HOW TO BUILD
CYLINDRICAL WATER TANKS WITH DOMES

(Volumes 23 and 46 cubic metres)

using ferro-cement which is

* more durable than other types of water tanks
* cheaper than convential water tanks
* easy to build and maintain
* 2,000 tanks have been build without problems.

For US$ 0.64 500 school children can each get 1.4 litres of water per school day in 30 years.

ERIK NISSEN-PETERSEN

ASAL CONSULTANTS LTD.
P.O.Box 867, Kitui, Kenya

1992

Copies of these manuals can be purchased for the equivalent of US$ 10 per copy in hard currency by Bankers Cheque inclusive of registered surface mail from:
ASAL Consultants Ltd. P.O.Box 867, Kitui, Kenya.

This series of photo-manuals on "How to Build and Repair" consists of the following manuals:

"How to Build Cylindrical Water Tanks with Domes"
"How to Build An Underground Tank with Dome"
"How to Repair Various Types of Water Tanks"
"How to Build and Install Gutters with Splash-guard"
"How to Build A Double VIP-latrine"
"How to Build Smaller Water Tanks and Jars"

The series will be expanded to include:

"How to Build A Shallow Well"
"How to Plan and Manage a Water Tank Programme"
"How to Build Sub-surface Dams"
"How to Build A Sand-storage Dam"
"How to Build A Small Earth Dam"
"How to Build A Rock Catchment Dam"
"How to Build A Spring Protection"
"How to Build A Handpump and A Self-closing Watertap"

Another series of manuals on "Harvesting Rainwater in Semi-arid Africa" by Erik Nissen-Petersen, 1990, can also be purchased from ASAL Consultants Ltd. for the equivalent of US$ 10 in hard currency by Bankers Cheque. This series consists of the manuals:

"Water Tanks with Guttering and Handpump"
"Small Earth Dam with Animal Traction"
"Rock Catchment Dam with Self-closing Watertap"
"Shallow Wells with Bucketlift"
"Sub-surface and Sand-storage Dams"
"Spring Protections"

ASAL Consultants Ltd. is a private company which is specialized in water supply systems based on rain water harvesting.

ASAL Consultants Ltd. offers consultancy services on appraisal, review and evaluation of water programmes, as well as training of staff in siting, design, construction and maintenance of water projects.

Contents **Page**

ACKNOWLEDGEMENTS

The author of this manual is most grateful to Kim Nissen-Petersen, Steve Robinson, Clare Gelsthorpe, Sue Clough and Richard Hanson for their proof-reading of this manuscript and for their very useful recommendations.

INTRODUCTION

These photo-manuals are illustrated with many photographs, accompanied by clear and short text, to describe step-by-step how to build various types of structures for harvesting rainwater.

This method of using a short series of consecutive photos with brief text to explain various construction methods for training artisans and supervisors has proved successful on several occasions.

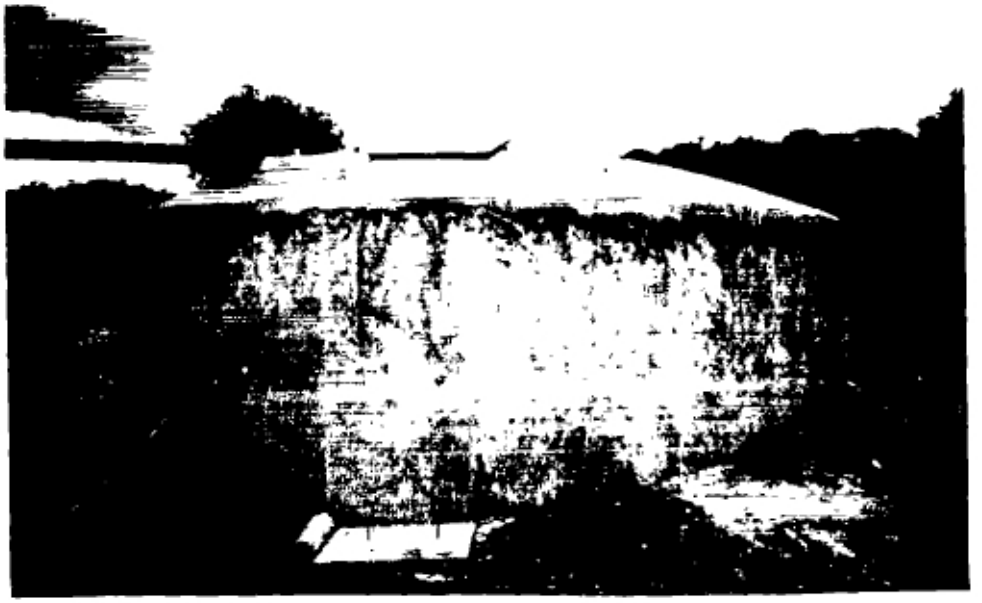
The techniques explained in this manual are based on the author's experience of training more than 500 artisans and contractors in designing and building water projects in Africa since 1974.

It is hoped that this manual will assist water programmes as well as local contractors and clients, in building long-lasting water projects which will provide water for people and livestock.

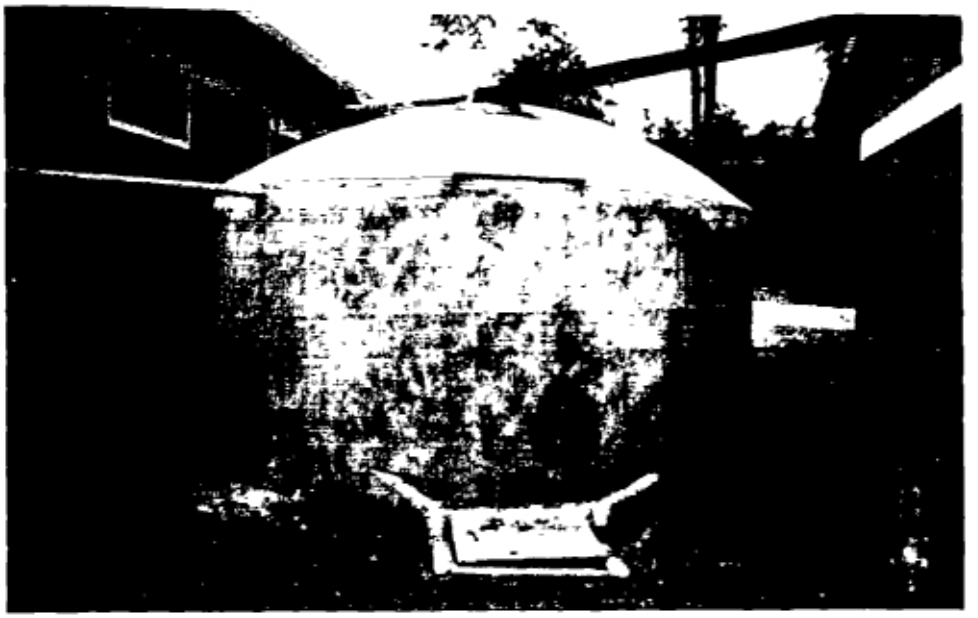
CYLINDRICAL WATER TANKS WITH DOMES.
(With volumes of 46 and 23 cubic metres)

This manual describes in text and photos how to build the 23 and 46 cubic metre water tanks with a dome of ferro-cement as seen on the photo below.

The description of building the 23 cubic metre tank is similar to that of the 46 cubic metre tank, except for the measurements and bills of quantities which can be found in the standard designs and in the annexes.



A 46 cubic metre water tank



A 23 cubic metre water tank

How to Estimate Demand and Supply of Water from Roofs:

In order to make water tanks for roof catchment of rain a perennial source of drinking water the following have to estimated:

Water Demand:
If a school has, say 500 pupils and teachers, and each person requires 2 litres of drinking water daily, that gives a daily demand of 1,000 litres.

Required Storage:
If a region has, say 130 school-days in a 7 month period without rains the required storage volume will be 130,000 litres which will require 3 tanks, each with a volume of 46 cubic metres (46,000 litres).

Estimated Rainfall:
Find the rainfall data for one of the poorer rainy seasons and use that for a realistic rainfall figure, say 200 millimetres.

Required roof area for rain catchment:
The size of the roof area required for filling one tank is found by dividing the volume of the tank (46,000 litres) with the rainfall (200 millimetres) which gives 230. Add 10% for wastage = 253 square metres of roof are required for one tank of 46 cu.m.

Utilization of Overflowing Waste Water:

If the roof is smaller the tank will not be filled, unless the rainfall is higher than estimated. If the roof is bigger the tank will just overflow into the tap station and from there to a waste pit with sugar canes. This waste pit could be extended into a small-scale irrigation of, for example vegetables or tree seedlings in a school garden.

Cost Estimating of Building Water Tanks

The building of 600 water tanks (46 cu.m.) for UNICEF and the Kitui Integrated Development Programme (KIDP) in Kenya during 1991 and 1992, has given the following costs for one 46 cu.m. water tank:

The donors' contribution

Site Surveyor, contracts and schedules with schools...	US$	36
Training contractors and manuals.....	"	10
Implementing Officer.....	"	36
Supervisors, drivers, storekeepers, clerks.....	"	70
Skilled labour, 3 contractors and 2 trainees.....	"	264
Purchased materials, (cement, reinforcement mesh,etc.)	"	608
Transport cost, (tractor, 4WD pick-up and motorcycle).	"	67
Tools and equipment.....	"	10
Donors' contribution for 1 water tank, 46 cu.m.....	**US$**	**1101**

Value of the school's contribution

Value of providing sand, stones, ballast and water....	US$	290
Value of assisting the contractors.....	US$	203
Value of the school's contribution.....	**US$**	**493**

Total cost and value of 1 water tank, 46 cu.m.....	**US$**	**1594**
Plus the cost of 50 metres of gutters for 1 tank..... (details can be found in the manual on gutters)	US$	178
Total cost for donor for 1 tank 46 cu.m., with gutters	**US$**	**1279**

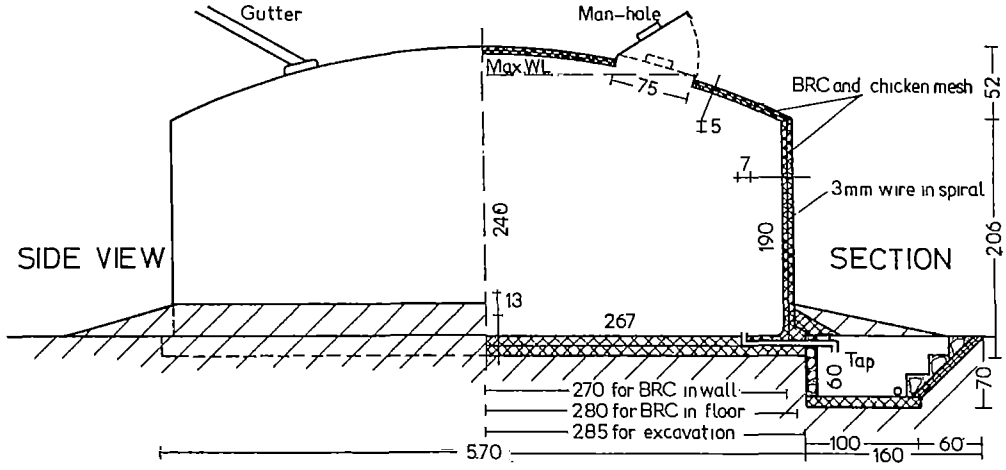
The cost of providing one school child with daily drinking water
For example;
When a total of 500 children and teachers are supplied with drinking water from 3 water tanks for 200 school days in a year, then every child and teacher can get 1.4 litres of water daily.

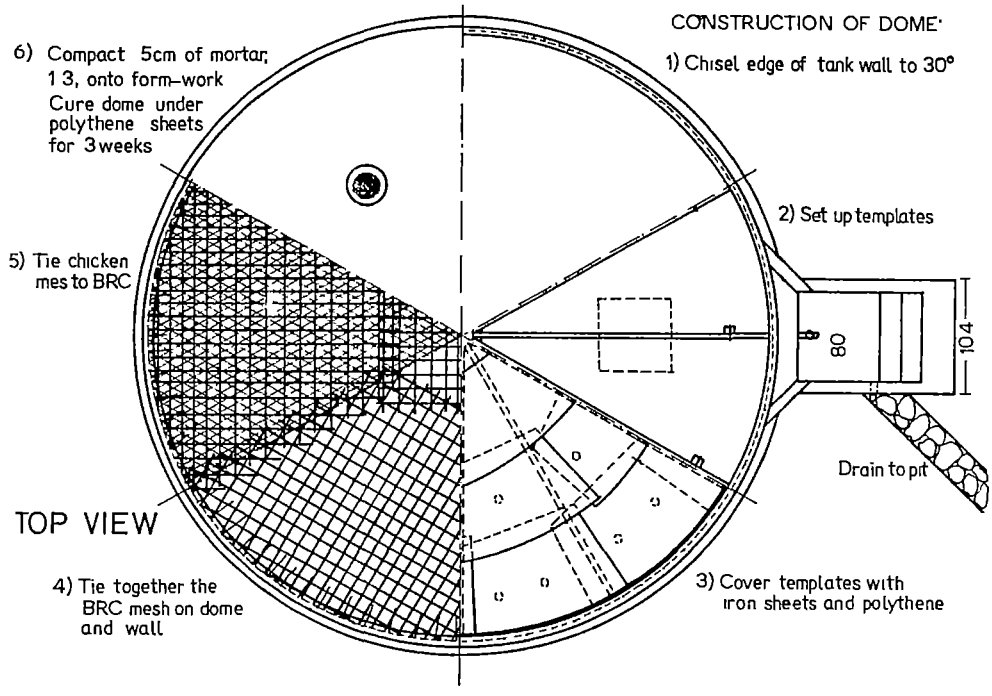
The 3 tanks with gutters cost the donor US$ 3837. With an expected life-time for the tanks of 30 years, the annual cost is USD 128. For 200 school days that gives a daily cost of US$ 0.64 for providing 500 persons with 1.4 litres of water daily.

In other words, for every US$ 0.64 spent on building one tank with gutters, 500 school children can get 1.4 litres of clean drinking water every school-day for 30 years.

