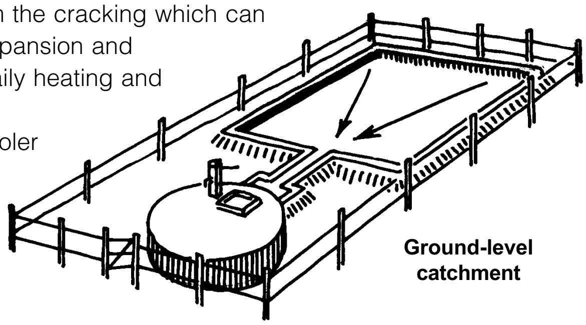
56. Buried and semi-submerged water tanks

This Technical Brief outlines the advantages and disadvantages of using buried and semi-submerged tanks for collecting and storing water. It also examines some of the design features and construction procedures.

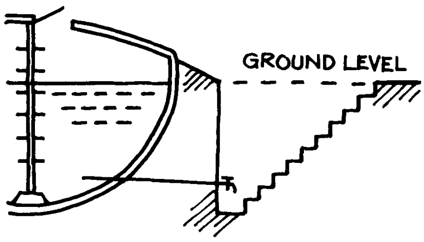
Advantages of an underground tank

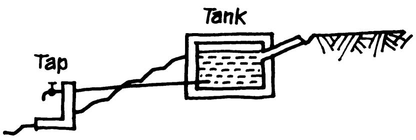
- If the soil is firm it will support the pressure acting on the walls of the tank so that cheaper walls — less robust than those of an above-ground tank — can be used;
- the tank is protected from the cracking which can result from the regular expansion and contraction caused by daily heating and cooling of exposed walls;
- the water in it remains cooler and is, therefore, more pleasant to drink; and
- water can be collected from ground-level catchment areas.



Disadvantages of an underground tank

- The source of any leakage is hard to detect and, therefore, hard to repair;
- polluted water may leak into the tank, particularly if the roof is buried;
- drawing water from a tap (more hygienic than using a bucket and rope) is only possible if steps are provided to give access to a low-level tap in a trench immediately adjacent to the tank (see right). If the buried tank is on a hillside, however, water will gravitate to an above-ground tap (see below right);
- if the level of water in the ground around the tank ever reaches a high level, an empty tank could float out of the ground like a boat!





Construction materials

Materials in common use include:

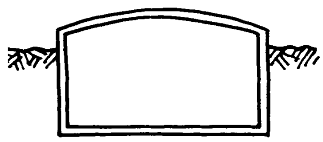
- clay or thin, impermeable, man-made membranes used to line excavations;
- brickwork, blockwork or stone masonry — particularly for walls, and occasionally for arched roofs;
- reinforced concrete for walls, and floor and roof slabs; and
- ferrocement for walls, roofs and, sometimes, floors.

Other matters to consider

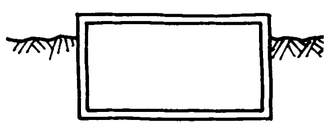
- two tanks, or a tank divided into two compartments, allow one tank to be maintained while the other continues to provide water;
- access manholes should have covers which can be locked and prevent contamination;
- if the floor of a tank slopes to a low point at which a pipe outlet is provided, it is easy to wash out any sediment that may collect in the tank.

Roofs

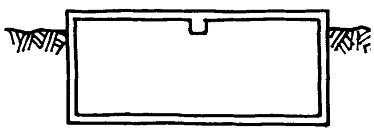
- Prevent nearly all evaporation;
- protect potable water from contamination and algae growth;
- prevent the breeding of mosquitoes — but only if *all* openings to the air are screened with mosquito mesh;
- can be exposed or buried (buried roofs must be very strong to withstand the weight of a vehicle);
- flat roofs are often made from reinforced-concrete (RC) slabs. Larger spans need RC beams and column supports;
- thin, domed ferrocement roofs are usually more cost-effective than flat roofs — they utilize the high compressive strength of the cement mortar. The mortar is reinforced with welded and woven wire meshes; and
- lightweight materials such as corrugated iron can also be used for exposed roofs, but timber supports are not recommended as they are liable to rot.



