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**Ministry of Works
and Development**

**Civil Engineering Directorate
Head Office**

**FERROCEMENT TANK
CONSTRUCTION FOR A
RAINWATER COLLECTION
SYSTEM**

Prepared by The Civil Engineering Directorate

New Zealand Ministry of Works and and Development

for the Ministry of Foreign Affairs

LO: 213.2 85 FE
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MINISTRY OF WORKS AND DEVELOPMENT

CIVIL ENGINEERING DIRECTORATE

HEAD OFFICE

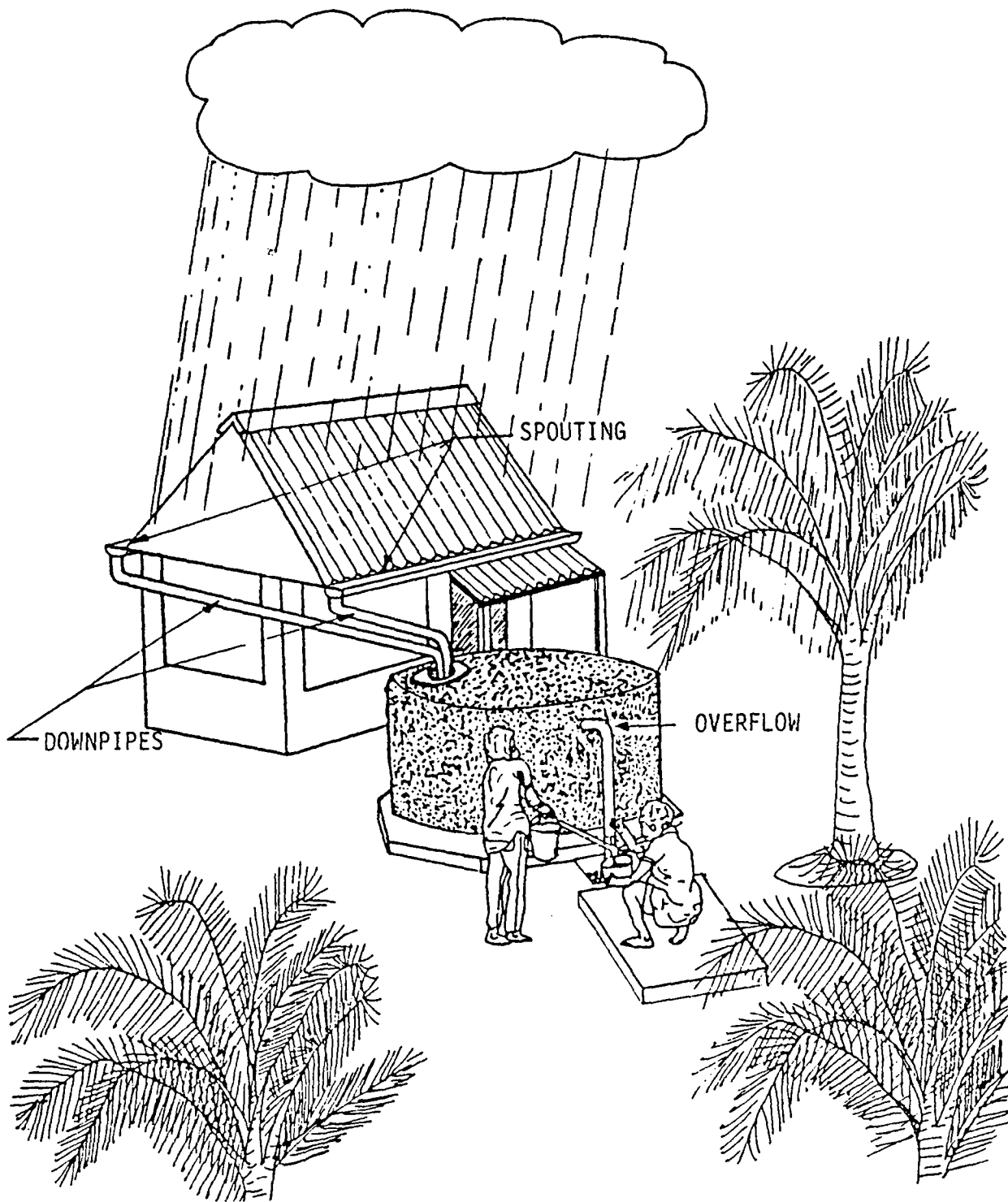
FERROCEMENT TANK CONSTRUCTION

FOR A RAINWATER COLLECTION SYSTEM

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Prepared by the Public Health Section of
the Civil Engineering Directorate
Ministry of Works and Development
New Zealand



CONTENTS

	<u>Page</u>
1. INTRODUCTION (WHAT THIS BOOK IS FOR)	1
2. DEFINITIONS (THE MEANING OF TECHNICAL WORKS USED)	2
3. MATERIALS YOU WILL NEED	5
4. TOOLS YOU WILL NEED	9
5. THE STEPS YOU MUST FOLLOW TO MAKE THE TANK	11
6. DETAILS OF HOW TO MAKE THE TANK	12
7. HOW TO PREPARE AND FIT THE WATER INLET	34
8. HOW TO FIT THE OUTLET TAP	35
9. HOW TO FIT THE OVERFLOW PIPE	35
10. HOW TO FILL THE TANK	35
11. WHAT THE FINISHED TANK WILL LOOK LIKE	36