STANDARD DESIGN

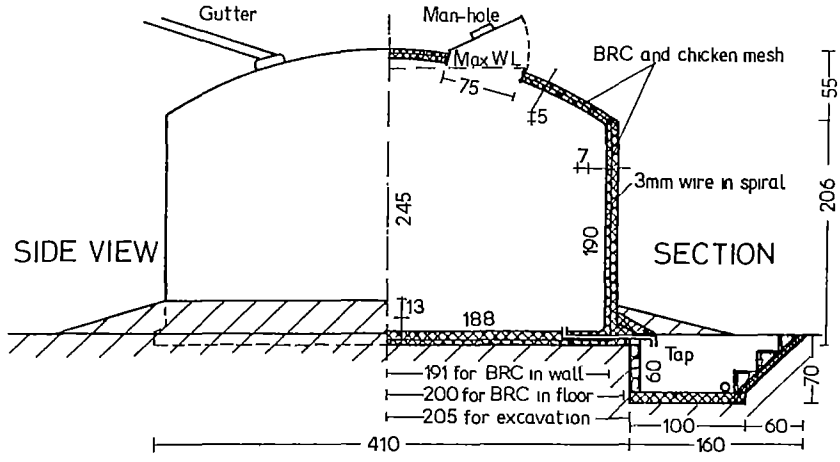
OF A 46 Cubic Metre WATER TANK

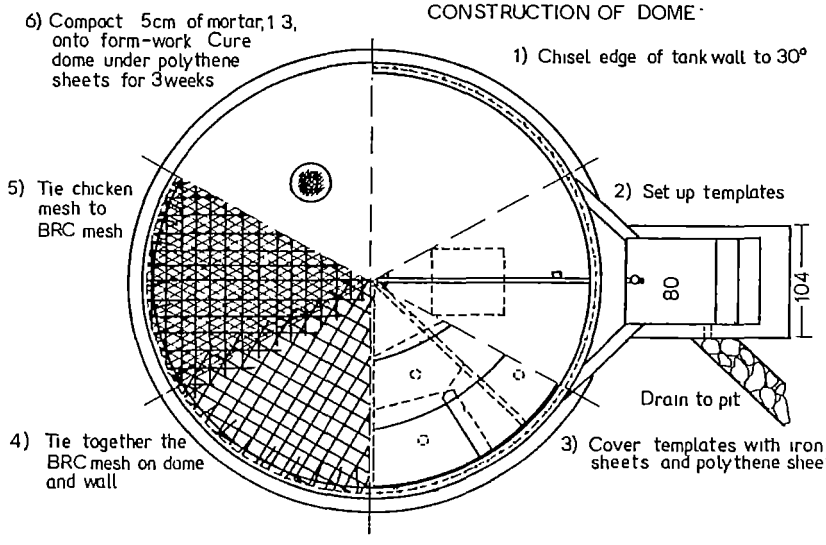


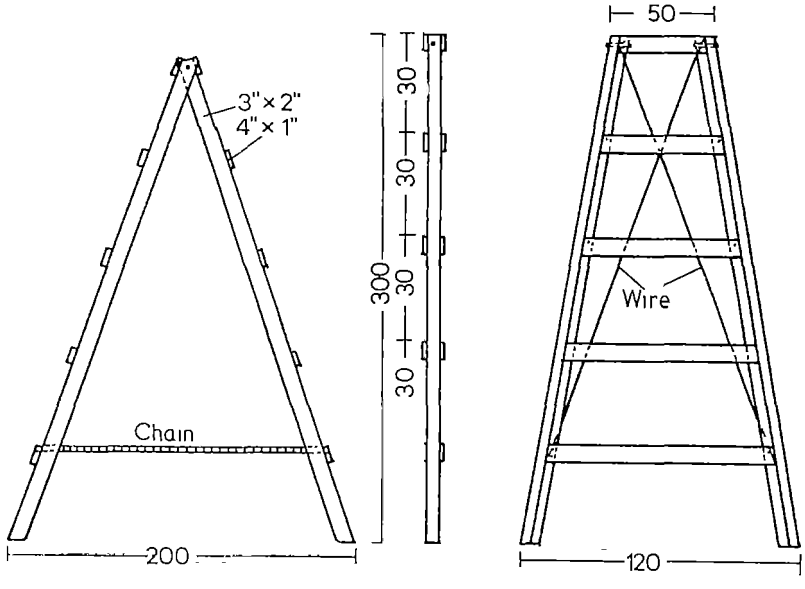


STANDARD DESIGN

OF A 23 Cubic Metre WATER TANK







COLLAPSIBLE DOUBLE LADDER

BILLS OF QUANTITIES

FOR A 46 CUBIC METRE AND FOR A 23 CUBIC METRE WATER TANK.

Item	Quantity for 46 cubic metre.	Quantity for 23 cubic metre
LABOUR		
Provided by organization:		
A-Contractor.....	9 days	..... 8 days
B-Contractor.....	9 days	..... 8 days
B-Contractor.....	9 days	..... 8 days
Trainee.....	9 days	..... 8 days
Trainee.....	9 days	..... 8 days
Skilled labour	45 days	40 days
Transfers to/from site	11 days	11 days
Total Skilled Days	56 days = US$ 264.	51 days = US$ 240.
Provided by self-help:		
Loading/off-loading sand	2 days x 15 people	1 day x 15 people
" "stones/ballast	6 days x 15 people	4 days x 15 people
Supplying water.....	15 days x 10 people	12 days x 10 people
Labour for construction.	15 days x 10 people	12 days x 10 people
Labour for curing tank..	20 days x 2 people	20 days x 2 people
Total Unskilled days	460 days = US$ 493.	355 days = US$ 380.
MATERIALS		
Provided by organization:		
Cement.....	50 bags.....	30 bags
BRC mesh, No.65 (1 roll 42 m).	50 metres.....	33 metres
Chicken mesh, 1",3"(1 roll 29 m)	80 metres.....	50 metres
Binding wire, 1.5 mm, black...	25 kg.....	12 kg.
Polythene sheets, g. 500.....	40 metres.....	30 metres
Sisal twine.....	2 kg.....	2 kg.
Pipe with tap (see design)....	1 unit.....	1 unit
Lockable man-hole of G.I.....	1 unit.....	1 unit
	Value US$ 608.	Value US$ 394.
Provided by self-help labour and included above:		
Sand, clean and coarse.....	10 ton/4 loads	7 ton/3 loads
Ballast, 1" to 2".....	4 ton/1.5 load	3 ton/1.2 load
Stones, 3" to 10".....	1 ton/0.5 load	1 ton/0.5 load
Water,.....	6 ton/30 drums	4 ton/20 drums
Total Cost and Value of Labour and Materials	US$ 1365	US$ 1014

Site Survey, Supervision, Transport and Overheads not included.

BILLS OF QUANTITIES PER STAGE OF WORK

FOR A 46 CUBIC METRE TANK

Key: Whbr = Wheelbarrows.

Stage of work	Work Days	Cement Bags	Sand Whbr	Ballast Whbr	Stones Whbr	BRC mesh	Chicken mesh
Foundation	2	11	22	30		15 m	
Wall	4	22	40			18 m	44 m
Dome	2	9	18			15 m	33 m
Tap station,etc.	1	4	8	1	6	Left-overs	
	9	46	88	31	6	50 m	80 m
Extra supply		4	12	13	4		
Total supply		50	100	44	10	50 m	80 m

Rules of thumb for volume versus weight.

1 bag of cement	50 Kg.
20 bags of cement	1 Tonne
1 jerry-can of water	20 Litres
1 drum of water	210 Litres
5 drums of water	1 Tonne
1 karai of sand	17 Kg.
1 wheelbarrow of sand, levelled with rim	100 Kg.
1 tractor trailer load of sand	2.5 Tonnes
1 karai of ballast	15 Kg.
1 wheelbarrow of ballast, levelled with rim	90 Kg.
1 tractor trailer load of ballast	2.5 Tonnes

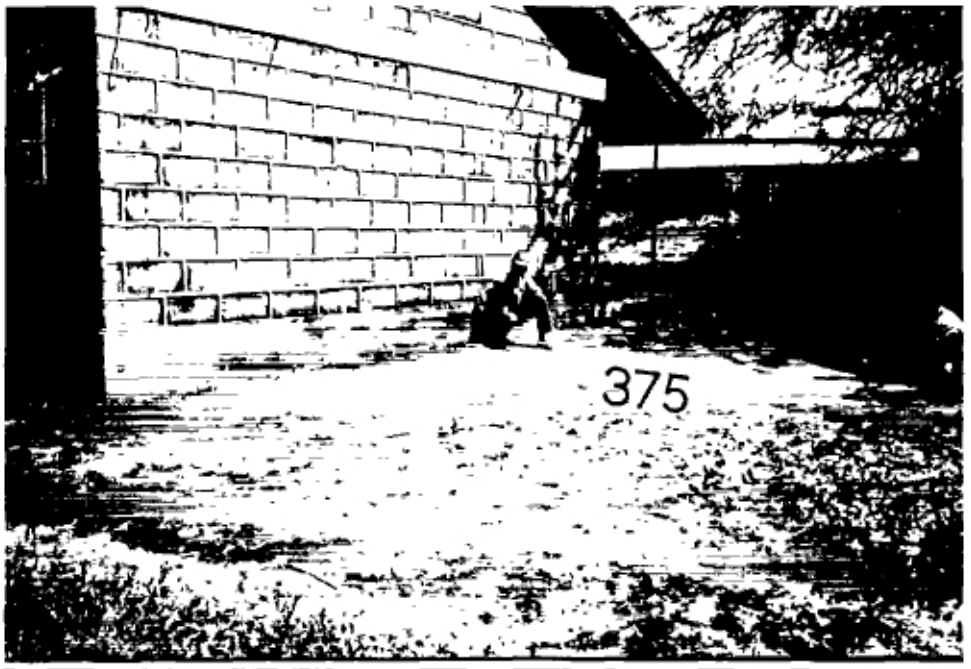
1 wheelbarrow, levelled with rim, contains 6 full karais.

1 tractor trailer load with sand or ballast and 4 labourers for loading and off-loading contains 25 wheelbarrows.

1 tractor trailer should not carry more than 2.5 Tonnes.

1 Canter lorry should not carry more than 3 Tonnes.

SITING & EXCAVATION FOR A 46 CUBIC METRE WATER TANK

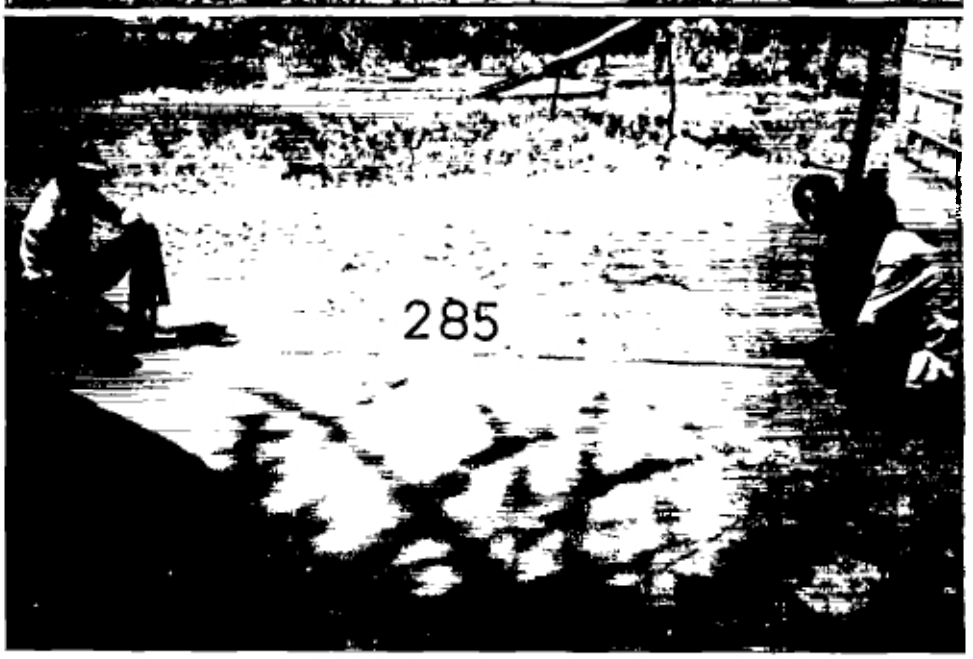


1) Preferably, a tank should be sited at the gable-wall of a building, but it can also be sited along the side of a building.

The site must be free of ant hills and excavations.

There must be no trees within 10 metres of the tank.

The centre of the tank is sited 375 cm. from the wall.



2) The radius of the excavation is 285 cm. thus leaving a space of 90 cm. between the wall and foundation.

3) The depth of the excavation must reach firm soil and be at least 15 cm. deep at the down-slope side of the land.

The floor of the tank has to be at least 300 cm. below the roof to allow for run-off water to enter the tank.

The floor of the excavation must be exactly horizontal all around.

Use a spirit level on a straight-edge to make the floor level.

CUTTING BRC MESH

4) Cut a circular piece of BRC mesh with a radius of 280 cm. consisting of 3 lengths of BRC mesh overlapping each other by 30 cm.

The total length of these 3 lengths of BRC mesh is 1640 cm.

5) Cut 1737 cm. off the roll of the BRC mesh and erect it to form a cylinder.

Make a 40 cm. overlap at the joint and tie it together firmly using binding wire for every 15 cm.

6) Bend the lower ends of the BRC mesh inwards and outwards alternatively.

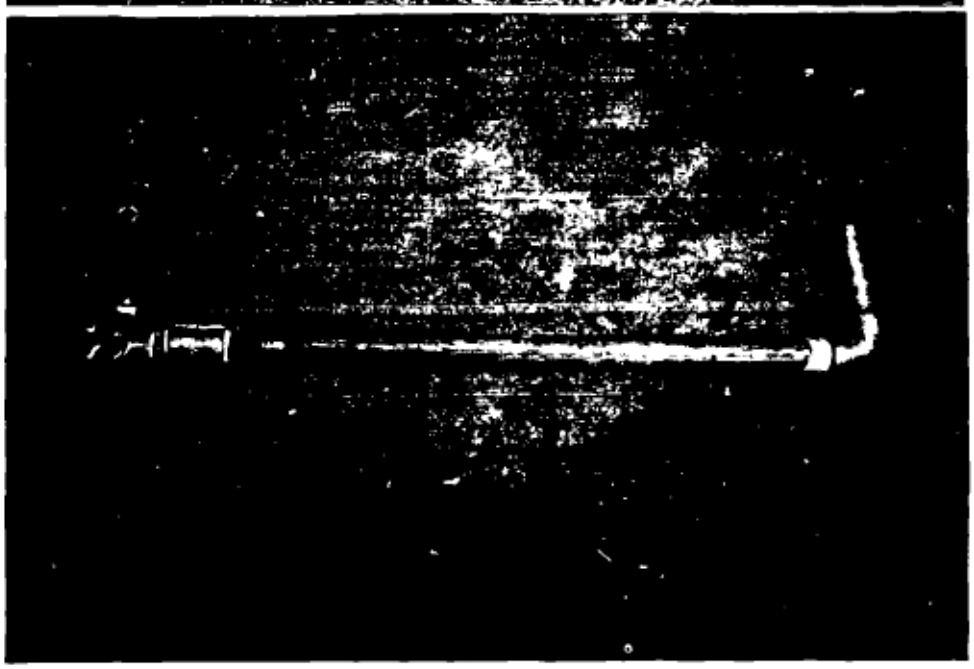
Tie the circular and the cylindrical BRC mesh together for every 15 cm. using binding wire.

