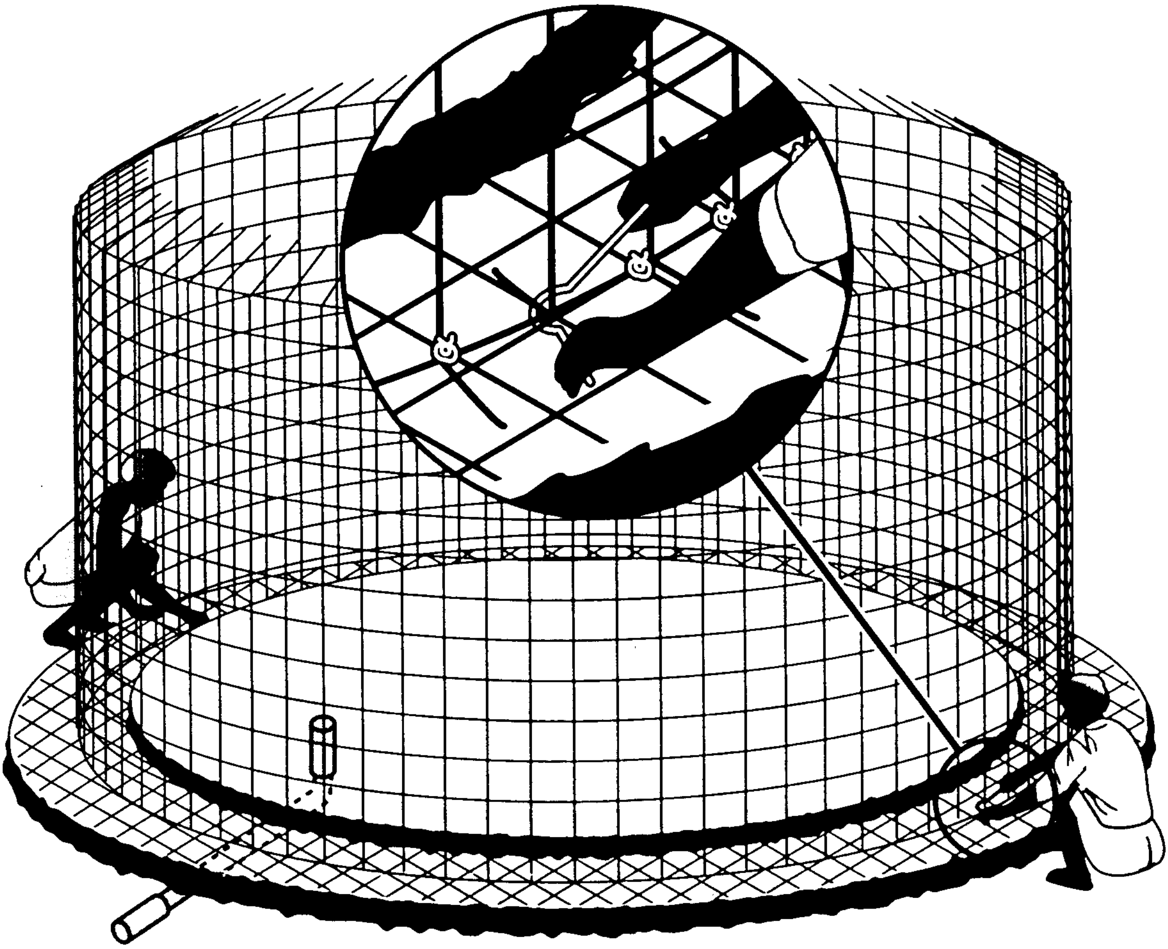


Figure 11.10 Foundation and wall preparation

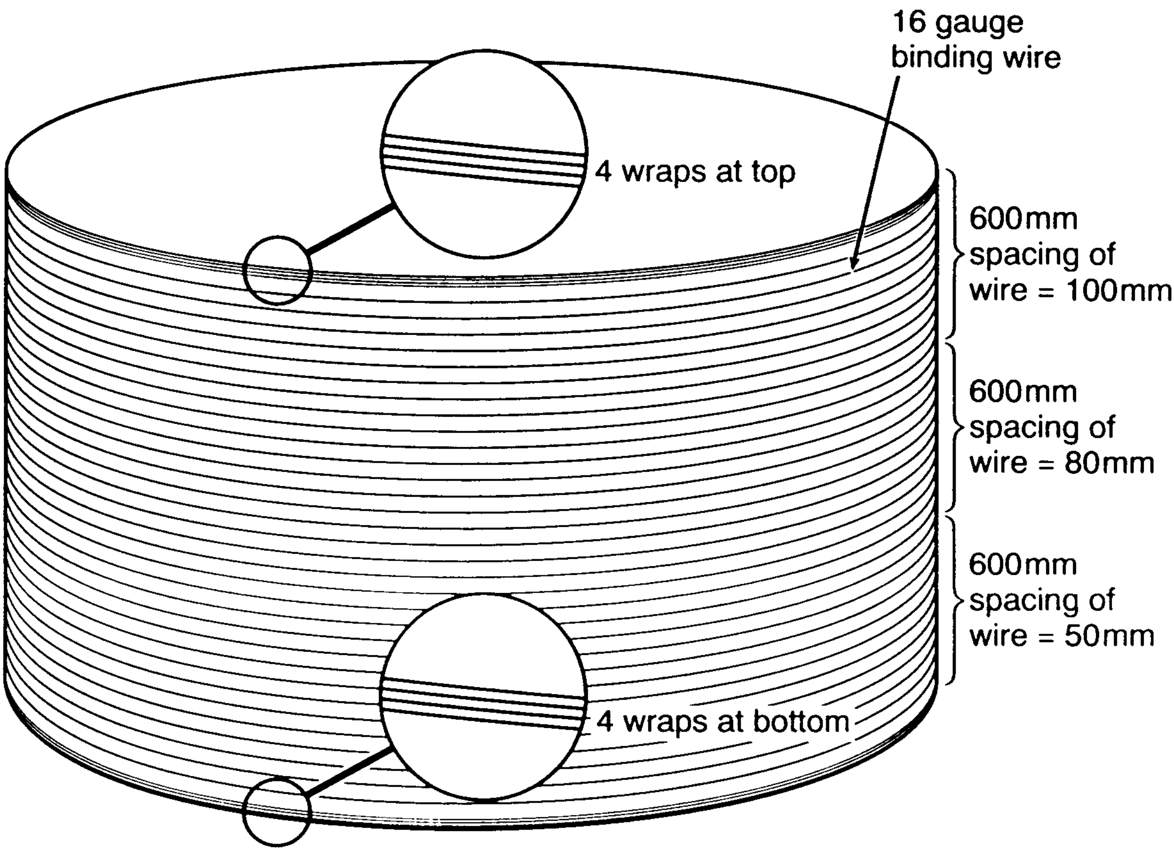


Figure 11.11 Wrapping the binding wire

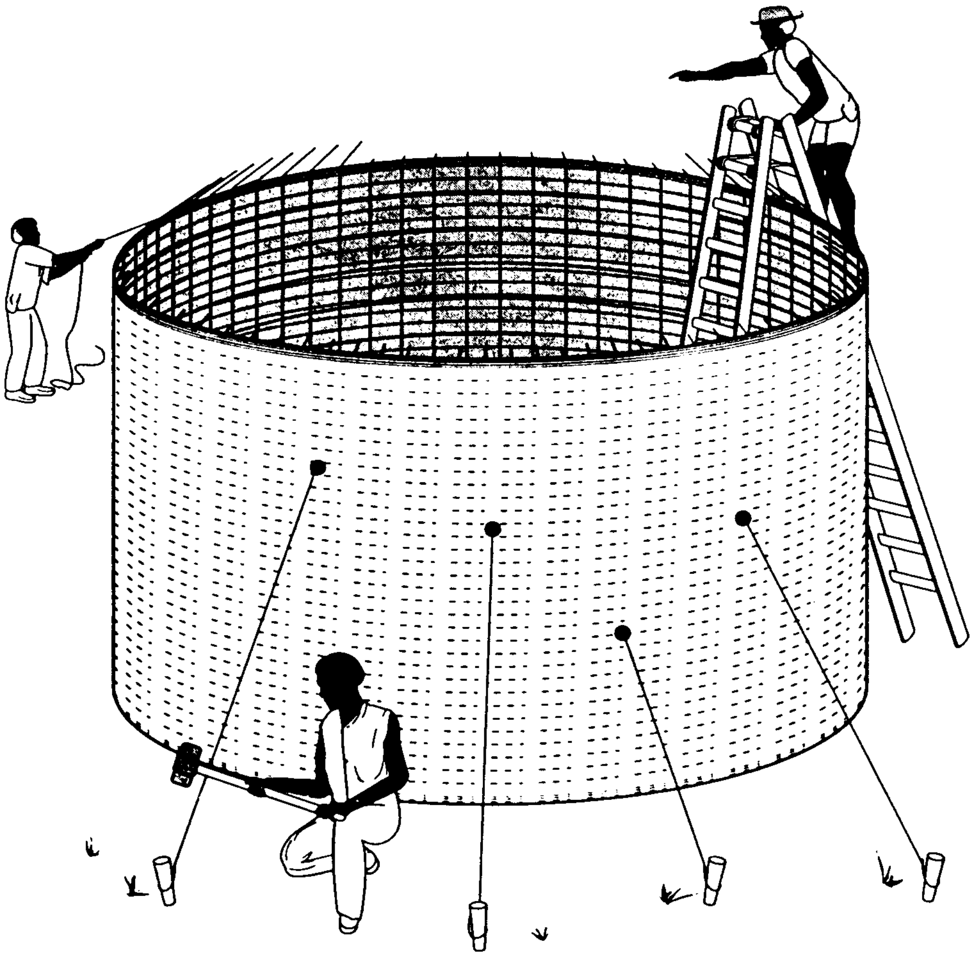