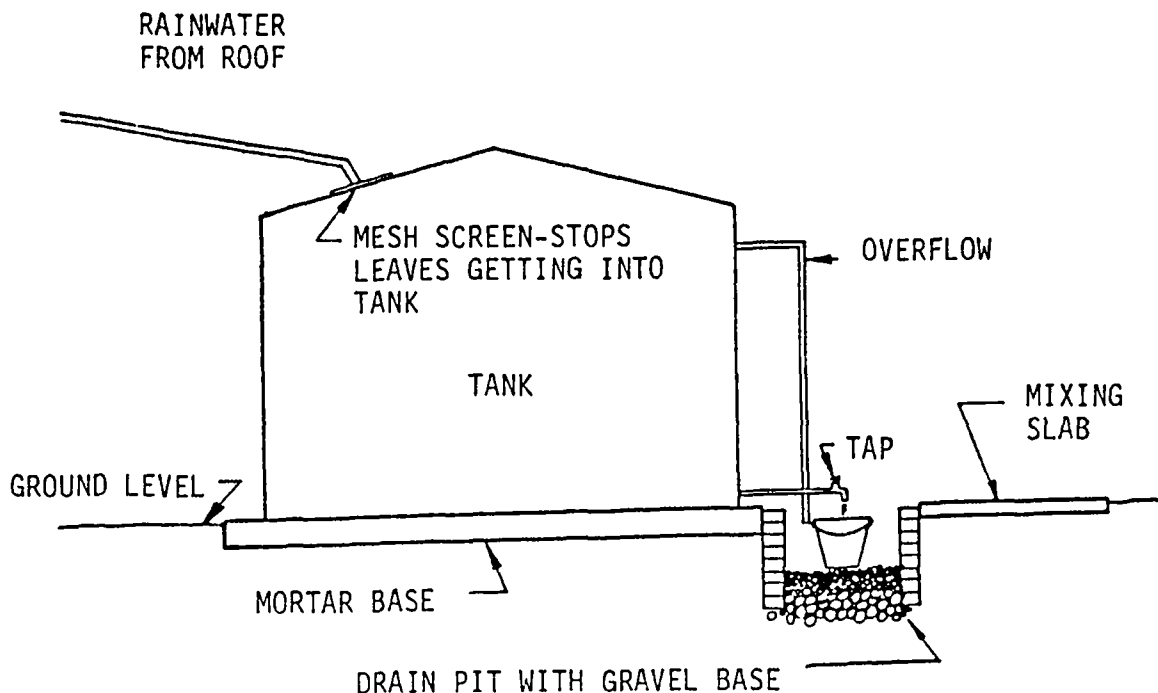
FERROCEMENT TANK CONSTRUCTION

1. INTRODUCTION

This is a guide for a team of three men to build a ferrocement tank for the village water supply using timber, bush stakes, vines, leaves and coral or volcanic sand (these should all be available in the Pacific Islands) and imported cement, wire and chicken netting.

It explains in words and pictures the materials required, quality control for the sand supply, how to prepare the mortar, the tools needed and how to build the tanks.

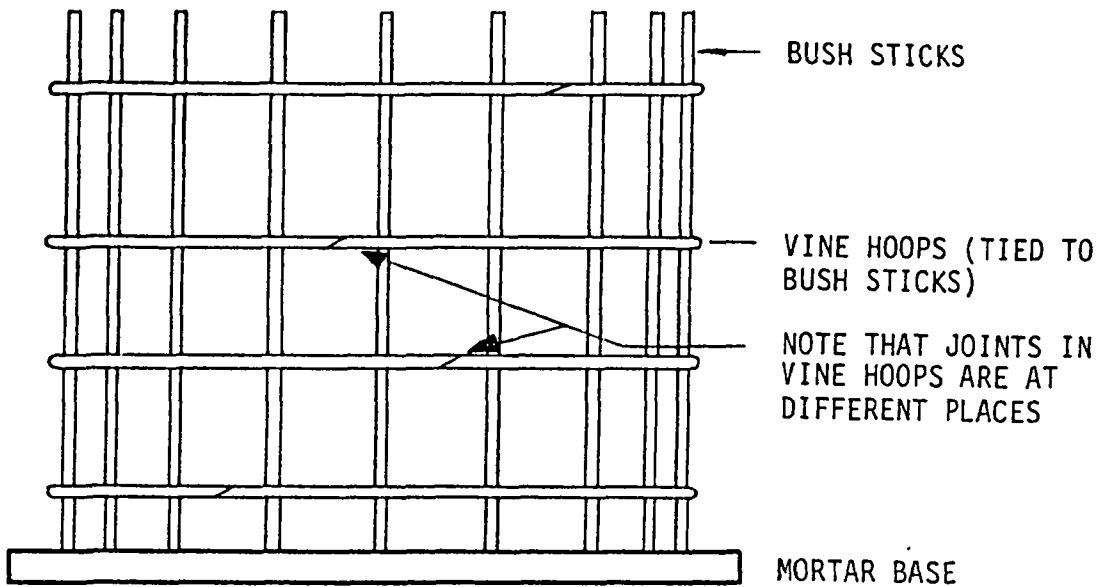
There are plenty of local materials available but imported cement, galvanised wire and galvanised chicken netting must be carried into the villages. If there is no "good sand" at a village, it must be brought from another place. Each tank will hold 13,640 litres. The tanks are 3.2 metres diameter and the walls are 1.73 metres high with a conical or sloping roof. The tank is shown in the picture below.



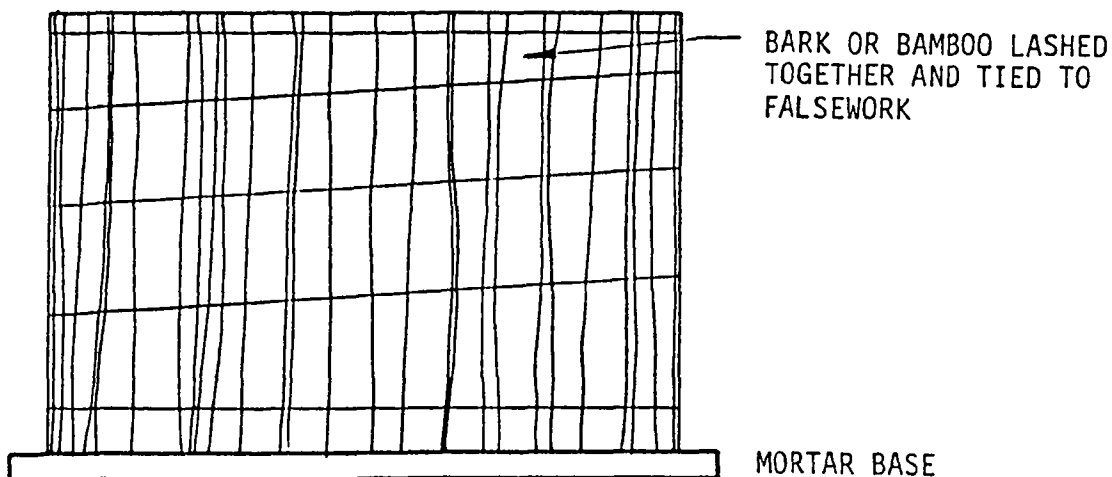
2. DEFINITIONS

Technical words used in this booklet:

Falsework : Is a framework of bush sticks and vine hoops to provide the tank shape and to also support a flattened bark or split bamboo formwork.