CONCRETING FOUNDATION

7) Mix 6 bags of cement with 12 wheelbarrows of clean coarse sand and 16 wheelbarrows of 1" ballast for making concrete with a ratio of 1:3:4. Then add water (see annex 3).

Lay out lines of concrete heaps and level them off horizontally to a thickness of 7 cm.

8) Thereafter fill in the spaces between the heaps with concrete and level them off to a horizontal level by using a straight-edge and a spirit level.



9) Then lift the cylindrical BRC mesh onto the concrete and place it evenly within the excavation.

Place the draw-off pipe at that side of the tank which is most convenient for the user and which allows surplus water from the overflow to be drained away from the tank.

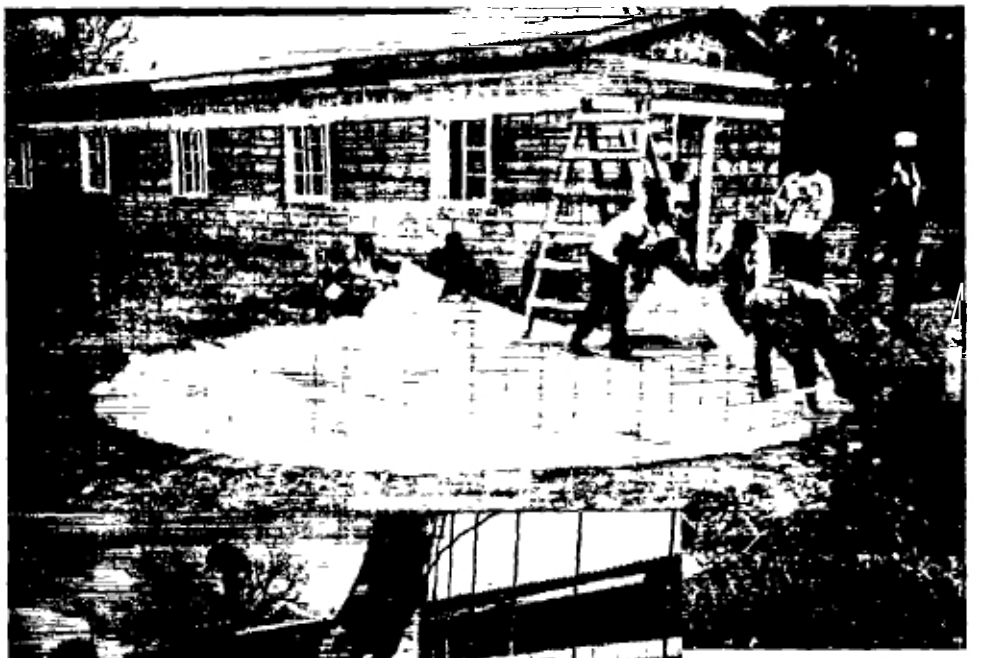
CONCRETING FOUNDATION

10) Mix 5 bags of cement with 10 wheel-barrows of ballast, and add water.

Pour this mixture as a 6 cm. layer upon the floor of the BRC mesh using the levelled heaps of concrete for aligning the floor horizontally.

Compact it well and leave the concrete with a rough finish.

Note: The concrete work for the foundation must be completed within 1 day.



11) Cover the concrete floor with polythene sheets and keep it most for 3 weeks.

12) Thereafter the sides of the cylinder of BRC mesh are set in an exact position by using a spirit level and a straight-edge.

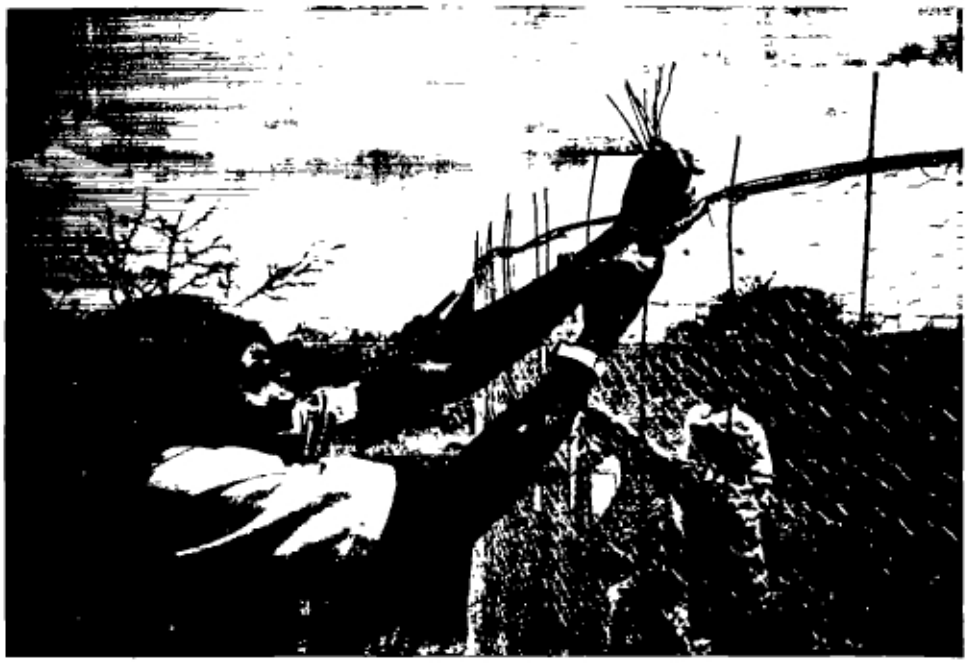
In order to keep the sides in a straigth and vertical position, binding wire is tied to pegs hammered into the soil.

REINFORCEMENT OF WALL

13) Chicken mesh is then wrapped around the BRC mesh.

Any overlap in the chicken mesh must be at least 15 cm. wide.

14) A handy tool for tying the chicken mesh together and onto the BRC mesh, is made from left-overs from the BRC mesh.



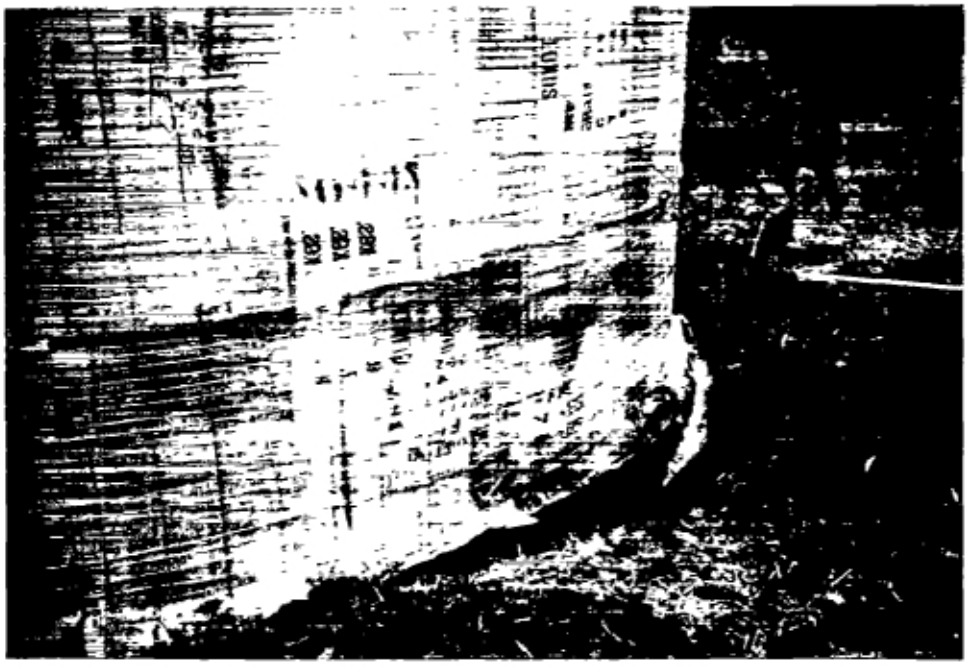
15) Binding wire, 1.5 mm., is then wrapped tightly around the top edge of the BRC mesh 6 times to form a ring-beam for the dome.

Thereafter the binding wire is wrapped around the whole structure at 10 cm. intervals.

At the bottom of the wall the wire is wrapped around an extra 4 times.

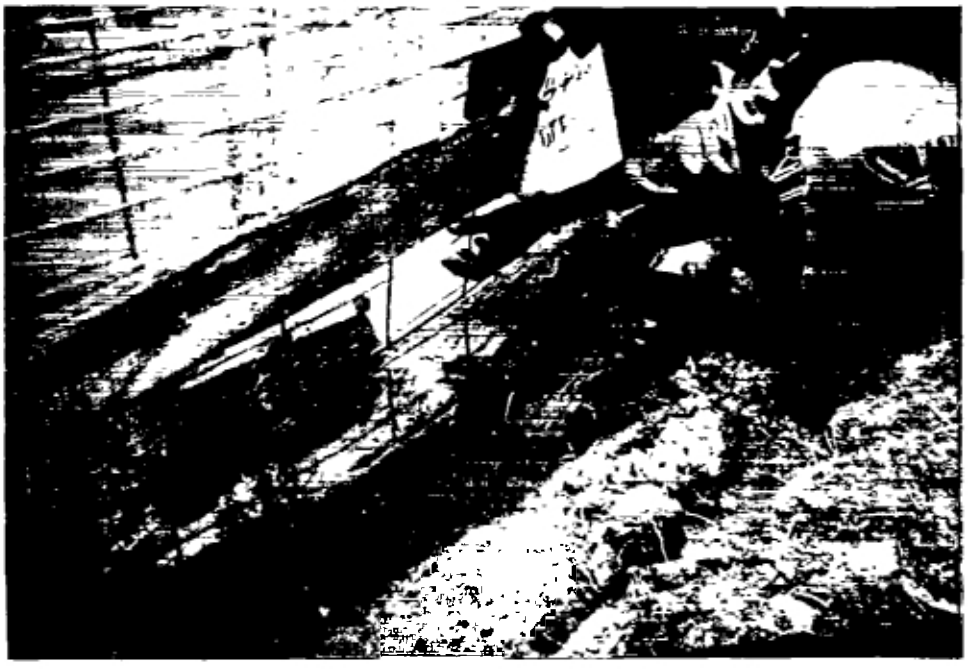
FORM-WORK OF SUGAR SACKS

16) Sugar sacks, cut open along their long sides, are then attached to the BRC mesh by hanging them on the protruding wires with overlaps of 10 cm.



17) Sisal twine is then wrapped around the whole structure covered in sugar sacks with spacing of 3 cm.

Start wrapping from the bottom in order to pull the sacks tightly against the BRC mesh.



18) Dig a trench around the foundation for the purpose of draining water away from the tank.

Clean carefully the joint between the wall and the floor with water and a broom or brush.

1ST AND 2ND COAT OF MORTAR ON WALL

19) Mix mortar, 1:3 (see annex 1) to a paste which can be smeared onto the inside of the tank in a 5 mm. coat.

This work must be completed in 1 day.

Keep the wall moist by covering it with polythene sheets.

20) On the second day, a 1 cm. thick coat of mortar 1:3 is thrown onto the inside of the tank.

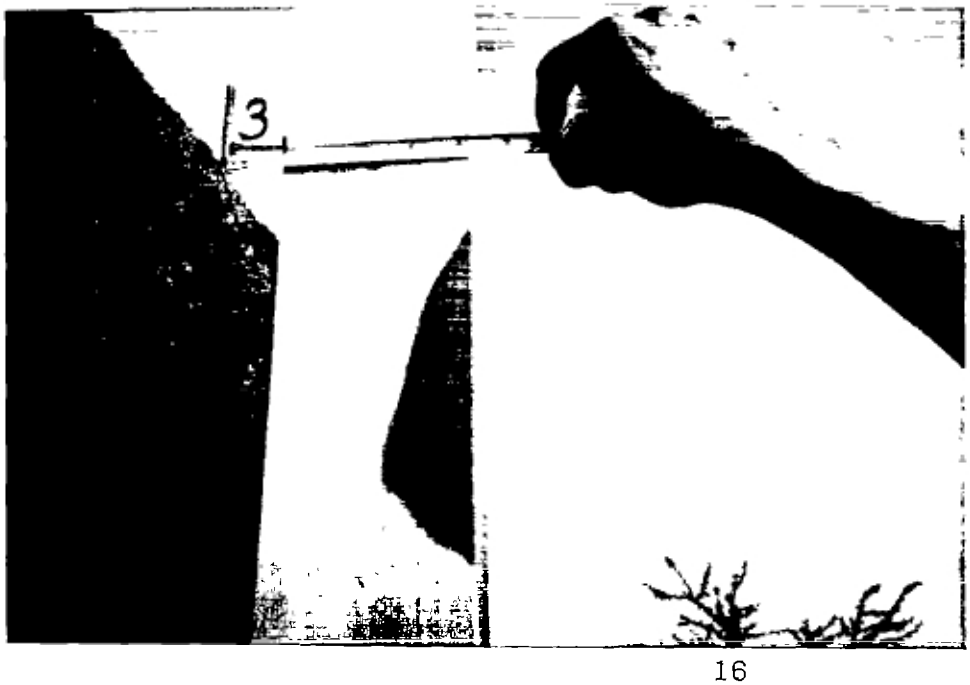
This work must also be completed within 1 day and the mortar kept moist under polythene sheets.

21) On the third day, the binding wire keeping the BRC mesh vertical is removed as well as the sugar sacks and sisal twine.

3RD COAT OF MORTAR ON WALL

22) Within the same third day of building the wall, it is moistened and the joint with the floor is cleaned carefully in order to make it water-tight.

23) Still within the third day,plaster of 1:3 is applied in a thin coat until - (see next photo)



24) - a thickness of 3 cm. from the BRC mesh is reached.