Figure 11.12 Pulling the tank into shape

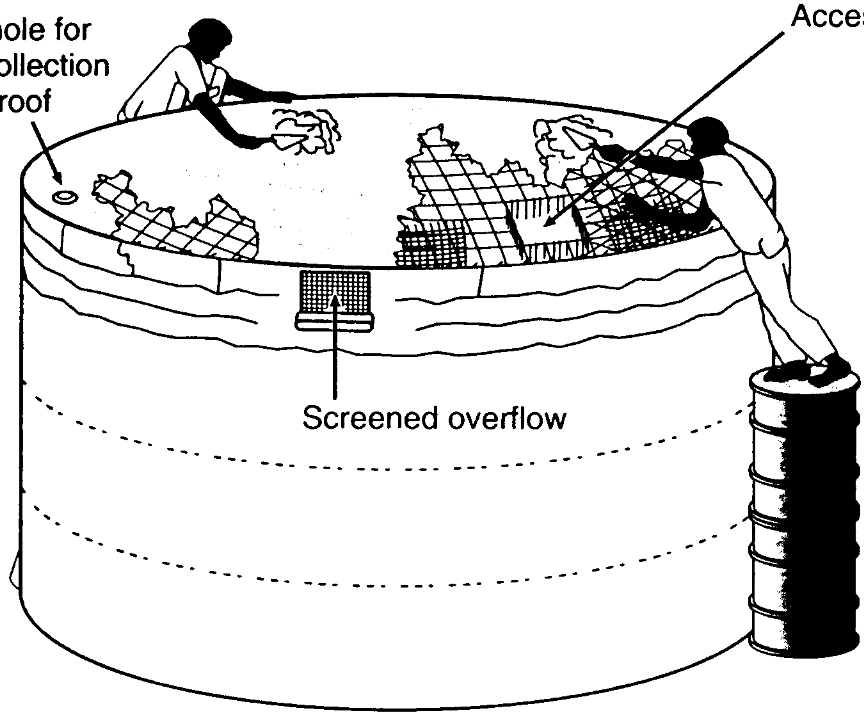


Figure 11.13 Plastering the tank roof

Key

(a). ferrocement dome: mesh & wire frame formed on the ground and plastered into place (b). access hatch, (c). circular ferrocement wall, (d). mild steel mesh and chicken wire reinforcement (e). temporary timber props (f). concrete base cast in the ground