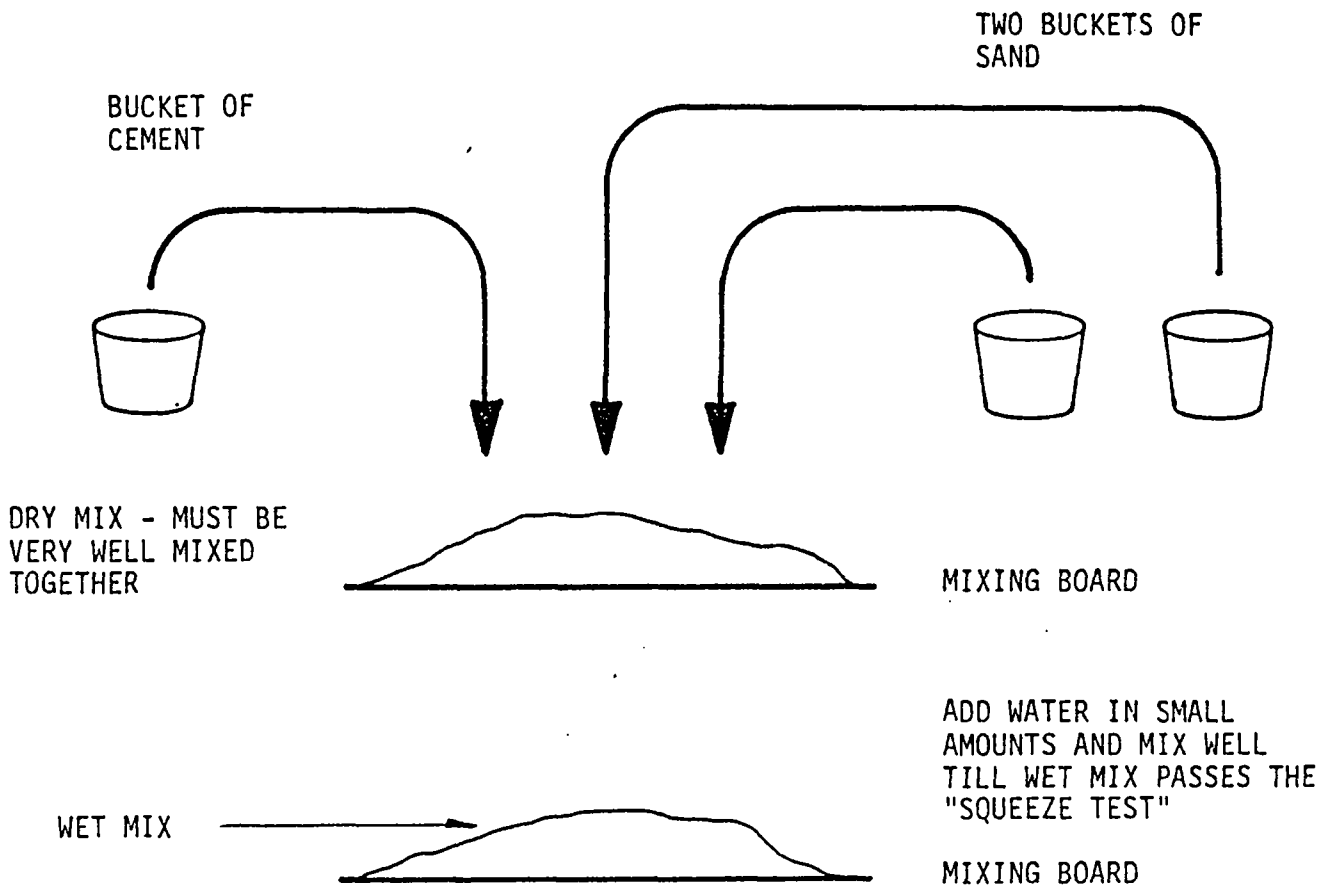


Formwork : Flattened bark or split bamboo lashed together to provide a shape and a barrier to place mortar against.



Galvanised : A protective coating often given to steel material to stop it rusting. Galvanised steel has a dull metallic look to it.

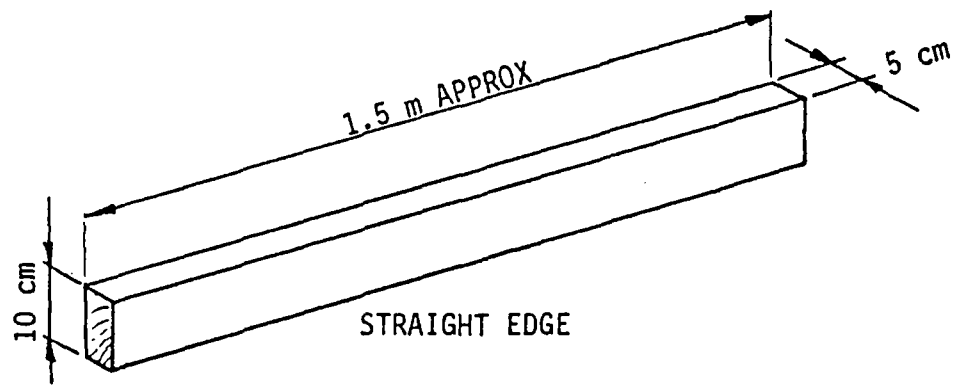
Mortar : Is a mixture of one part cement and two parts sand mixed together with some water.



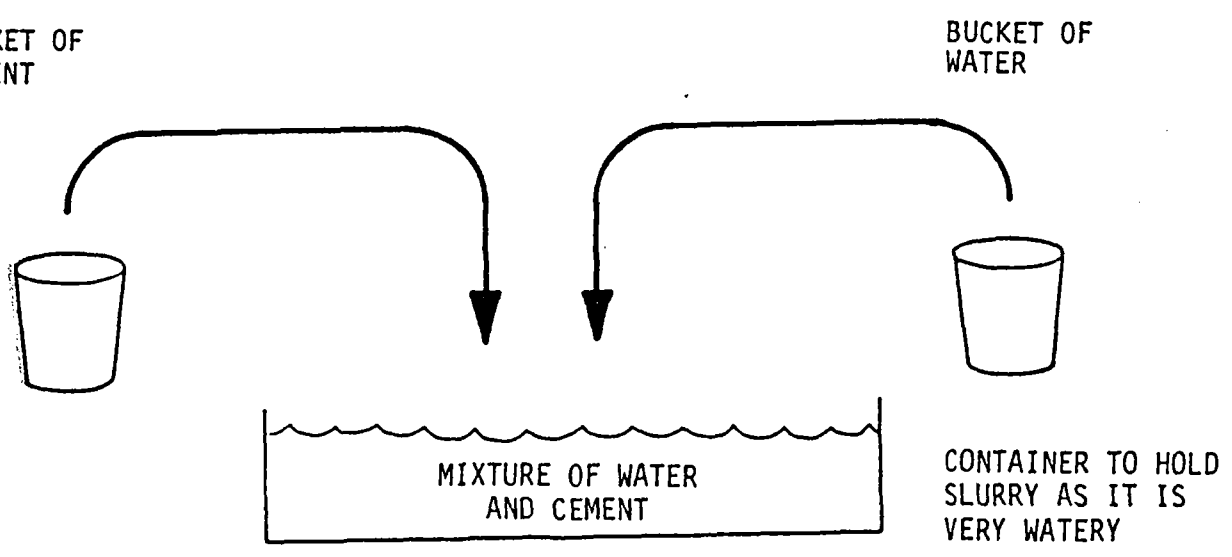
NOTE:

1. The "squeeze test" is a test which ensures that the correct amount of water has been added. A handful of wet mix is gently squeezed in the hand. The mix is too wet if it wets the hand and is too dry if it crumbles.
2. Each batch of mixed mortar must be used within an hour.

Screeding Board : A straight board with a clean straight edge to be used for spreading out the mortar to obtain an even thickness and finish.



Slurry : Is a mixture of one part cement and one part water.