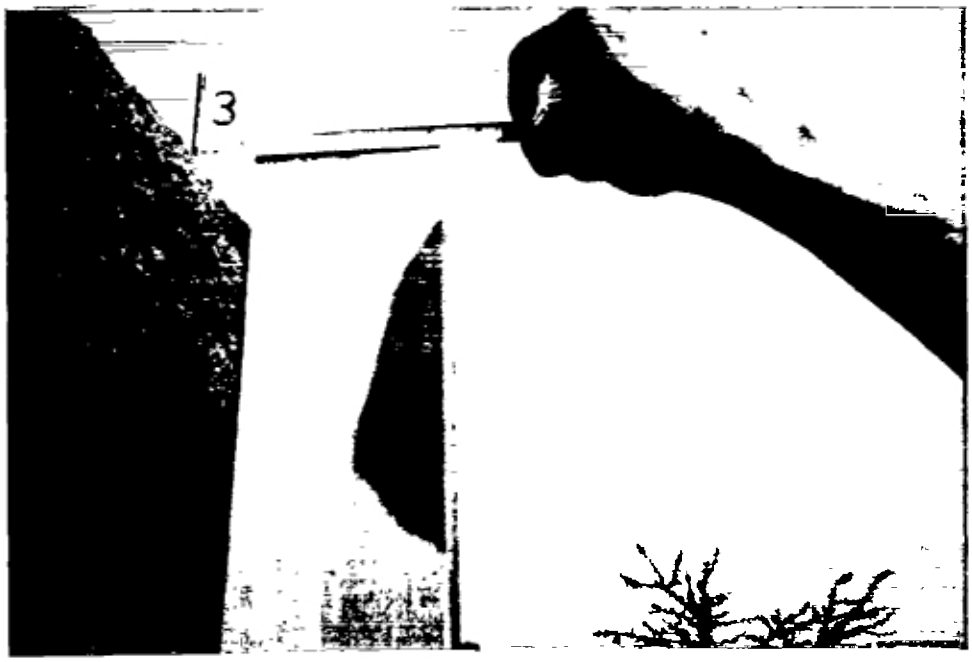
The plaster is straightened off by suing a straigth-edge in vertical movements.

4TH COAT OF MORTAR ON WALL

25) Complete the plaster with a smooth finish by using a straight wooden float.

This coat of plaster must be also be completed within 1 day and the wall kept moist under polythene sheets.

26) On the fourth day, the interior of the tank wall is completed by applying a 2 cm. coat of plaster 1:3 until -
(see next photo)



27) - thickness of 3 cm. is reached from the BRC mesh.

These four layers of plaster described give the wall a final thickness of 6.5 cm.

28) Within the same fourth day of plastering the wall, a water-proof layer of NIL (see annex 2) is applied to the still fresh mortar, with a can and a steel trowel.

29) The NIL is pressed into the mortar until a hard and very smooth surface appears.

This coat of NIL must be completed in 1 day.

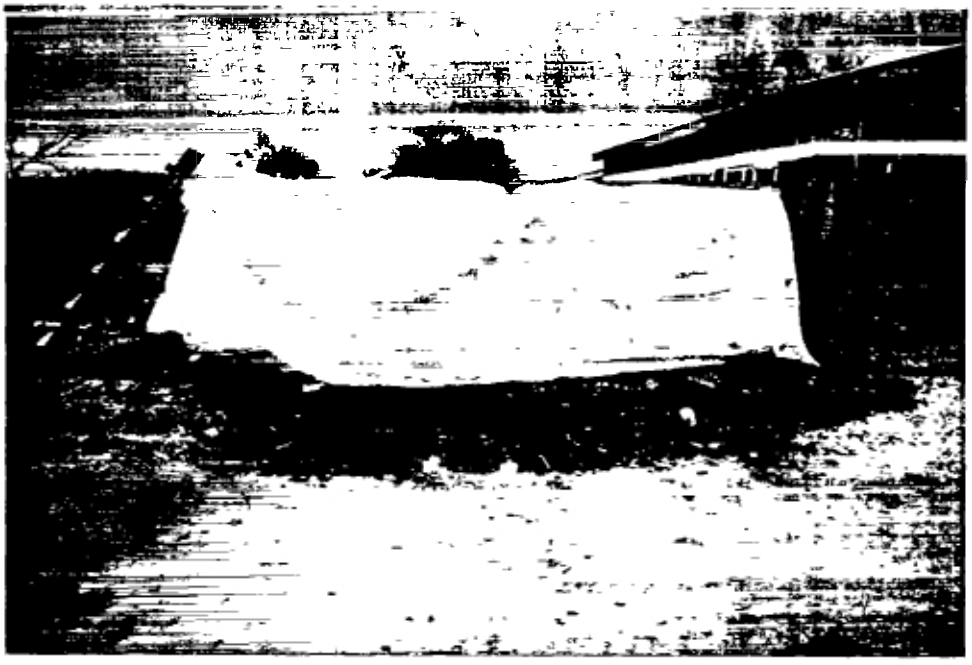
Thereafter the wall is covered with polythene sheets so that it is covered and being cured on both sides simultaneously.

30) Preferably, but not necessarily, within the same fourth day, the floor is covered by a compacted 2 cm. layer of mortar 1:3.

Fill the corner between the floor and the wall with mortar 1:3 and round it with an empty beer bottle.

Within the same day, a water-proof coat of NIL is applied to the rounded corner and the floor.

CURING OF WALL & FORM-WORK FOR DOME



31) Thereafter the interior of the wall and floor is covered with polythene sheets for proper curing.

32) For the next 7 days the walls must be wetted twice a day under the polythene sheets.

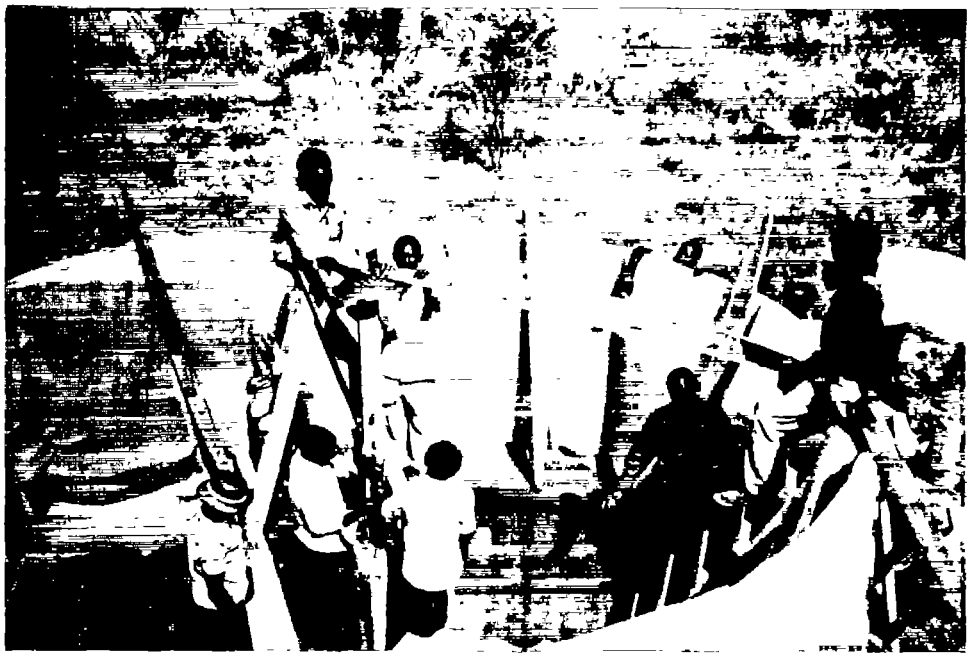
There should be water standing in a 10 cm. depth on the floor for its curing during the next 5 weeks.

33) A couple of days after having completed the plaster on the floor, the form-work can be erected.

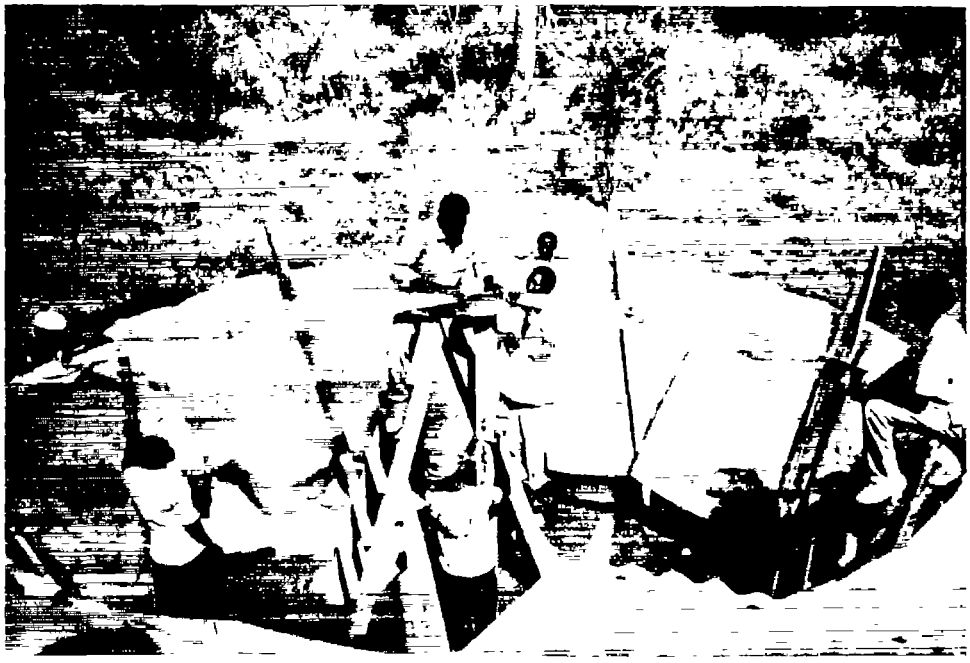
The form-work consists of 12 templates and 1 king-post which will be covered with a layer of 29 flattened oil-drums and polythene sheets (see annexes 4 and 5).

First the king-post is placed on a piece of timber (to protect the floor) in the centre of the water tank.

Notice the water on the floor and the polythene sheets on both sides of the wall for curing.



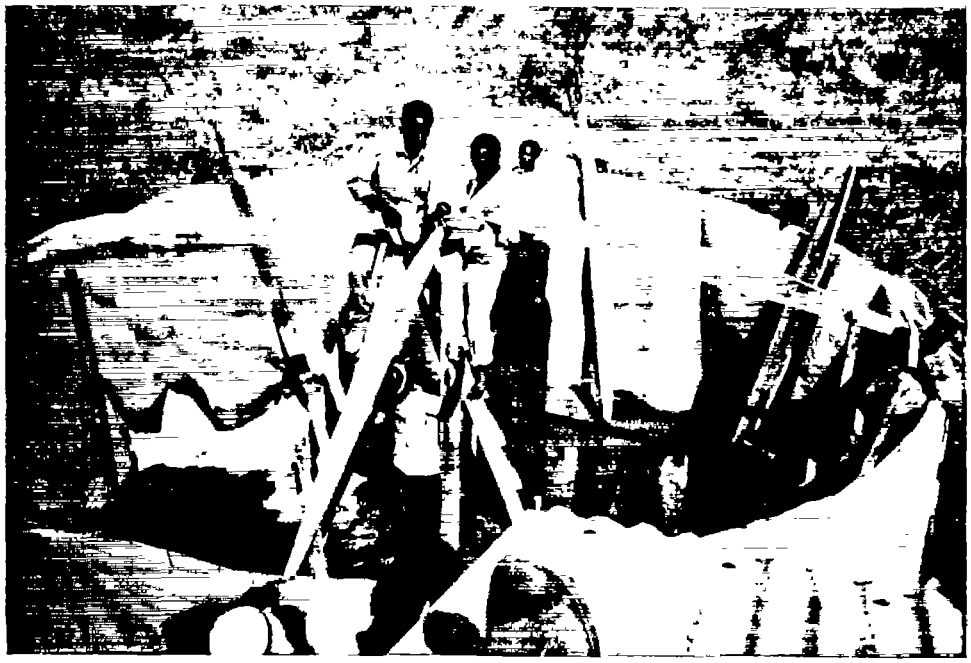
34) Thereafter the first template is tied with binding wire onto the BRC mesh in the wall and laid upon the king-post.



35) The exact opposite point of the lower end of the first template is found by measuring the circumference of the tank (1716 cm.) and dividing it by 2 (858 cm.)

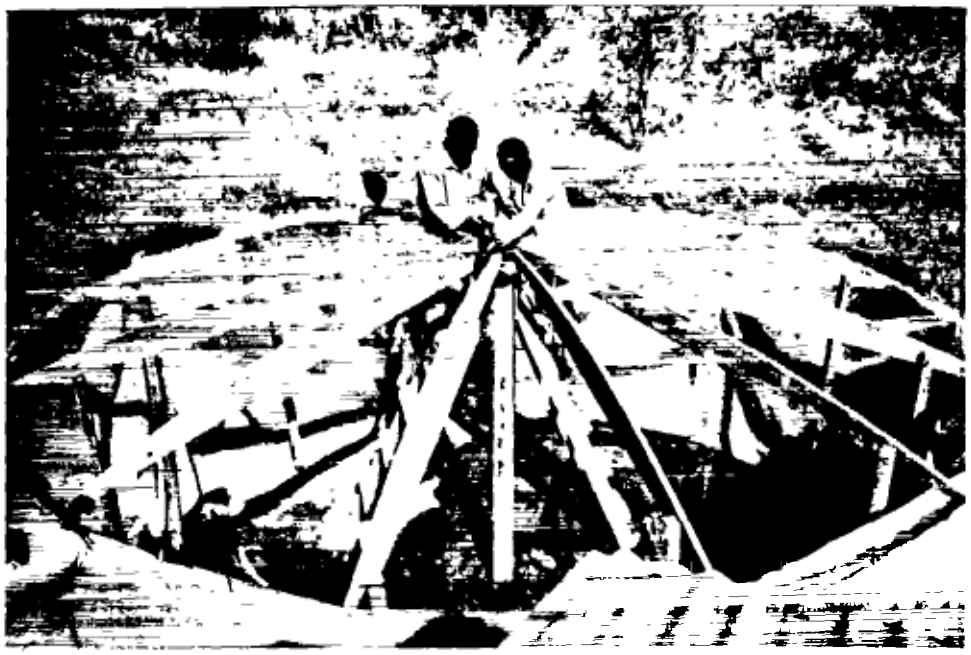
The lower end of the second template is tied to the BRC mesh at that point.

The upper ends of these two templates are tied together on the top of the king-post.



36) The 3rd and 4th templates are placed exactly half-way between the first two templates (429 cm.) and tied into position with binding wire.