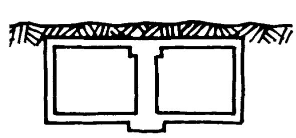
Arched slab



Flat slab



Slab and beam



Slab and column

Buried and semi-submerged water tanks

Outline construction notes for a partly submerged, hemispherical ferrocemen

Important notes

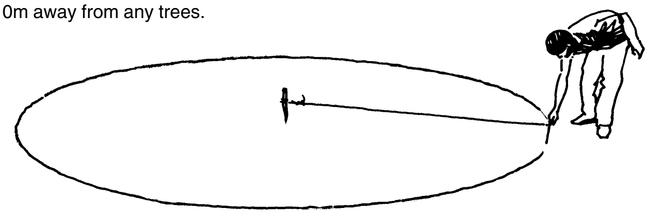
Ferrocement is a mixture of cement mortar and wires. This design is a particularly cost-effective method of in-ground tank construction. Full construction details are found in Nissen-Petersen (1992). See the other books listed on page 96 for more detailed advice on producing good concrete and good ferrocement.

- Select clean sand carefully — it must not be too fine;
- keep ferrocement damp between the application of different layers and for some time (ideally, three weeks) after applying the last layer. This 'curing' is also important for concrete. Where possible, use polythene sheeting (or wet sand on the floor and roof) to reduce evaporation of curing water;
- for the ring-beam, use a 1:3:4 concrete mix (i.e. 1 volume measure of cement: 3 measures of coarse sand: 4 measures of stones graded up to 25mm);
- use a mortar mix for the ferrocement of 1:3 (i.e. 1 volume measure of cement : 3 measures of sand). Measure volumes carefully, and keep the water content as low as possible;
- apply 'nil' (a mixture of water and cement with a porridge-like consistency) to improve the water-tightness of the ferrocement.

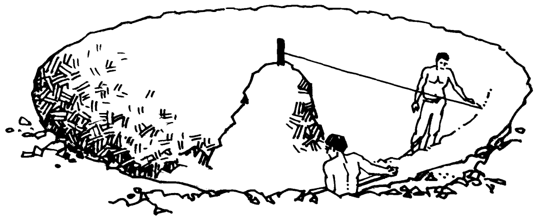
Main materials needed

- Cement: 73 bags
- BRC welded mesh No.65 (5.4mm diameter bars on a 150mm grid): 2m x 35m
- 50mm GI pipe for roof support: 4.5m
- oil drums for sheets: 48
- barbed wire: 1.6mm wire, 25kg
- chicken mesh (25mm holes): 0.9m x 175m
- access cover: 1
- handpump or pipework and tap for water collection
- timbers; poles; flat irons; angle irons and 'u' bolts for ladder on king-post
- stones for wall, aggregate for concrete, sand for concrete and ferrocement
- binding wire: 2kg
- polythene: 2m x 30m
- nails 50mm: 2kg
- sand: 17 tonnes
- concrete aggregate: 1 tonne
- stones for wall: 12 tonnes

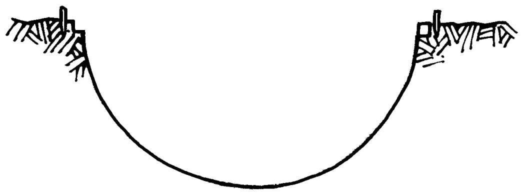
1
- Mark out the circumference of excavation on the ground using a 3.12m length of string on a peg at least 10m away from any trees.



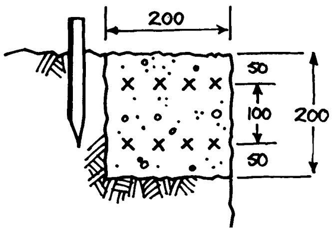
2
- Excavate 3.12m radius hemisphere around a temporary pillar of soil which remains to support the peg.
- The soil must be firm to support the tank.



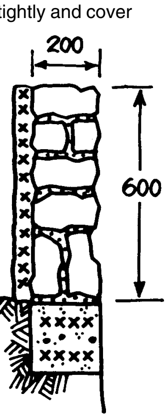
3
- Offset pegs 250mm from the edge of the excavation.
- Mark horizontal line on pegs.
- Excavate a 200mm × 200mm shelf for wall foundation.