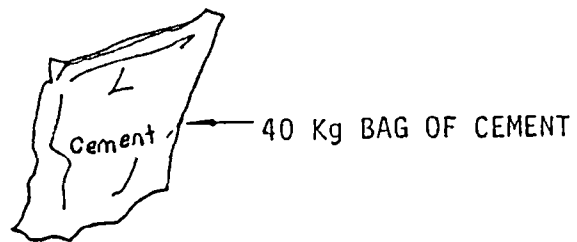


3. MATERIALS NEEDED

The materials needed are cement, sand, water, chicken netting, galvanised wire and local timber, vines, bark, leaves and lashings.

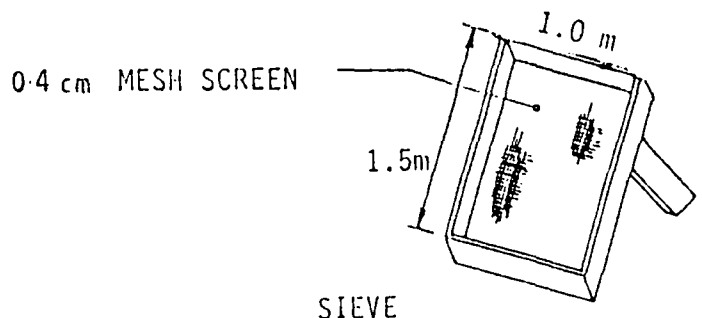
3.1 Cement

This comes from New Zealand, Australia, Japan or the United Kingdom in bags which are different sizes. It is best to use the smaller 40 kilogram bags because they are easier to carry. You will need 42 40 kg bags.



3.2 Sand

The sand is the most important of all materials. It is also the material which is most variable. Sand can be taken from rivers or beaches. If the sand has a lot of silt and mud in it, it should not be used. Beach sands and some river sands are washed well and are clean. These sands should be used if at all possible, but beach sand should be washed in fresh water to remove the salt. All sand should be put through a 0.4 cm mesh screen or sieve, and only the material passing through should be used. You will need 2.5 cubic metres of sand.

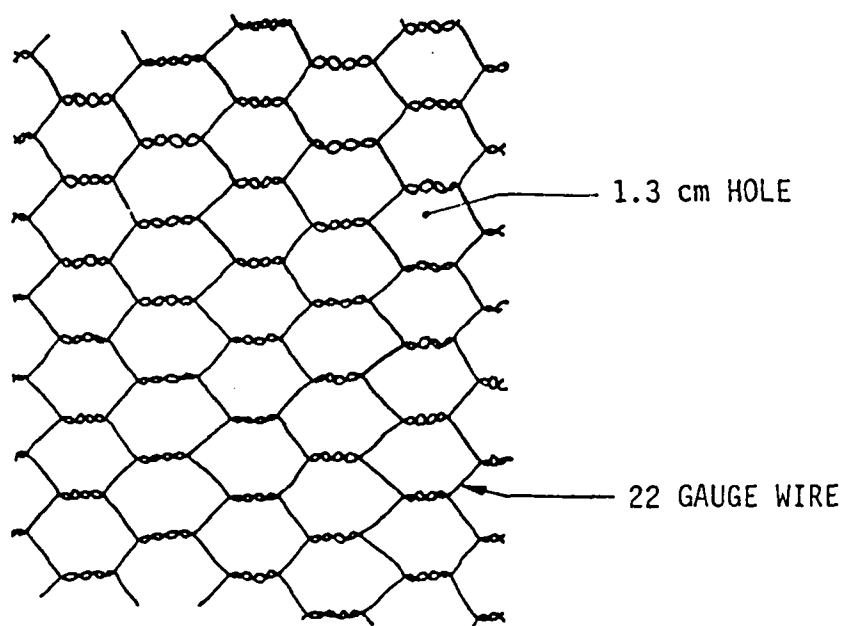


3.3 Water

A lot of water is needed. It is needed to make the mortar, to keep it moist while it is getting hard, and to clean shovels and tools after they have been used. The water to use should be clean, clear water that is suitable for drinking. It is best if it comes from a stream or collected when it rains. It should not be used if it is badly discoloured or if there is any rubbish such as weeds or leaves or small pieces of wood in it.

3.4 Netting

Galvanised chicken netting 1.3 cm hole size should be used. 90 cm wide rolls of netting should be used otherwise the tank walls will be too low. Usually the netting comes in 90 x 1.3 cm x 22 gauge x 50 metre long rolls. You will need 60 metres of netting.

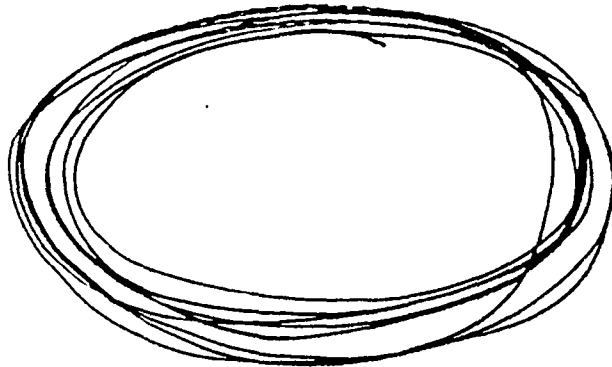


CHICKEN NETTING

3.5 Wire

No. 8 gauge plain galvanised wire in 25 kg coils must be used. It is to reinforce the floor and for hoop reinforcement in the walls of the tank. This wire is approximately 0.4 cm thick. You will need two 25 kg coils of wire.

No 8 GAUGE WIRE
(25 Kg COIL)

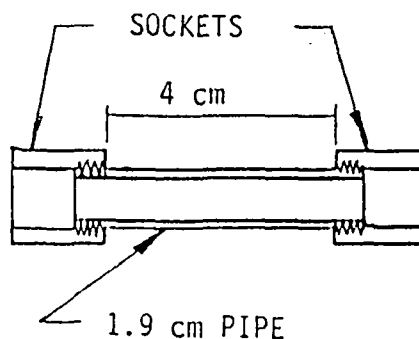


NOTE DIAMETER OF WIRE
APPROX 0.4cm

No. 20 or 22 gauge plain galvanised wire is useful for tying wire and chicken netting. This wire is approximately 0.1 cm thick. If available several bundles of pre-cut lengths should be obtained or failing this a piece of a coil about 100 metres long