(g). temporary cloth covering fixed to outside to plaster against inside

(h). mesh and wire extensions to connect to next stage

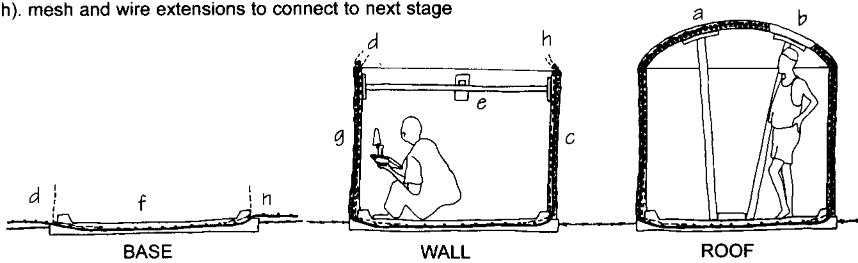
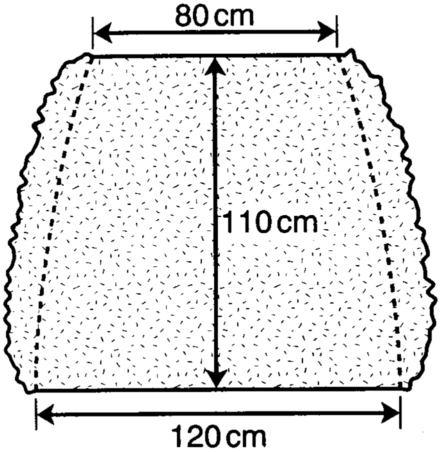


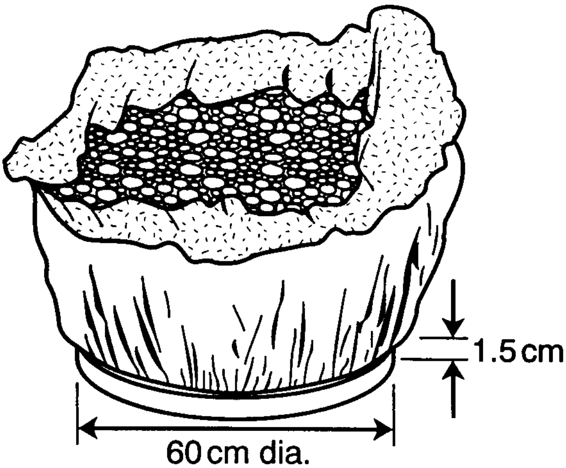
Fig. 6.35 Diagram showing three steps in the construction of a ferrocement water tank. Ferrocement construction is suitable for a range of water tank sizes. 10 cubic metres: 1.8m high, 2.7m diameter; 30 cubic metres: 1.8m high, 4.7m diameter.

ADAPTED FROM HASSE AND WATT

Stages in the making of a water jar in unreinforced mortar.