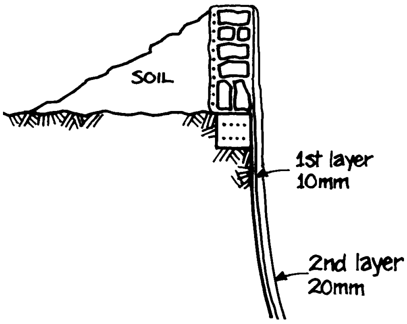
4
- Cast a level-concrete (1:3:4 mix) ring-beam foundation with two layers of four strands of barbed wire.
- Cure.



5
- Build a 0.6m-high horizontal wall on the ring-beam, using bricks or stone masonry.
- When it is firm, wrap 12 strands of barbed wire round tightly and cover with cement mortar (1:3 mix).
- When the mortar has hardened, cure and then pile the excavated soil against the wall.



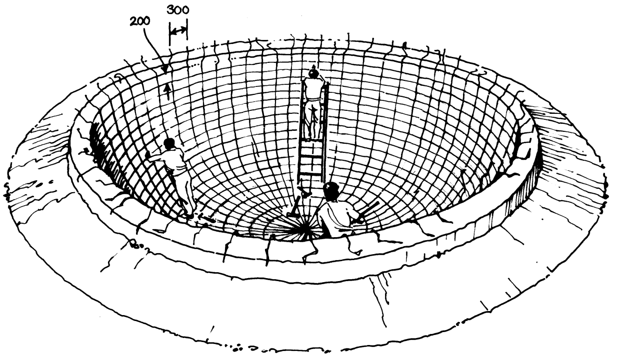
6
- Apply 10mm thickness of cement mortar to the soil and to the inside face of the wall. Cure.
- A day later, add a second 20mm-thick layer of mortar. Cure.



t water tank of $80m^3$ capacity

7

- Next day, nail a spiral of barbed wire onto the mortar using 50mm nails. The spacing between the wires should be 200mm. Then add radial wires with a maximum spacing of 300mm at the top of the wall. These wires should project above the wall by 300mm (so they can later be incorporated into the roof).
- Now cover the inside of the tank with at least one layer of chicken mesh (with 25mm apertures) with overlaps of at least 200mm between adjacent layers. If using a tap, install the pipe into an adjacent excavation and construct steps to reach the tap.