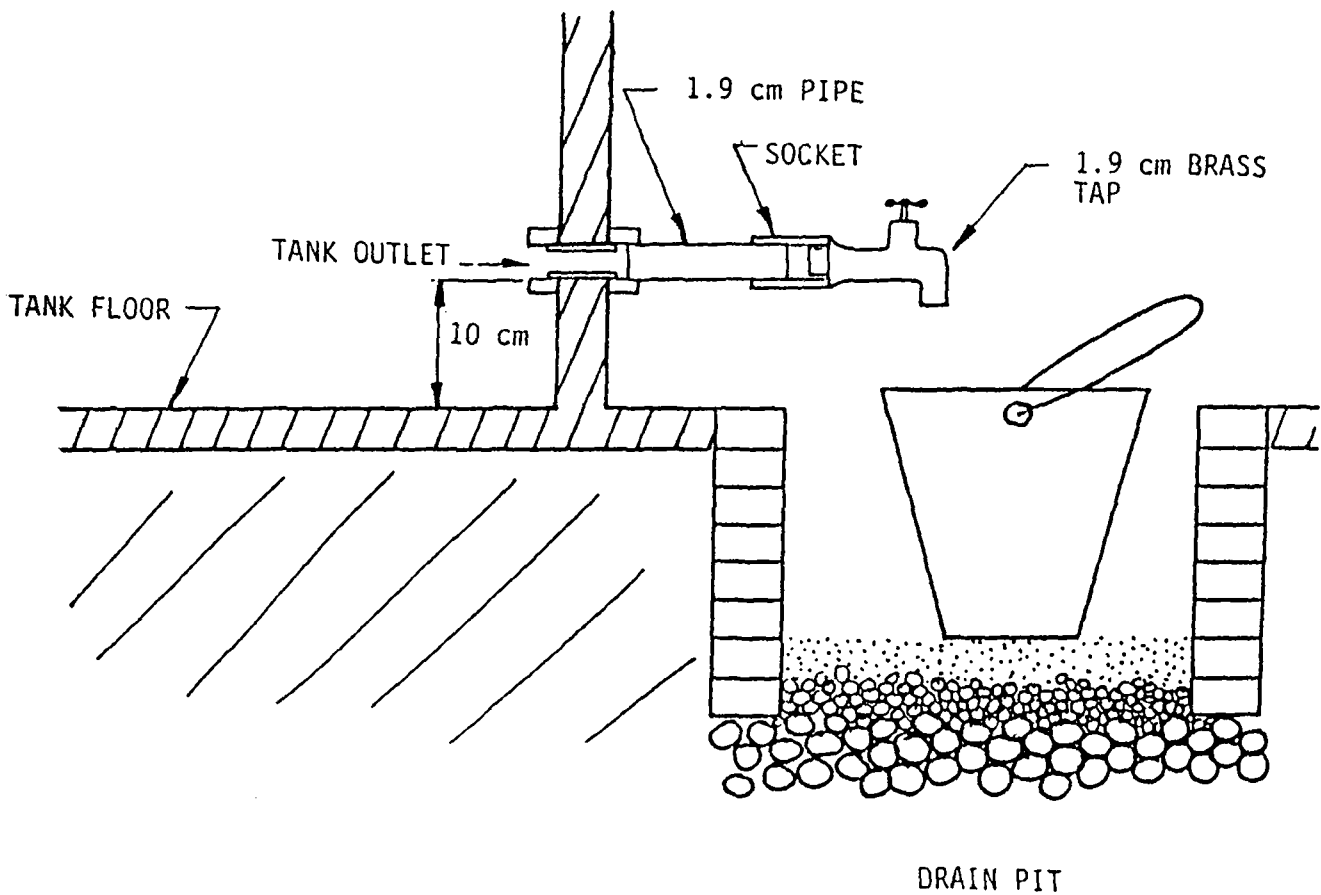
3.6 Outlet Fittings

A length (approximately 7 cm) of 1.9 cm galvanised iron pipe threaded at both ends is required for the outlet. A socket is fitted to each end and screwed on until there is 4 cm between the sockets. At that point a wrench should be needed to move the sockets.



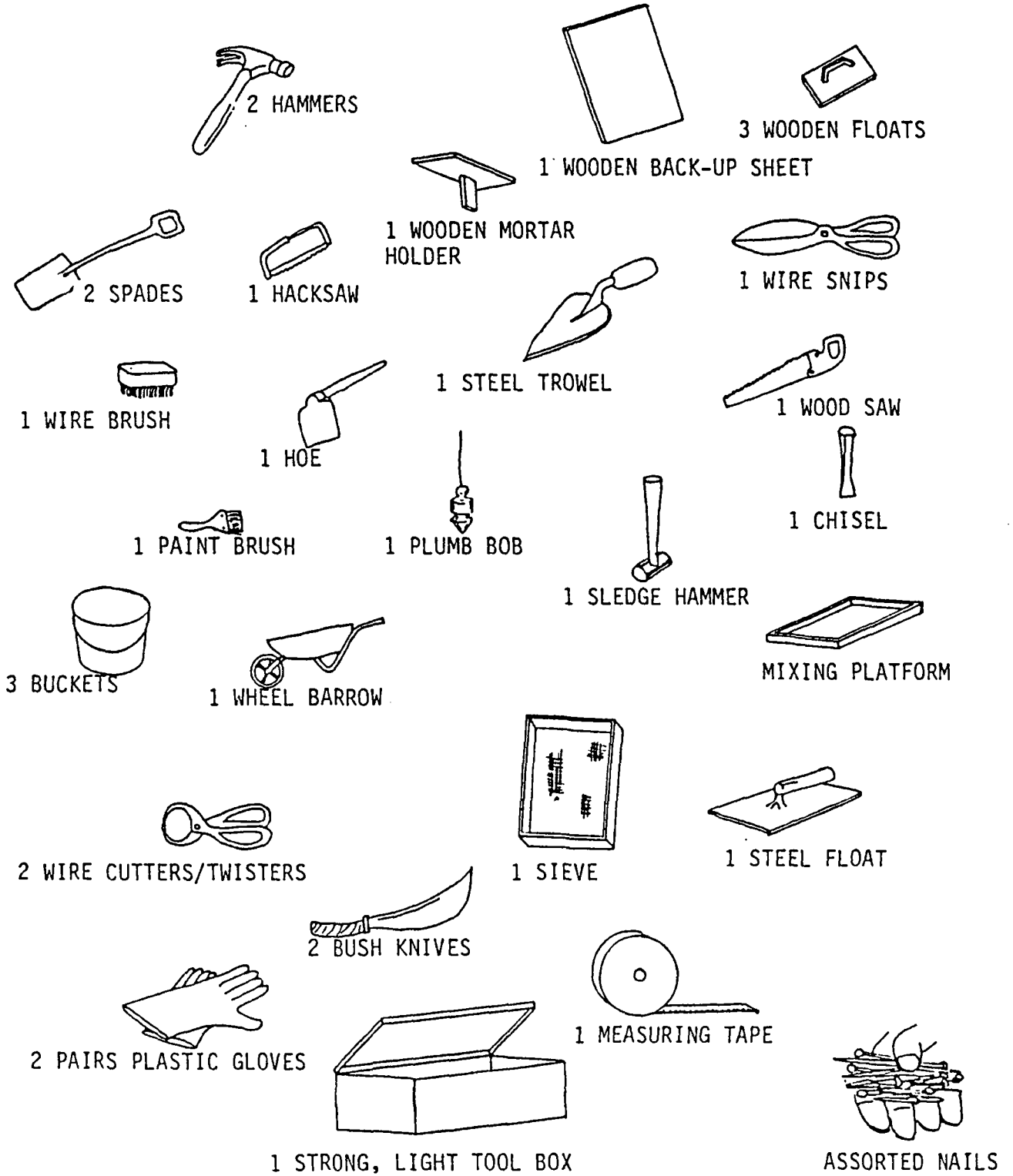
The connection for the tap is fitted to the tank 10 cm above the floor of the tank as shown in the picture below (see also section 6-11).