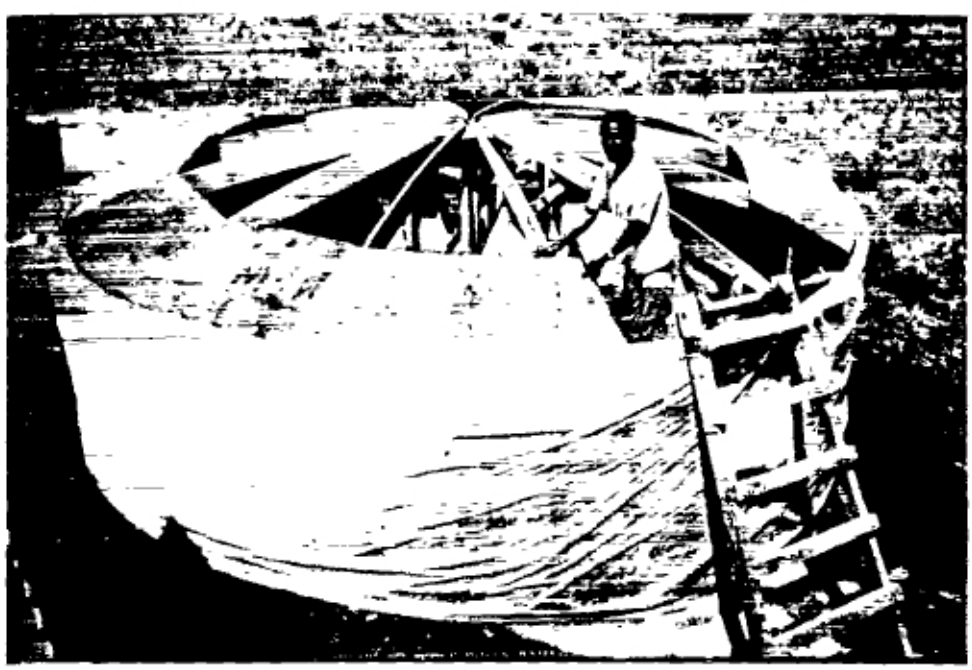
FORM-WORK FOR DOME



37) The remaining eight templates are tied into their positions of equal distance (143 cm.) between the first four templates.

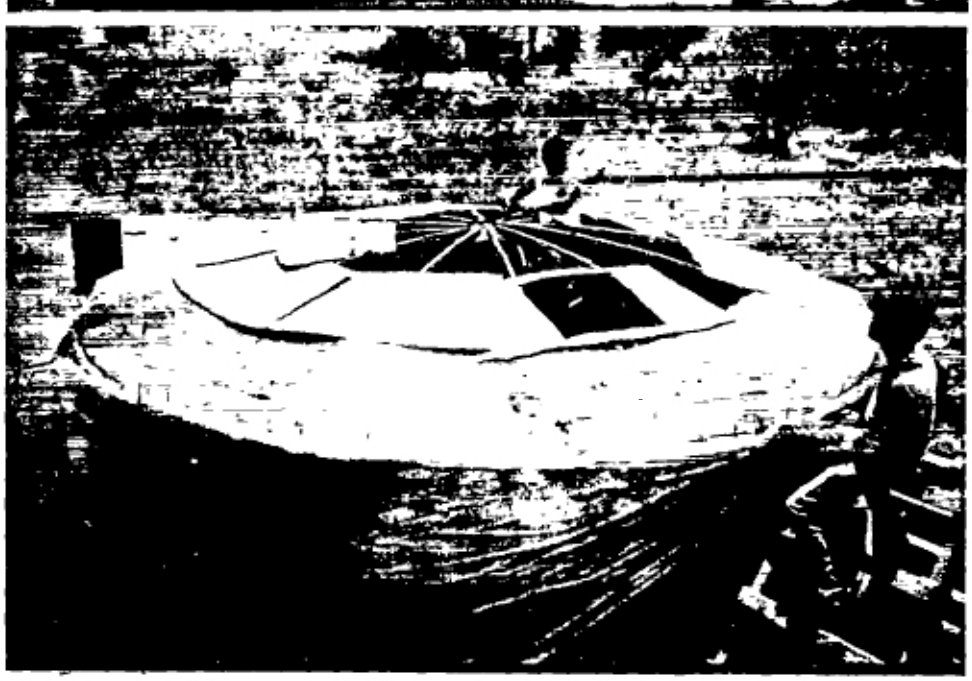
The top ends of the templates are then spaced equally and tied together with the king-post.

The lower ends of the templates, all tied to the BRC mesh in the wall, are then adjusted to a height of 1 cm. below the top of the wall by using wedges under their vertical timbers.



38) The top of the wall is then cut clean for loose mortar and to create an inward slope of 45 degrees.

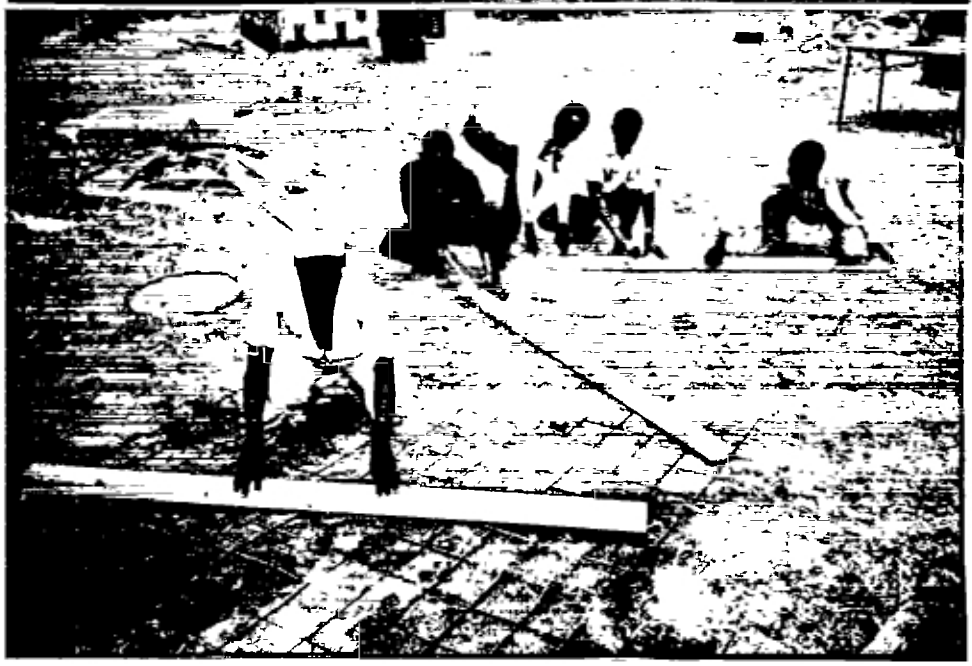
Flattened oil-drums with sides cut into a shape corresponding with that of the tank (see annex 4 and 5) are laid on the templates.



39) The second round of sheets is tied to the top of the king-post with binding wire.

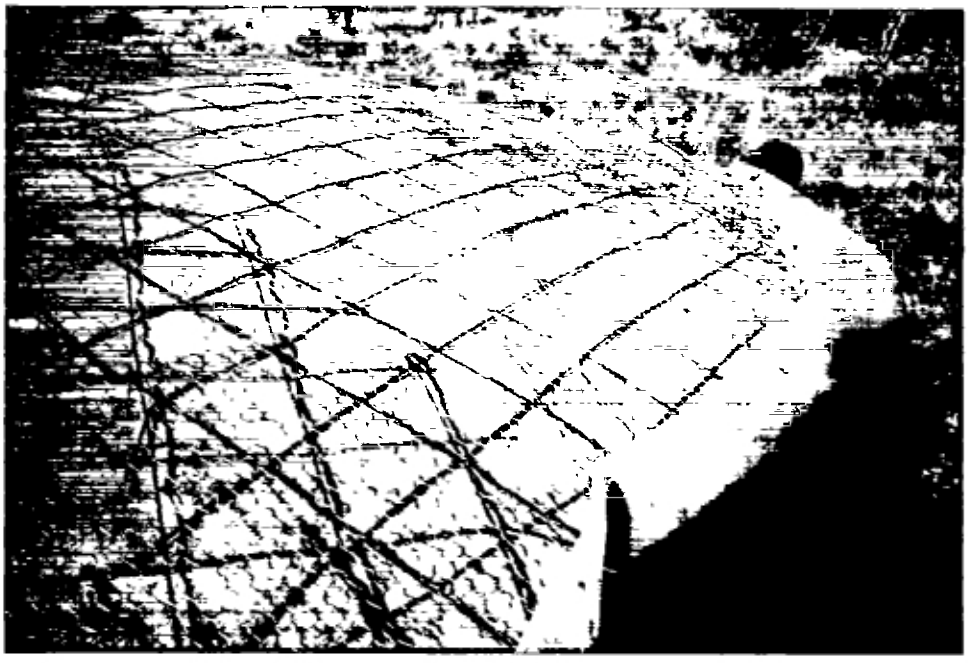
One of the sheets has a square hole cut for the man-hole. This sheet is placed right over the tapping station because the man-hole will also function as overflow. The tapping station will act as an apron to avoid erosion of the tank site.

40) Alternatively, a lockable steel lid can be concreted into the dome on this sheet instead of the lid made of ferro-cement as shown on the following pages.



41) When the templates are covered with iron sheets, then BRC mesh is cut into triangles (see annex 5).

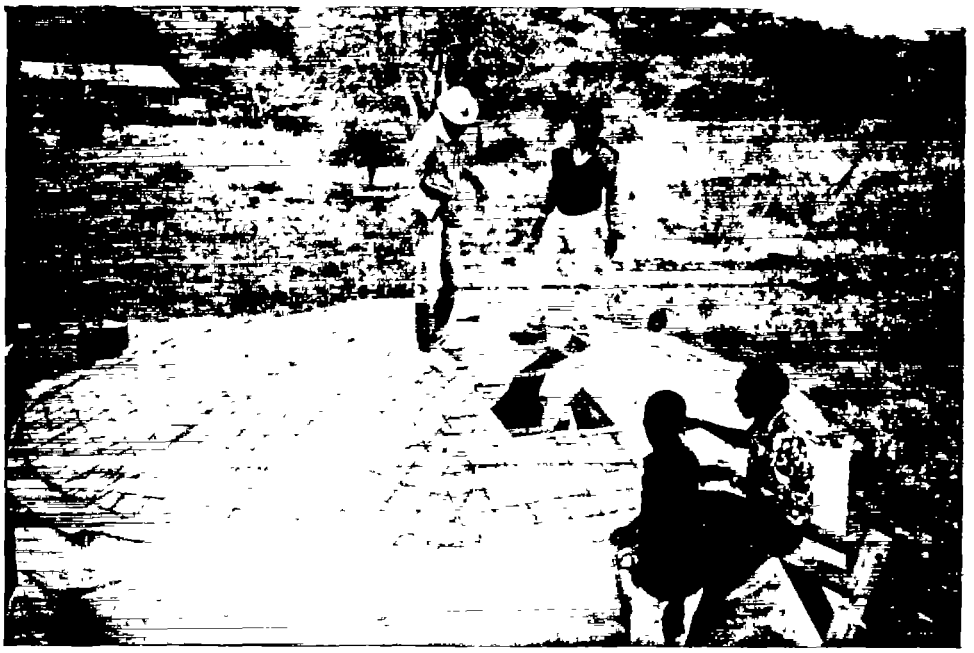
Altogether a total length of 1538 cm. of BRC mesh is required for the dome.



42) The dome of the flattened oil-drums is covered with polythene sheets to facilitate easy removal of the oil-drums after curing of the dome.

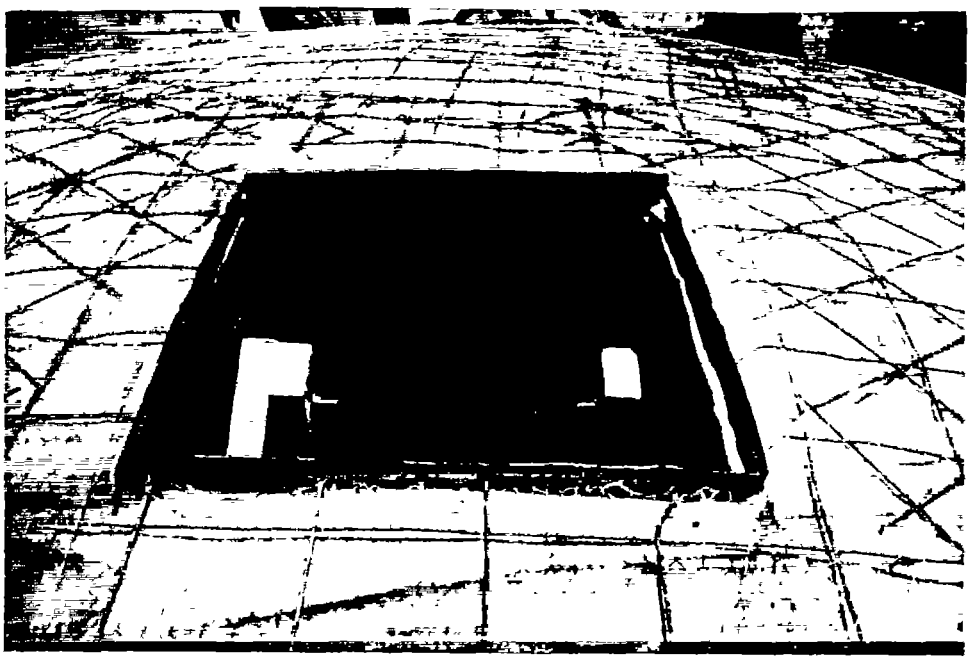
The triangular pieces of BRC mesh are laid upon the polythene sheets with an overlap of at least 15 cm. and tied together with binding wire.

REINFORCEMENT OF DOME



43) The BRC mesh protruding up from the wall is bent over the dome and tied onto the BRC mesh on the dome.

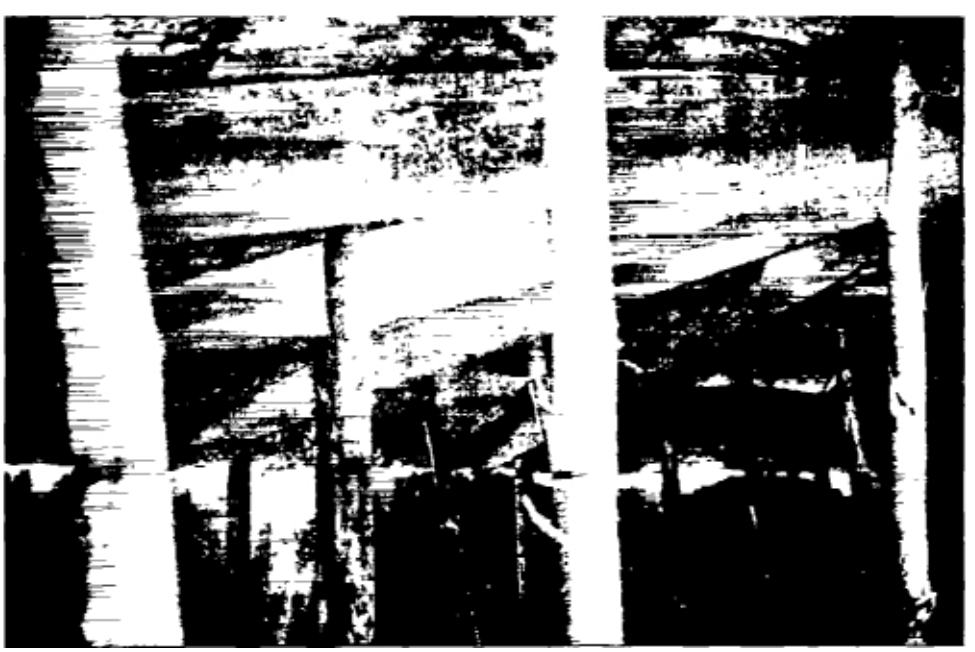
The BRC mesh is then covered with chicken mesh which will have a minimum of 10 cm. overlap.