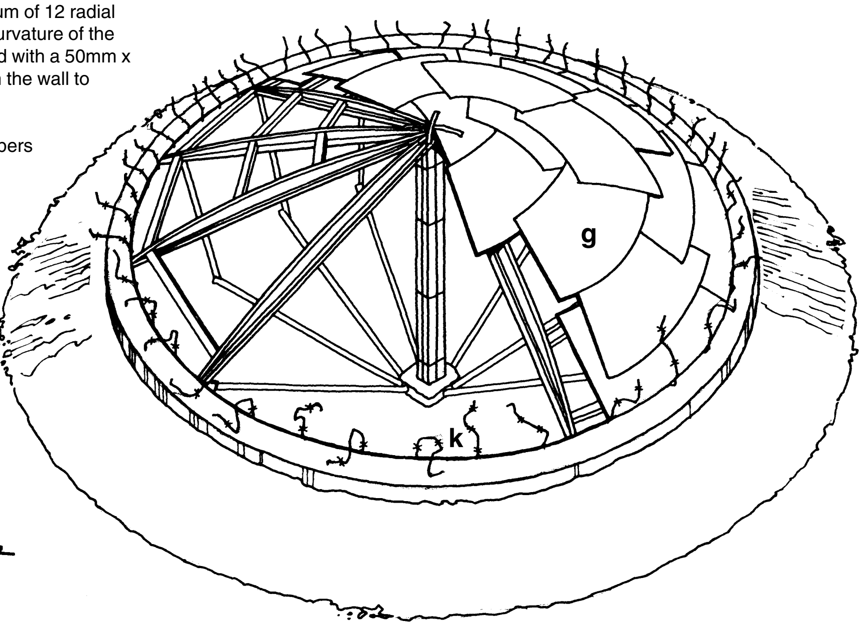


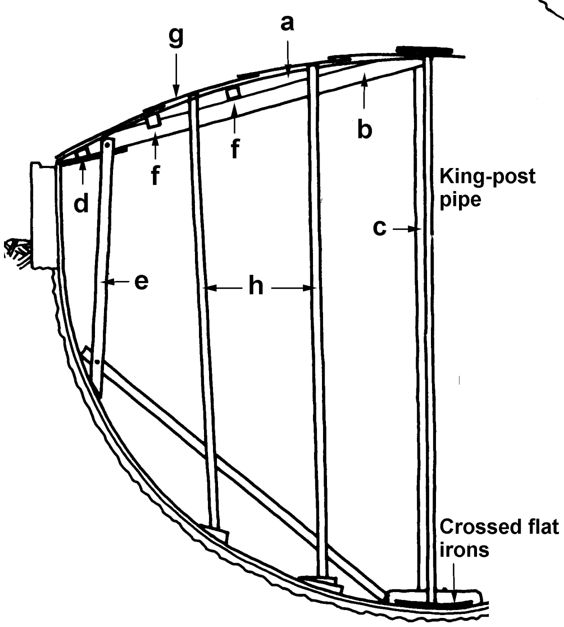
8

- Apply 30mm of 1:3 mortar to cover the inside of the hemisphere and, on the same day, add a thin layer of nil. Cure for at least three weeks — you can still work on the roof.
- The arched roof is supported by a 50mm-diameter galvanized-iron pipe which projects for 1m above the wall around the tank. Later, bolt angle-irons onto this 'king post' to act as a ladder below the access cover, near the centre of the roof. Position the pipe at the centre of the tank on top of two, crossed, flat irons which spread the load onto the floor; then cover these irons with mortar.
- Fix two more crossed flat irons across the top of the pipe which projects 25mm above the roof shuttering so that the irons are cast into the roof.

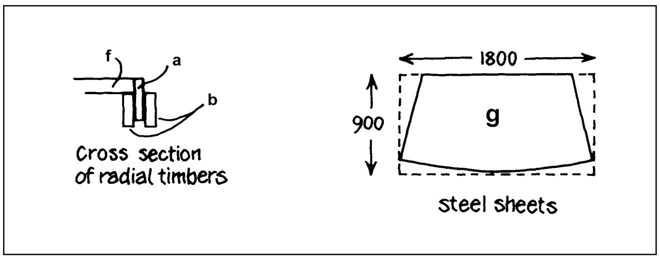
9

- For roof shuttering (formwork) erect a minimum of 12 radial timbers **(a),** 150mm x 25mm shaped to the curvature of the roof (a vertical radius of 6.25m), strengthened with a 50mm x 100mm timber **(b)** on each side, to span from the wall to vertical timbers **(c)** tied to the king-post.
- Strengthen the tapered ends of the radial timbers near to the walls with short pieces of 10mm-diameter bar **(d)** wired onto their underside.
- Support the ends near the wall with more vertical posts **(e)** 1.9m long.
- Nail some 50mm x 50mm timbers **(f)** on the 50mm x 100mm radial timbers to stiffen the formwork and support the edges of the steel-sheets **(g)** used for shuttering; these sheets can be cut from flattened 210-litre oil drums (you need 48), but ensure that one edge has a curve of 3.06m radius while the corners on the other edge are cut off as shown.