To position the tap over the drain pit a galvanised pipe extension threaded at both ends is used to fit the tap to the tank (see the picture below).



4. THE TOOLS

The tools needed by a team of three men are:



Checklist for Manpower and Materials

Manpower : Three men for about seven days.

Materials :

ITEM	AMOUNT
40 kg bags Portland Cement	42
Clean sand able to be sieved in 0.4 cm mesh sieve to give	2.5 m ³
Clean water approximately	3,000 litres
Netting 90 cm x 1.3 cm x 22 gauge	60 metres
Wire No. 8 gauge 25 kg coils	2
Wire No. 20 or 22 gauge	100 metres or equivalent in bundles
Pipe 1.9 cm diameter galvanised iron threaded for 3 cm both ends	7 cm
Pipe 1.9 cm diameter galvanised iron threaded for 3 cm both ends	Length to suit drain pit - approx 40 cm
Galvanised iron sockets to fit thread on 1.9 cm pipe	3
Brass tap to fit galvanised socket	1
Nails	1 kg of 7.5 and 10.0 cm long nails
Polythene sheet 2 m wide	8 metres
Timber frame for base slab 7.5 cm x 5.0 cm	30 metres
Sticks or bamboo poles)	See sections 6.2, 6.8 and 6.13
Vines)	
Bark or leaves)	
Spouting and downpipe	To suit size of catchment building and distance to tank

5. ORDER OF STEPS TO BE FOLLOWED IN TANK CONSTRUCTION

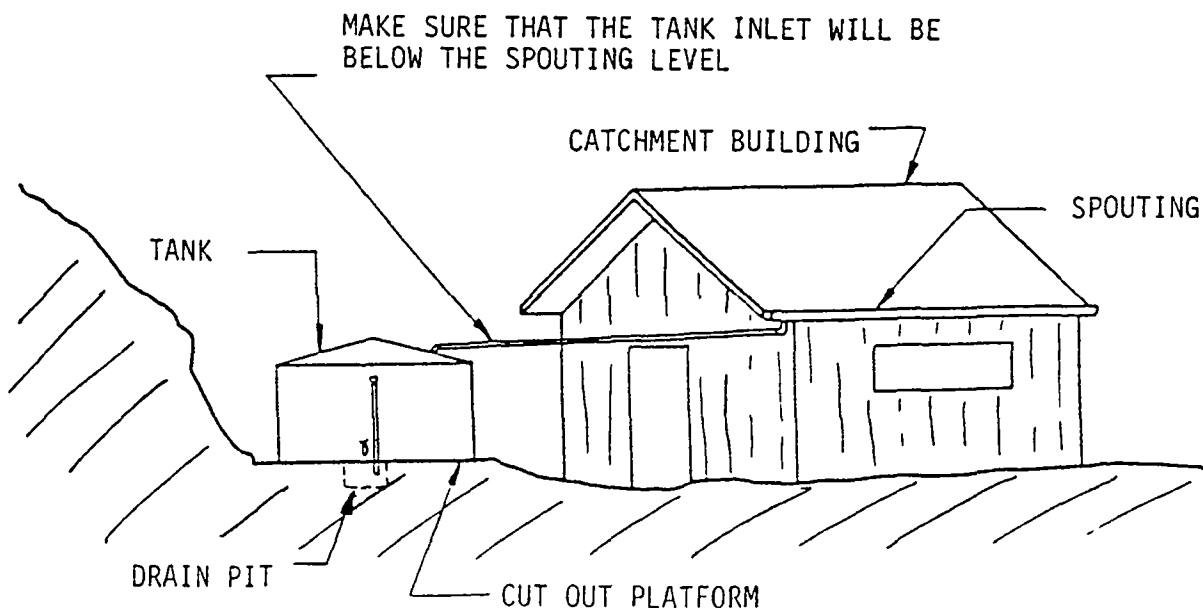
- (1) Prepare site.
- (2) Cover site with leaf roof.
- (3) Make mixing pad and pit and slab.
- (4) Prepare boxing for base.
- (5) Lay first layer of mortar on base.
- (6) Position starter wires and wire circles on base.
- (7) Lay second layer of mortar on base.
- (8) Remove boxing carefully from base.
- (9) Construct falsework and place on base.
- (10) Construct formwork.
- (11) Wrap No. 8 wire around formwork.
- (12) Wrap chicken netting around formwork.
- (13) Wrap more No. 8 wire around formwork.
- (14) Mark and position overflow and tap connection.
- (15) Place mortar around outside of tank.
- (16) Remove falsework-formwork from inside tank.
- (17) Place mortar around inside of tank.
- (18) Construct and position roof framework.
- (19) Cover roof framework and place mortar on roof.
- (20) Remove roof framework from inside tank.
- (21) Fit overflow pipe and tap.
- (22) Direct roof water to tank or fill up tank from other suitable source.