44) A man-hole, measuring 62 x 67 cm., is cut in the meshes.

The sides of the man-hole are lined with 4 cm. high strips of cut-off metal from the oil-drums.

If a steel lid is to be fixed, then it will be tied onto this form-work.



45) Sisal poles are used for supporting the form-work between the templates.

CONCRETING OF DOME

46) The tip of the wall is cleaned and wetted in order to secure a firm and water-tight bond between the wall and the dome.

47) Mortar, 1:3, is then mixed and laid upon the form-work and compacted well around the BRC mesh until the mortar has a thickness of 4 cm.

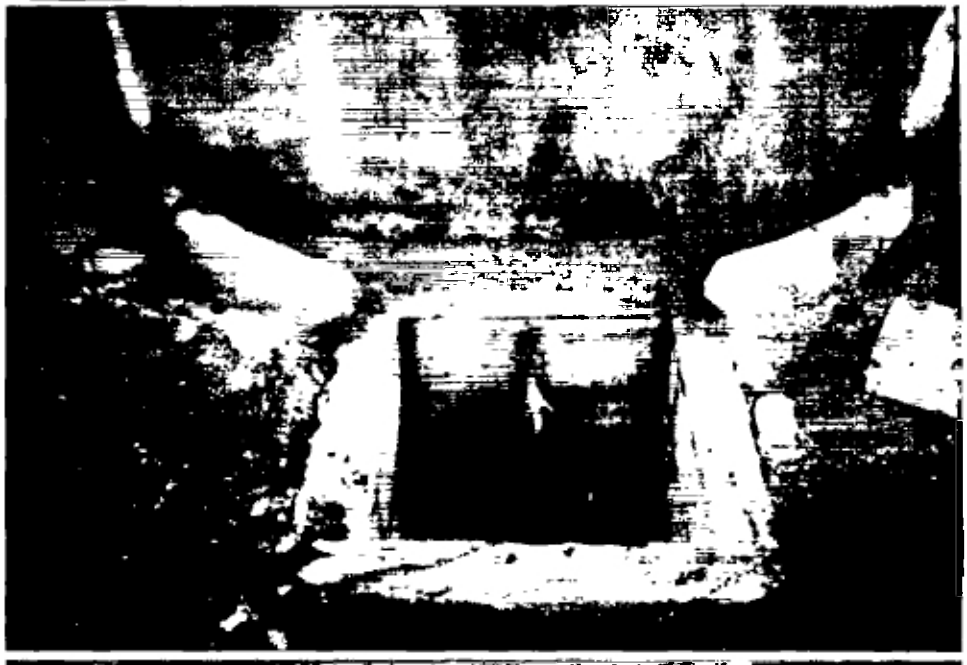
48) The mortar is levelled off by using a length of the cut-off timbers from the making of the templates.

IMPORTANT: The construction of the dome MUST be completed in 1 day.

CURING OF DOME & TAP STATION

49) When the joint between the dome and the wall has been smoothed to a nice finish, then the dome is covered with sand or soil and kept moist for at least 4 weeks.

The form-work must not be removed for at least 7 days.



50) During the 7 days curing of the dome, the guttering is made and installed.

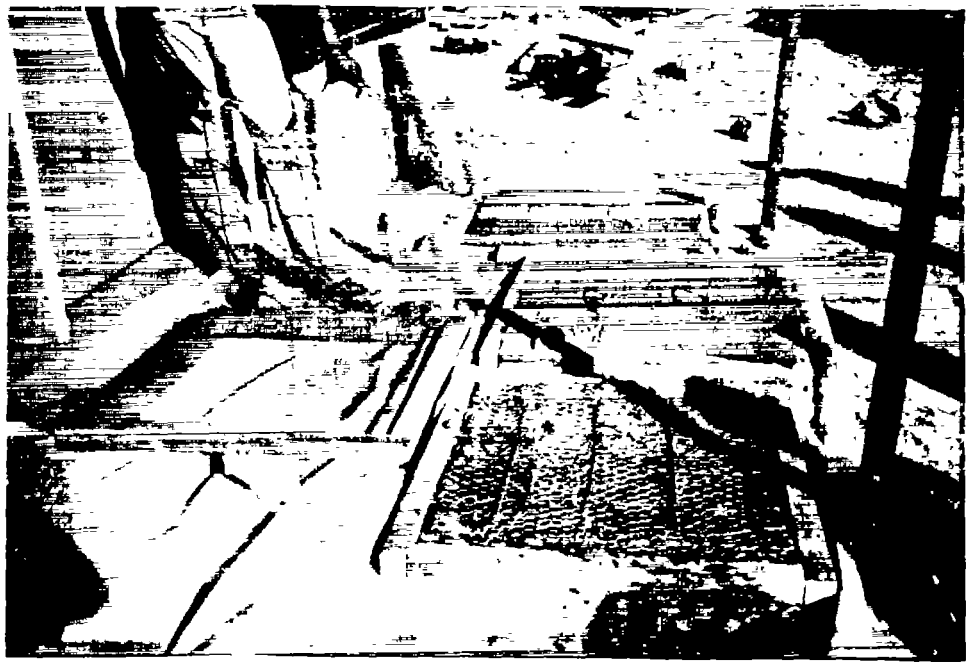
The tapping station is also built during this time. The excavation measures 160 cm. x 104 cm. and it is 70 cm. deep.

Its floor, walls and steps are build of unhewn stones set in mortar 1:3 and plastered.

51) An ditch is dug from an outlet hole in the tapping station to a pit some 10 metres away from the tank.

Sugar canes, bananas and cabbages could be planted in the pit for utilizing the waste water.

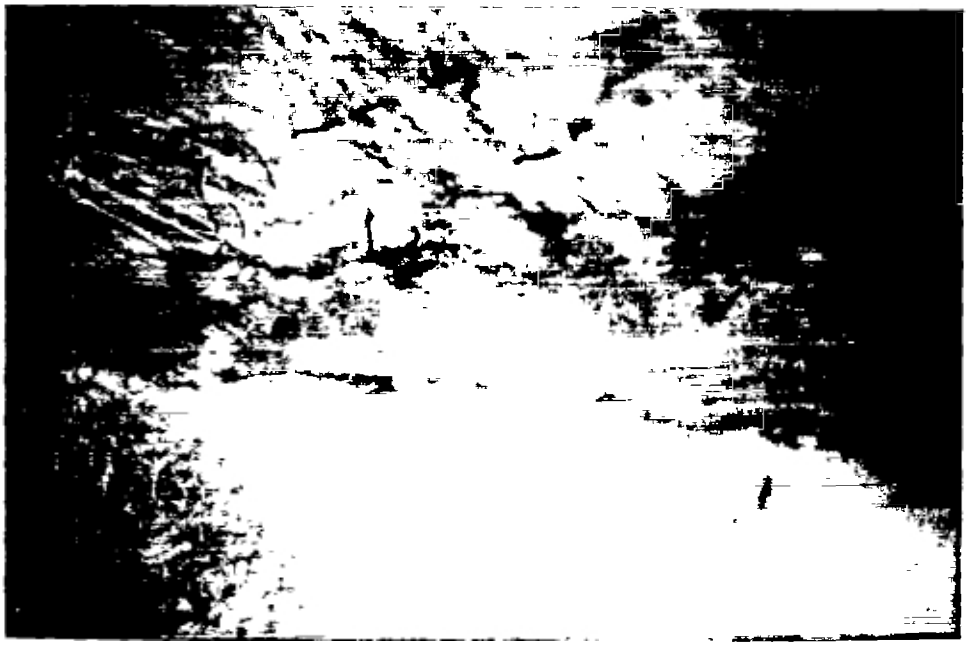
LIDS, APRON & SEALING JOINT



52) If a man-hole of steel is not concreted into the dome, then a lid is made of ferro-cement for the man-hole.

Its reinforcement consists of BRC and chicken mesh.

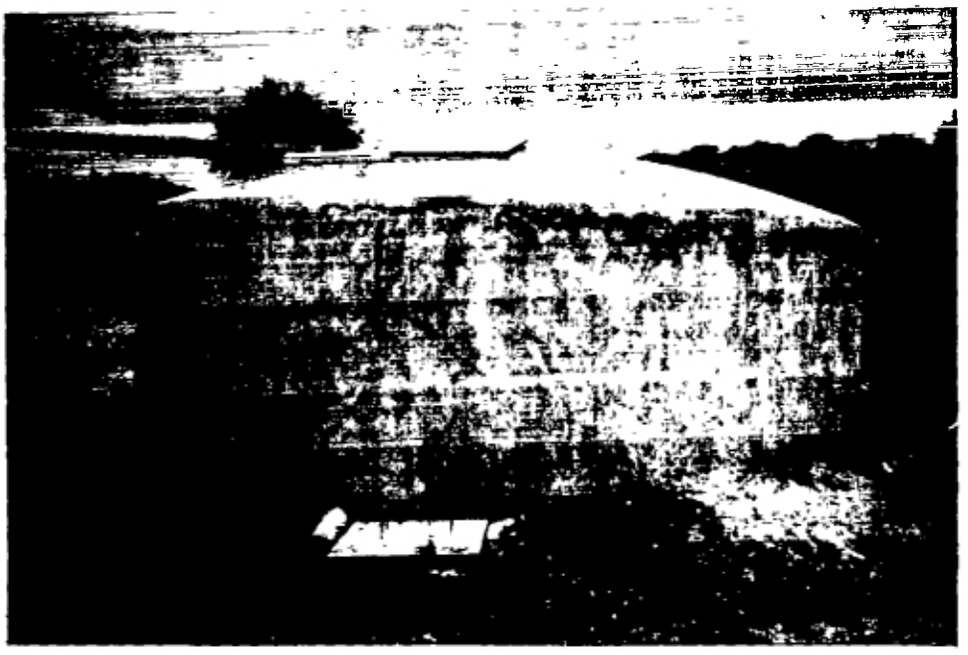
53) A drain-away apron is made of soil from the excavation of the foundation. The soil is placed around the tank to avoid water-logging near the foundation of the tank.



54) After at least 7 days of curing, the form-work for the dome is removed.

The interior joint between the dome and the wall is cleaned for loose mortar and plastered with mortar 1:3 and NIL to make it water-tight.

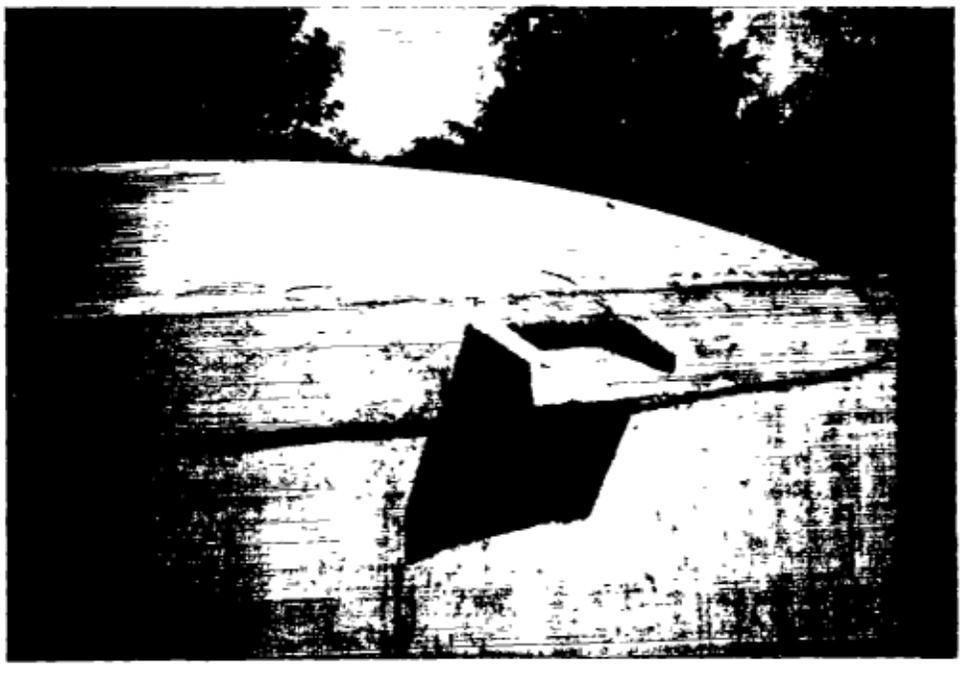
CURING AND ALTERNATIVE OVERFLOW



55) Upon completion of the tank it is wrapped in polythene sheets which is hold in position with sisal twine so that wind cannot loosen the sheets.

The owner of the tank is shown how to pour water under the polythene sheets for curing which will take 4 weeks. Thereafter the owner can use the polythene sheets for other purposes.

The contractors should not be paid the last 15% of their fees until it is proved that the tank is water-tight during a rainy season.



56) If a tank should leak between the dome and the wall due to poor workmanship, then such a leakage can be avoided by lowering the waterlevel in the tank by lowering the overflow.

Unfortunately, this will reduce the volume of the tank by 4,000 litres, but the unpaid 15% of contractors's fee will cover for the loss.

ANNEX 1

Mixing mortar 1:3

It is very important to mix mortar correctly for ferro-cement structures, and to cure the ferro-cement work with water and polythene sheets for at least 3 weeks.

For the purpose of proper curing, 20 metres of polythene sheets are given to every school and the headmaster instructed in the procedures of the daily curing.

The correct mixture for mortar for ferro-cement is 1 portion of cement to 3 portions of sand, called 1:3.

The sand for this mortar has to be clean and coarse river sand. Any lump of soil or clay, or a piece of straw, will create a leakage in the water tank.

Mixed mortar has to be kept in shade and used within 1 hour.

1) Mortar is mixed in portions consisting of:

1 bag of cement,(50 kg).

2 wheelbarrows of coarse and clean river sand levelled off to the rim of the wheelbarrows.