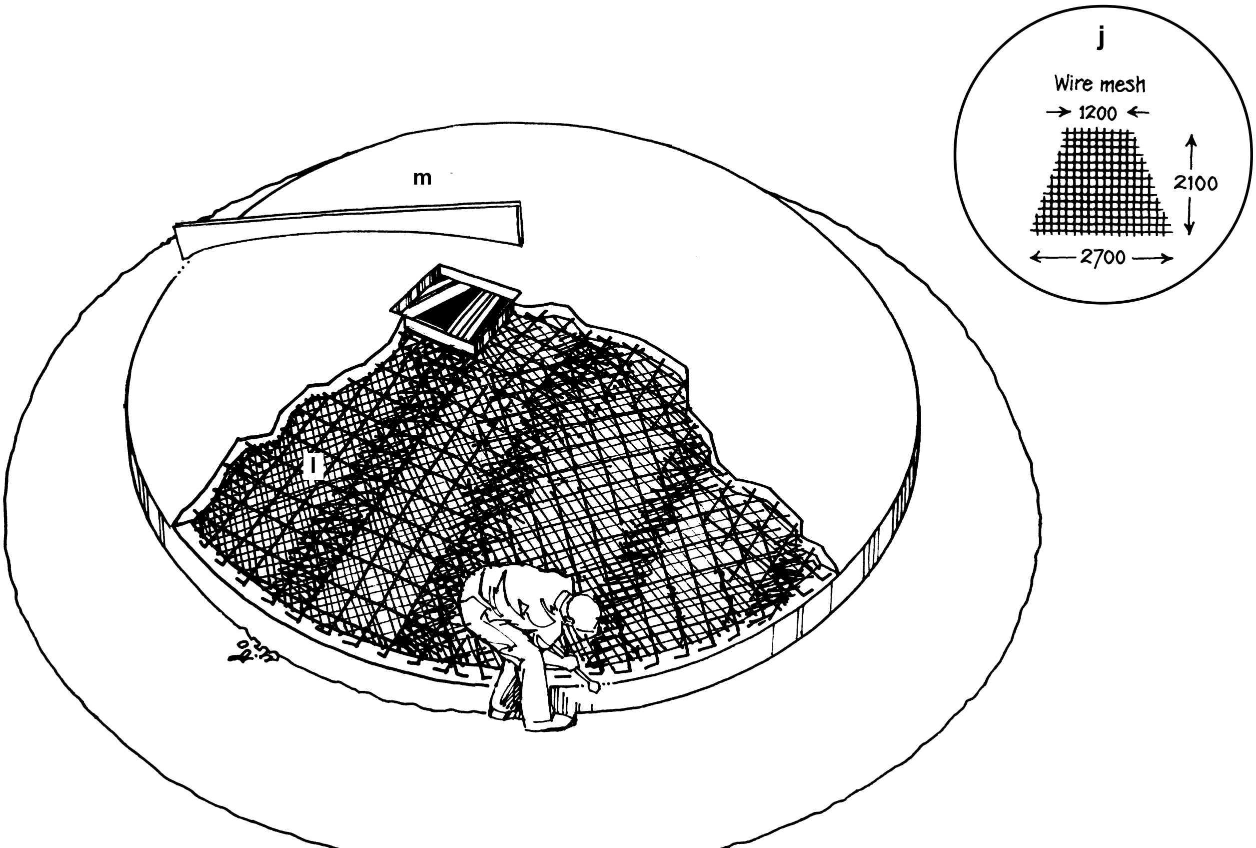
- Cut to size about 50 additional poles **(h)** (sisal poles are ideal) and use vertically inside the tank to support the sheets and make a strong curved formwork. Wire, but do not nail, so you can remove the shuttering more easily.



Buried and semi-submerged water tanks

10

- Cover the dome with polythene, followed by trapezium-shaped pieces of welded mesh **(j)**. The mesh is BRC mesh 65 (i.e. 5.4mm diameter bars at 150mm centres).
- Wire adjacent sheets of mesh together with an overlap of at least 200mm. The barbed wire **(k)** from the walls (see Box 9) is tied to the welded mesh and everything is covered with one layer of chicken mesh **(l)** with 200mm overlaps. The whole roof is now covered with a 50mm layer of well-compacted cement mortar. The reinforcement is lifted into the centre of this layer before compaction is completed. A curved timber **(m)** is rotated around the centre of the roof to get the right shape.
- Cure the roof for at least three weeks, although you can remove the supports after ten days. Once the shuttering and polythene is removed, apply mortar as necessary to any patches under the roof which need repairing so that all reinforcement is properly covered. Seal the joint between the wall and the dome with cement mortar.



Further reading

Reed, R.A., Shaw, R.J. and Skinner, B.H., Ferrocement water tanks, Technical Brief No. 36, *Waterlines,* Vol.11 No.4, IT Publications, London, 1993.

Watt, S.B., *Ferrocement Water Tanks and their Construction*, IT Publications, London, 1978.

Nissen-Petersen, E., *How to build an underground tank with dome*, ASAL Consultants Ltd., PO Box 38, Kibwezi, Kenya, 1992.

Prepared by Brian Skinner and Rod Shaw

WELL

WATER AND ENVIRONMENTAL HEALTH AT LONDON AND LOUGHBOROUGH (WELL) is a resource centre funded by the United Kingdom's Department for International Development (DFID) to promote environmental health and well-being in developing and transitional countries. It is managed by the London School of Hygiene & Tropical Medicine (LSHTM) and the Water, Engineering and Development Centre (WEDC), Loughborough University.

Phone: +44 1509 222885 Fax: +44 1509 211079 E-mail: WEDC@lboro.ac.uk http://www.lboro.ac.uk/well/