6. DETAILED METHOD OF CONSTRUCTION

6.1 Site Preparation

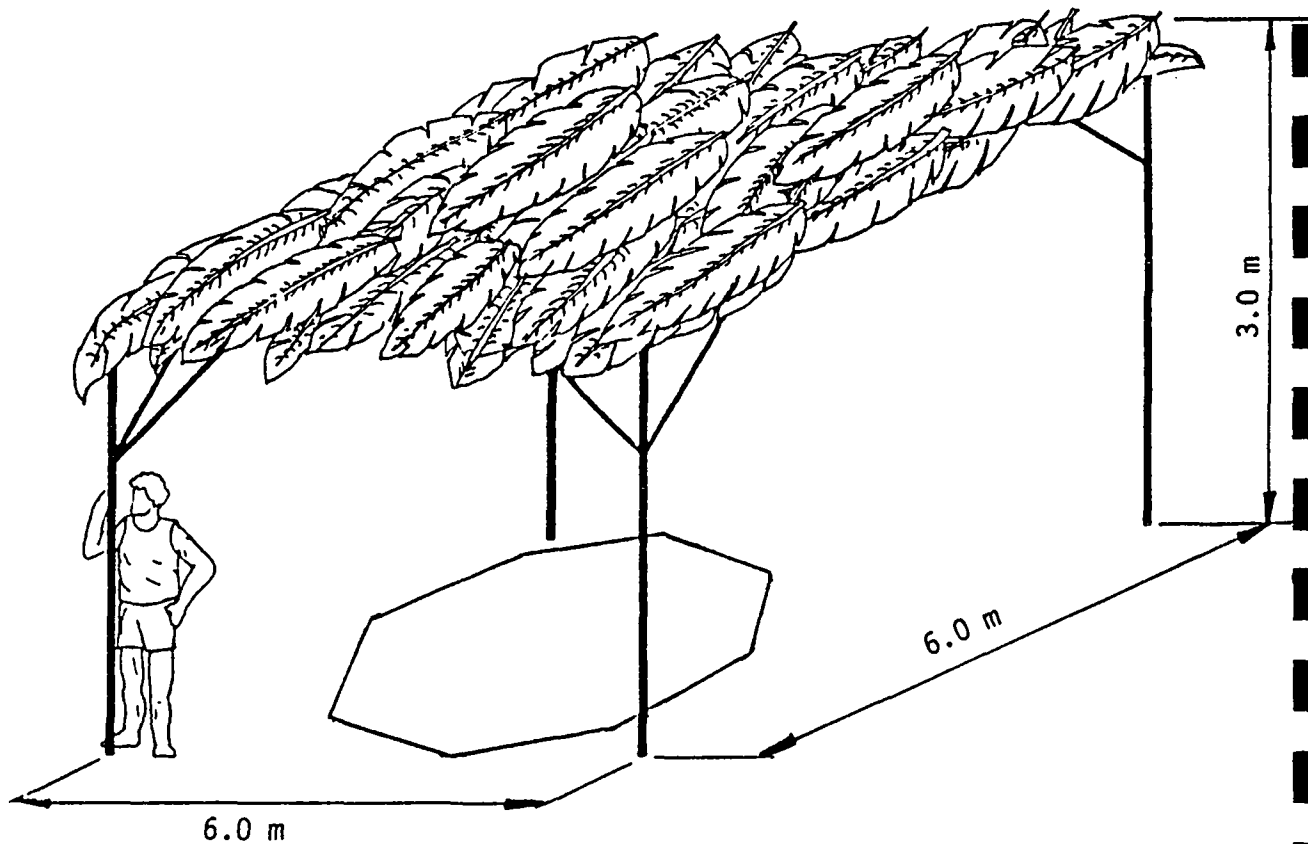
The site for the tank should be as high as possible above the ground so that the tap can be located as low down the well as possible. It should not be built so high that water cannot be piped into the tank from an existing roof beside the tank. Allow at least a 1 cm fall for every metre length of the pipe from the roof to the tank. This will help the water to flow into the tank.

The ground can be prepared either by cutting out a platform from a hillside slope, or by building the tank on the existing ground beside the catchment building provided it is firm, well compacted material that will not settle under the load of the filled tank.



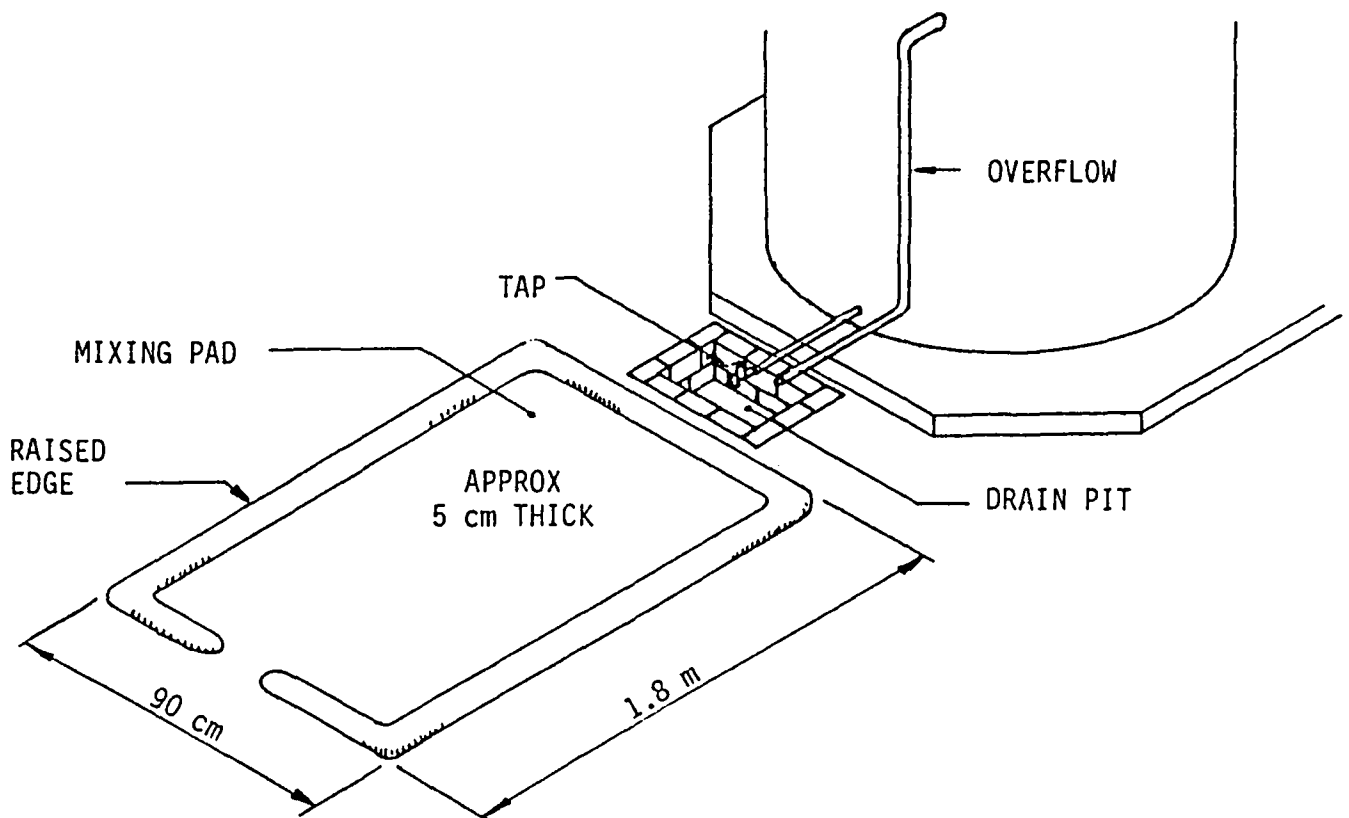
6.2 The Leaf Roof

Before any work is started on the tank a leaf roof should be built over the site for the tank. This roof will shade the tank from the hot sun and stop the mortar from cracking as it dries.