2 3/4 buckets of fairly clean water, (40 Litres).

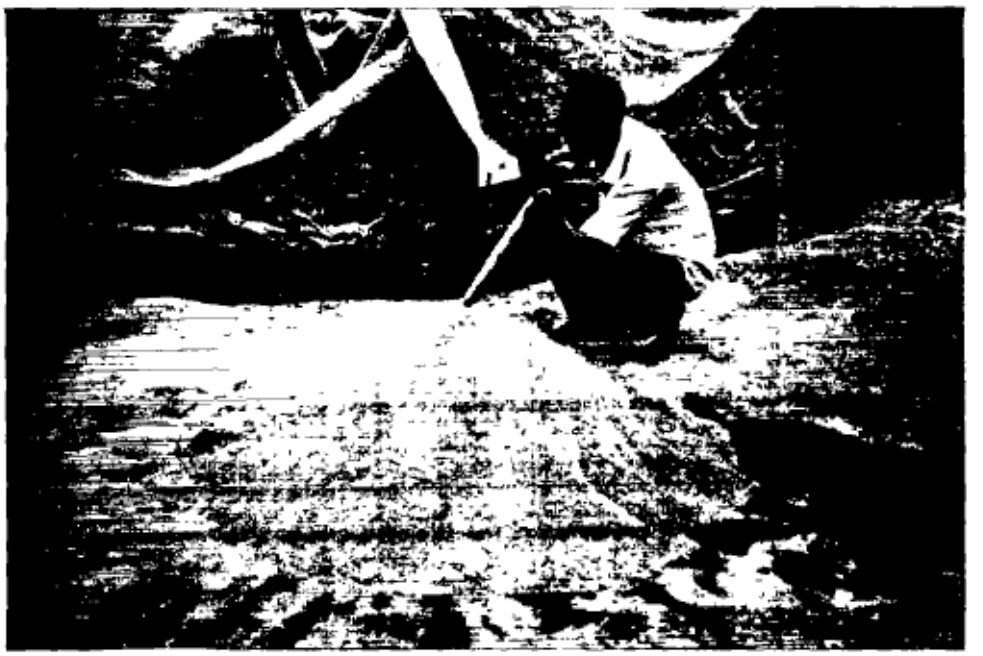
2) Mixing should take place on a clean slab and not on the ground as shown here.

The procedure for mixing is:

a) Off-load the sand in the two wheelbarrows into a heap on the mixing slab.

b) Open the bag of cement and pour it over the heap of sand.

c) Turn the sand and cement into another heap next to the first heap.



3) Turn over the heaps 4 times without water.

The colour of the heaps must be uniform; without any portions being either too sandy or too grey with cement.

4) Scoop the heap of the dry mixture into a volcano-shaped cove.

Add the 2 3/4 buckets of water into that cove slowly, so that the mixture has time to soak up as much water as possible.

5) When water starts to overflow the rim of the heap, close the overflow with dry mixture from the floor.

6) Continue adding dry mixture to the top of the rim, until all the water poured into the heap is absorbed.

7) Then, quickly overturn the wet mixture into another heap while mixing it with shovels.

Turn the wet mixture over a second time.

8) After the second turning, the mortar is ready to be used.

The mortar must be used within 1 hour or it will lose its strength and be useless for building a water tank.

Keep the heap of mixed mortar under shade and overturn it now and then to keep it from setting.

Do not add water to the mixed mortar because that will spoil its strength.

ANNEX 2

Mixing NIL for Water-proofing.

Water-proofing cement is not used for building these tanks because:

- Water-proofing cement is expensive and difficult to purchase in rural areas, and
- Water-proofing cement gives the artisans a false feeling of being able to cover up a poor mixture of mortar.

Instead of using Water-proofing cement, the traditional method of using cement-slurry, called NIL, is advocated.

1) The process of making NIL is quite simple:

a) Fill a bucket halfway with water.

b) Pour in dry cement in small amounts until a consistency equal to that of uji (millet porridge) is achieved.

Do not mix more NIL that can be used in 1/2 hour.

2) Apply this NIL mixture with a tin can and a square steel trowel to walls and floors that have been plastered that very same day.

ANNEX 3

Mixing concrete 1:3:4 for foundations of water tanks.

Concrete for a foundation for a water tank is mixed in 2 portions:

- half of the required volume of concrete which is poured into the foundation before the reinforcement is placed in the foundation, and

- the other half of the required volume of concrete which is poured when the reinforcement has been placed. By doing so, the reinforcement will be placed right in the middle of the foundation.

Building the foundation for a 46 cubic metre water tank:

1) Off-load 12 wheelbarrows, loaded to the level of their rim, with coarse and clean sand onto the mixing slab.

2) Pour 6 bags of cement over the heap of sand.

3) Mix and turn-over the sand and cement 4 times, or more, until it is uniform in colour.

4) Off-load 16 wheelbarrows of ballast over the heap and level it evenly.

5) Turn over the sand/cement with the ballast whilst water is added.

6) When the mixture is uniform, it is ready to be poured into the excavation for the foundation.

The water required for this volume of mixture is 450 litres which is equal to 30 buckets of water.

The work on a foundation for a water tank has to be completed in 1 day.

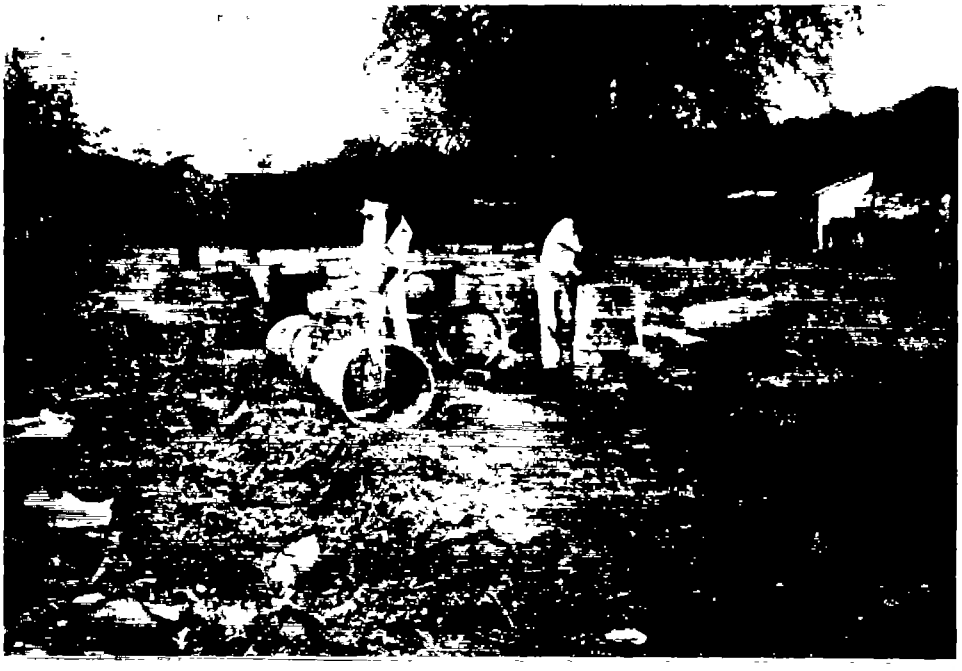
ANNEX 4

Form-work for the Dome.

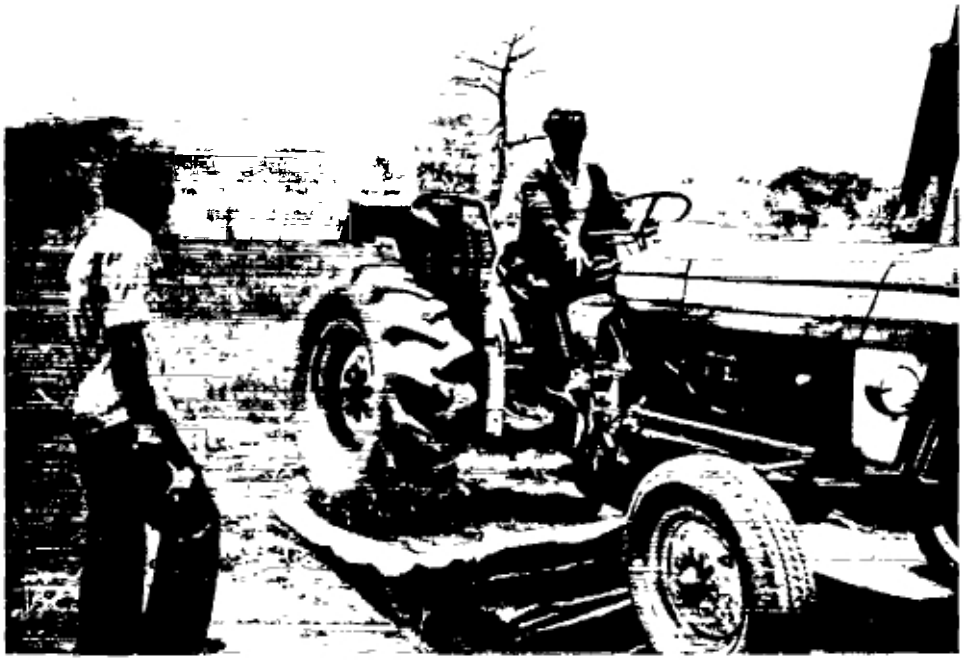
A set of form-work for the dome can be used for building more than 50 water tanks before it is worn out.

The cost of a dome made of ferro-cement and a set of form-work for building it, is cheaper, stronger and longer-lasting than any other forms of roofing a water tank.

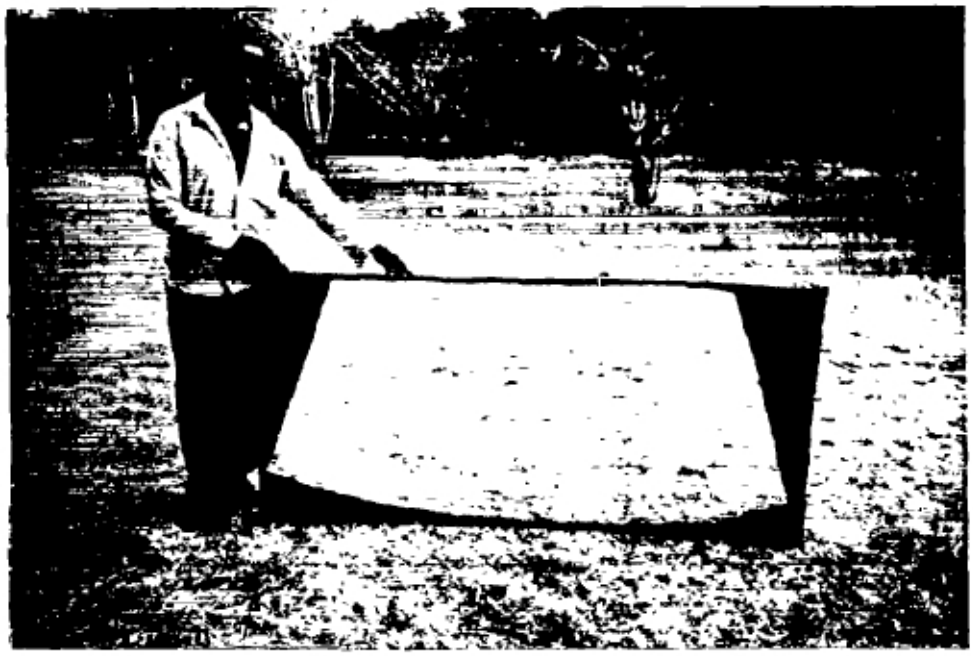
A dome over a water tank eliminates evaporation losses almost entirely, and it keeps the tank's water clean and free of insects, etc.



1) Cut open 29 old oildrums and flatten them out to sheets with hammers.



2) If available, the rear wheels of a tractor or a lorry can flatten the sheets nicely.



3) Mark one side of a sheet with the inside curve of the rim of the water tank. Mark the ends of that sheet with the centre-lines of the tank.

Cut the sheet along the lines with a hammer and chisel.

4) After having confirmed that this sheet has the correct shape, it is used for marking the other 28 sheets which are to be cut into the same shape.

The king-post is made from 2 pieces of 4" x 2" timbers, each 240 cm long, which are nailed together.

A karai (steel basin) is nailed as a platform onto the top end of the king-post. The 12 templates will rest on that platform.

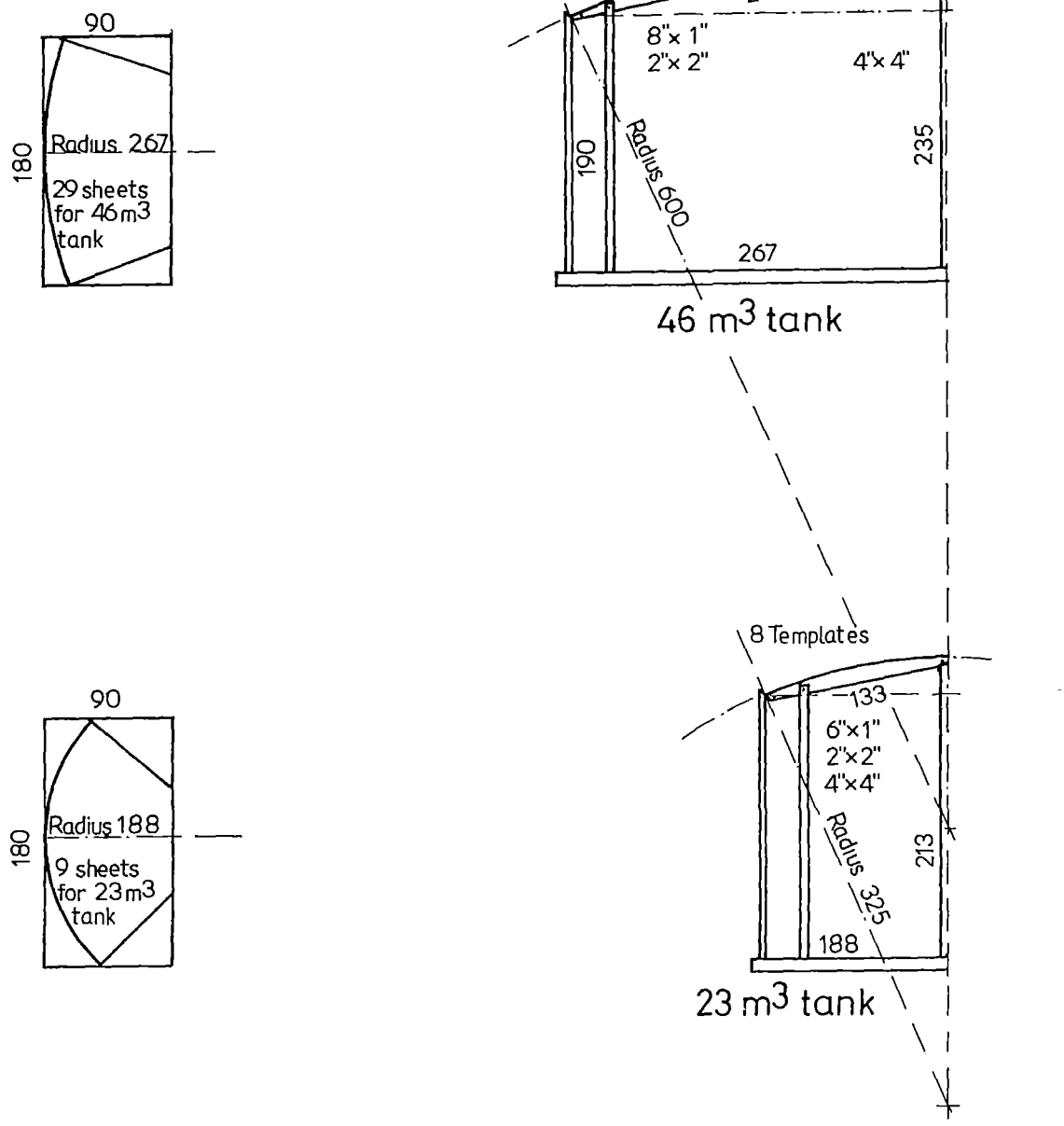
5) The 12 templates are made from 12 pieces of 8" x 1" timbers, each being 270 cm. long.