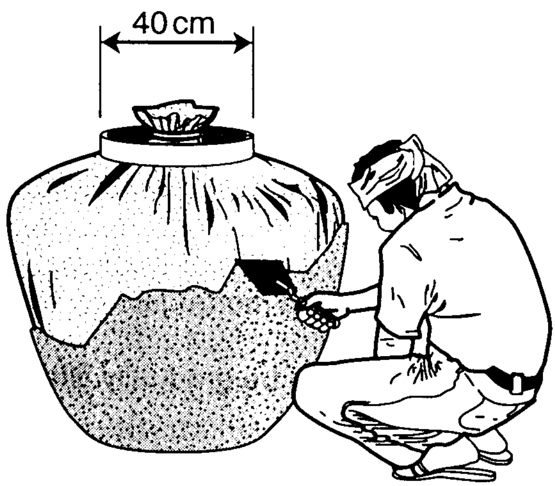


1. Cut two pieces of sacking, 125 cm × 110 cm, mark out as shown, place together and sew along the sides only. Turn inside out.



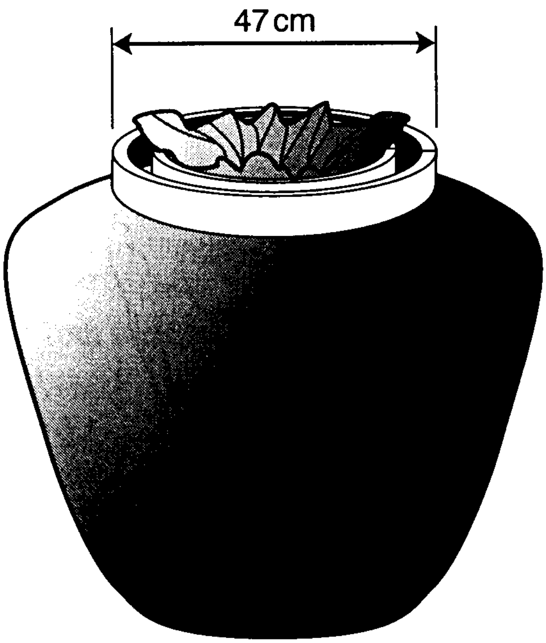
2. Place sack on a pre-cast mortar bottom plate, 60 cm dia. × 1.5 cm thick. Fill sack with sand. Ensure bottom plate sticks out from under the sacking.

3. When full, tie the top sacking and form into a jar shape by tapping with a block of wood. Spray with water before plastering.

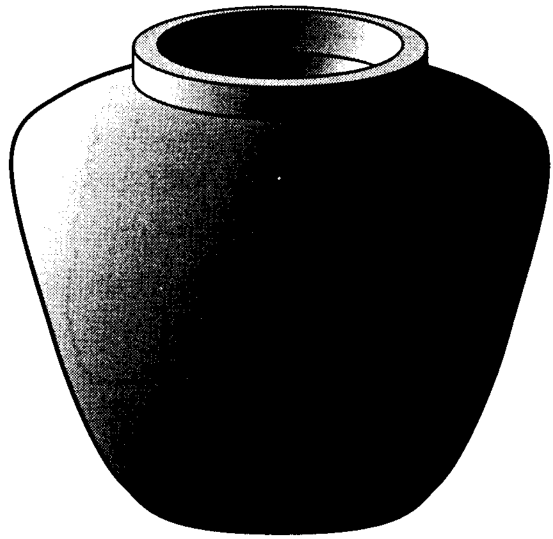


4. Place a metal ring on top of the jar as a mould for the opening. Place the first layer of mortar onto the sacking to a thickness of 0.5 cm.

Construction of household water storage jars



5. Add a second layer of mortar to give a total thickness of 1 cm. Check thickness of mortar by pushing in a nail. Form an opening at the top with a second metal ring.



6. Remove the sand, sacking and rings two days after plastering. Repair any defects with mortar. Paint the inside with cement slurry. Cure for two weeks.

The mortar is a 1:2 (cement:sand) dry mix, by volume.

A 250 litre jar requires 50 kg of sand and 25 kg cement.

Jars up to 1 m^3 have been made this way.
Unreinforced mortar jars can be considerably cheaper than clay jars.

The jars can be gradually filled starting four days after curing:

1st day of use – not more than half full
2nd day of use – not more than three-quarters full
3rd day of use – the jar can be filled.

A cover should be fitted to the jar when in use.

From Pickford, 1991, and Watt, 1978