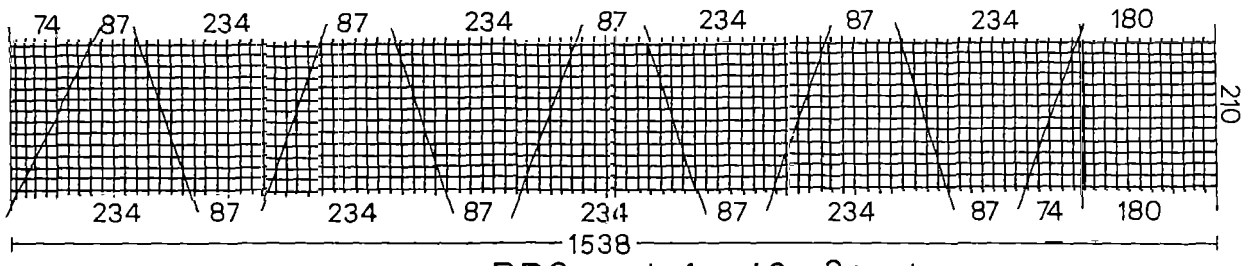
The curved upper side of the templates is marked with a pencil in a string with a radius of 600 cm.

A 5 mm. hole is drilled into each end of the templates. A leg, 190 cm. long, is made from 2"x 2" timber which is then bolted onto the template.

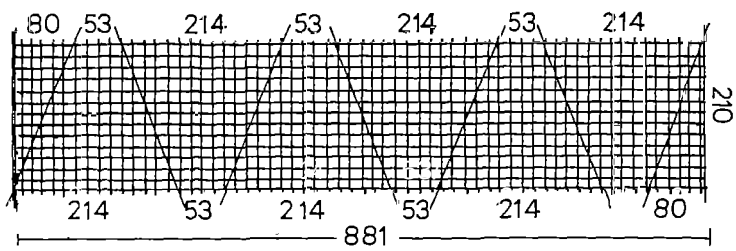
ANNEX 5

DESIGN OF FORM-WORK FOR DOME AND CUTTING BRC MESH





BRCmesh for 46 m3 tank



BRC mesh for 23 m3 tank

ANNEX 6

STANDARD TOOLS AND EQUIPMENT FOR CONTRACTORS

Item	A-Contractor	B-Contractor	B-Contractor
Tools			
Tape measure, 30 metres	1		
Tape measure, 2 metres	1	1	1
Mason trowel	1	1	1
Mason hammer	1	1	1
Mason chisel	1	1	1
Mason square	1	1	1
Steel trowel, square	1	1	1
Wooden float, curved	1	1	1
Straight edge, 6 ft	1	1	1
Spirit level, 3 ft	1	1	1
Builders line, nylon	1	1	1
Sisal brush	1	1	1
Lockable wooden tools box	1	1	1
Equipment			
Sieve for sand, 3 ft x 5 ft.	1		
Oil drums for storing water.	4		
Large empty sugar sacks	35		
Templates for form-work	12		
Kingpost for form-work	1		
Flattened oil drums	29		
Sisal poles, 7 ft. to 9 ft.	25		
Double ladder, 8 ft.	1		
Wheelbarrows	2		
Buckets	2		
Shovels	4		
Karais	6		
Pick-axes	2		
Jembes	2		
Pangas	2		
Tents	1	1	1
Stationeries			
Photo-manual	1	1	1
Note books	1	1	1
Muster roll	1		
Duplicate book	1		

ANNEX 7

AGREEMENT FORM BETWEEN SCHOOL AND PROGRAMME.

This is an agreement for the construction/repair of .... water tank(s) of ....cubic metre volume, and of .....metres of V/U shaped gutters with splash-guard, and for ..... double VIP-latrine(s) between this programme and .....school which has .....pupils and is situated in .....location.

The programme will provide:

1) All purchased materials (cement, reinforcement, gutters, etc.) and delivery of these items to the school store.
2) Skilled labour, consisting of 3 trained contractors and 2 contractors in training.
3) Supervision of construction.
4) A tractor and trailer to assist the school in transporting sand and stones for the tank(s) and latrine(s).
5) Provide following tools on **LOAN**: 1 shovel, 1 pick-axe, 1 iron rod and 5 mason hammers. The tools have to be returned to the programme upon completion of the work.

The school will provide free:

1) Unskilled labour (parents) from 8.00 a.m. to 5.00 pm. every working day for the following works:

a) Complete digging of pits for latrines before .../.....

b) Loading .... loads of coarse riversand and .... loads of stones from .....day .../.. to ....day .../..

c) Complete breaking stones into ballast before .../.....

d) Supply daily.... drums of water during construction works.
e) Provide daily 10 able-bodied people for construction works.
f) Cure the tank(s) with water daily for 4 weeks.
g) Provide a trust-worthy storekeeper and a lockable store.
h) Provide a safe campsite for the contractors' tents.
i) Provide food and accommodation for the tractor driver.

I, ...the Headmaster/Headmistress, hereby agree that in case I cannot deliver the requirements stated above on time, the programme is free to leave this school with their tools and materials, and to cancel any further assistance to the school.

I also declare that I will be responsible for carrying out maintenance of the tank(s), gutters and latrine(s) as explained in the leaflet I have received today. Failure to do so might result in cancellation of any further assistance to the school.

Date .../.....On this we agree:..... .....

Headmaster Programme Surveyor

ANNEX 8

CONTRACT BETWEEN CONTRACTOR AND PROGRAMME

This contract is drawn between this programme ..... and Mr.....ID No..... Contractor No..... as contractor to carry works under these terms and conditions:

1) To construct/repair of .... 46 cu.m. water tank with dome and .....metres of V/U gutters with splash-guard at ..... school in ..... location in ..... division.

2) **The contractor will supply** skilled labour for the construction work in accordance with the standard designs and instructions given during his training period with this programme.

3) The above contract is agreed for the total amount of Shs..... (in words.....) to complete work as required Payment will be made in 3 instalments as follows:

a) 15% of the agreed amount = Shs..... (.....) on transfer to the site.

b) 70% of the agreed amount = Shs..... (.....) on completion of the work.

c) 15% of the agreed amount = Shs_____(.....) on approval of the work after a rainy season. Shs_____ in total

4) The programme will provide:

a) Tools and equipment on loan basis, any shortfall will be deducted from payments to the contractor.
b) Transport for the contractor's team, tools and equipment.
c) Siting, design, bills of quantities and supervision.
d) Delivery of all materials to the site before the contractor's arrival.

5) The school will supply:

a) Unskilled labour, at least 10 able-bodied persons, every day.
b) Water for construction works and curing.

CLAUSE I

In the case where the contractor does not follow the designs and instructions given, the contractor will be liable for penalty, determined by this programme, and the sum deducted from payment.

CLAUSE II

In case this programme does not provide the items listed under 4),the contractor will be paid compensation for working days lost

CLAUSE III

This programme may terminate this contract in writing, for any unsatisfactory work or in accordance to any of the above clauses.

The above terms and conditions have been understood and agreed upon, This date ../.....199..

Signed..... Signed.....
Programme Officer Contractor No.....

ANNEX 9

MAINTENANCE OF TANKS AND GUTTERS

As part of the agreement between this programme and each school, it is the Headmaster or Headmistress's responsibility to ensure that maintenance of the tanks and gutters is carried out after these instructions:

Gutters:
The roof and the gutters supply water to the tank(s) and must be clean in order supply water suitable for drinking, therefore:

1) Prune any trees over-hanging roofs and gutters so that they do not drop their leaves on the roofs and in the gutters.

2) The first rainshower in a season carries dust, dirt and leaves which pollutes the tank. Divert this dirty away from the tank by lifting the down-pipe out of its seat in the tank before the onset of a rainy season, and lift it back in its seat when the rainwater is clean.

Tanks:
A water tank can crack if a tree grows near a tank or if water is allowed to settle on the surface near a water tank, therefore:

3) Cut any tree down which grows within 8 metres from a tank.

4) Backfill the apron of soil around the tank before any rainy season, so that water will drain away from the tank.

5) Clean the trench draining water away from the tap station before any rainy season and ensure that water can run freely to the waste-pit in which sugar canes should be planted.

6) If the watertap does not function well, then have it repaired in good time before a rainy season.

7) If the tank leaks, then report it in writing to the programme immediately, so that the contractor can repair or seal it before he gets his final payment for building the tank.

8) Always keep the man-hole closed and locked so that animals and children cannot enter the tank.

9) If the tank runs dry for water, then use this opportunity to clean the interior of the tank with a brush.

WATER SUPPLY SYSTEMS

based on

RAIN WATER HARVESTING

RELIABLE WATER SUPPLY

Rain Water Harvesting can provide reliable water supply systems in all climatic regions, except in deserts with an annual rainfall below 100 millimetres
The techniques of rain water harvesting have proved viable in most climatic regions of the world over several thousands of years The oldest known rain water harvesting systems functioned for two thousand years in the Negev Desert of Israel.

FEASIBLE SOLUTION

In many regions of the world rain water harvesting is the only feasible solution to provide water supplies due to the problems of

- saline ground water,
- polluted rivers or lakes,
- high cost of drilling bore-holes and pumping ground-water up to the surface, and of pumping water from surface reservoirs through pipelines, and
- lack of qualified manpower for maintenance and management of mechanical water supplies, and foreign exchange to purchase spare-parts.

SOUND ENVIRONMENTAL ASPECTS

Rain water harvesting is environmentaly sound because it collects and stores rainfalls where they precipitate, thereby reducing soil erosion caused by rain storms Rainwater harvesting goes hand in hand with Soil and Water Conservation

RECHARGE OF GROUND WATER

Some types of structures for rain water harvesting also act as recharge of ground water, which benefits recharge of shallow wells and bore holes.

SUSTAINABLE DEVELOPMENT

Rain water harvesting is ideal for sustainable development because it consists of low-technology inputs which require only local skills and locally available materials for construction and maintenance.

COST EFFICIENCY

Compared to more advanced types of water supplies, rain water harvesting systems are the most cost-efficient to construct and maintain.

INFORMATION ON ASAL CONSULTANTS LTD.

Legal status

ASAL Consultants Ltd. was incorporated as a Limited Company in Kenya in April 1990.

Objectives

The main purpose of ASAL Consultants Ltd. is to utilize the experience of seasoned advisers to assist development organisations and governmental departments in assisting the rural people of Africa in obtaining a higher standard of living.

Associations

ASAL Consultants Ltd. is associated with regional and international consultants with many years of experience in rural development

Main activities

Most of our expertise is, however, concentrated on self-help activities on water programmes based on Rain Water Harvesting, and Soil and Water Conservation.

Clients

Since ASAL Consultants Ltd. commenced operations in 1990, it has carried out assignments on:

- Appraisals,
- Reviews and Evaluations,
- Training,
- Production of Manuals,
- Site Surveys and Designs,
- Management

FOR·

- Danida in Kenya and Tanzania,
- SIDA in Kenya and Tanzania,
- Danchurchaid and LWF in Zimbabwe and Zambia,
- IRCSA in Kenya and Taiwan,
- Danish Red Cross/Kruger Consult A/S in Sudan,
- BTC in Botswana,
- MOA, KIDP and UNICEF in Kitui, Kenya

ASAL Consultants Ltd
P.O Box 867, Kitui, Kenya.
Telephone
0141•22706 & 22123
Fax
254•0141•22571
254•2•740524

TYPES OF STRUCTURES FOR RAIN WATER HARVESTING

Water for households and livestock:

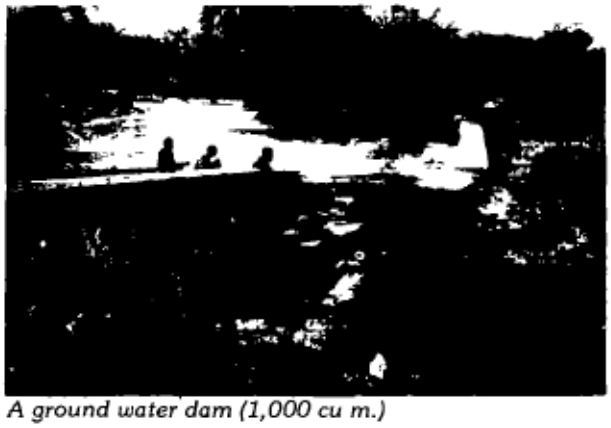
- Water Tanks and Jars
- Earth Dams and Pans.
- Ground-water Dams (sub-surface dams and sand-storage dams.)
- Rock Catchment Dams
- Shallow Wells and shallow hand-drilled boreholes.
- Spring Protections with gravity-fed pipelines.

A water tank (46 cu m)

A rock catchment dam (5,000 cu m)

Water for farming and forestry:

- Micro-catchments.
- Macro-catchments.
- Flood diversion (spate).
- Soil conservation



A ground water dam (1,000 cu m.)

A small earth dam (800 cu.m.)

A shallow well

Should your organization be interested in learning more about the benefits of using the services of ASAL Consultants Ltd., please do not hesitate to contact us.

We can give you a free quotation for a consultancy if you provide us with information on your objectives or on water-related problems.