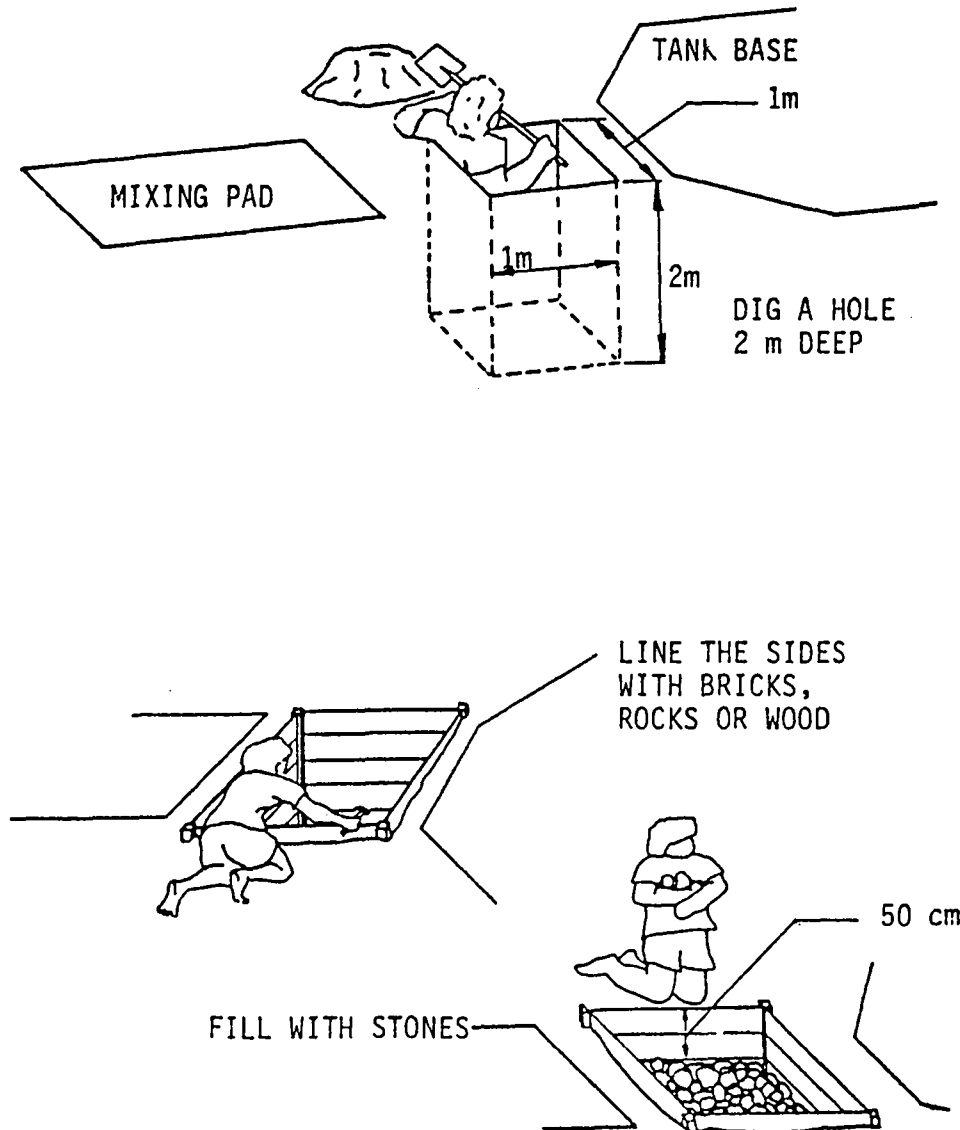
6.3 The Mixing Pad

This is made and located in front of the tap and drain pit as illustrated below. It is made using mortar mix of two parts of sand and one part of cement. This mixing pad has two uses, first it is a mixing pad for mortar and later, when the tank is finished it can be used as a clean hygienic path or entrance to the tap and drain pit. It will stop the area near the tank becoming muddy and messy.



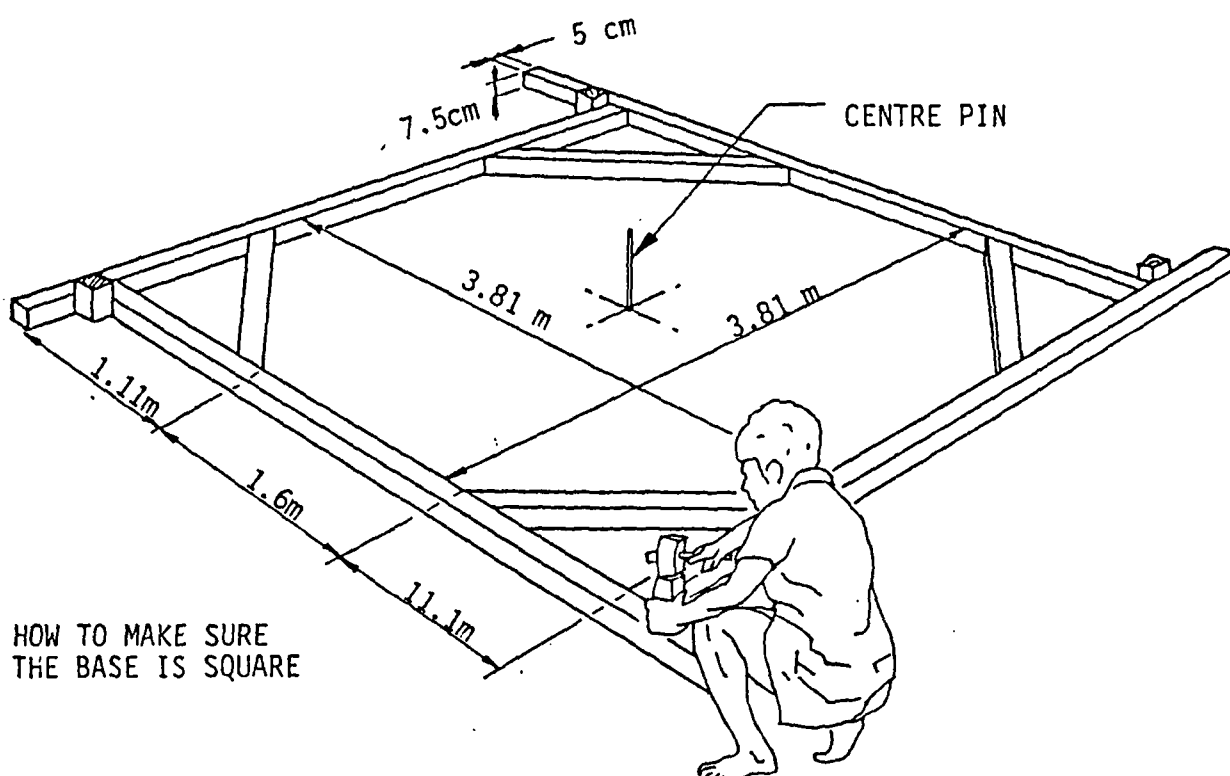
6.4 The Drain Pit

If the ground does not soak up water quickly, a hole should be dug between the mixing pad and the tank. This hole should be approximately 1 metre square and 2 metres deep. The sides of the hole should be lined with brick or wood to stop them falling in. The hole should then be filled in with rocks until it is 50 cm below ground level. A thin layer of sand may be placed on top of the rocks to give a smooth surface. This drain pit is to allow spilt water to drain away without making a mess, see the picture below. If the ground is coral or sand then the water will drain away quickly and you will only need to dig a hole deep enough to get a bucket under the tap.



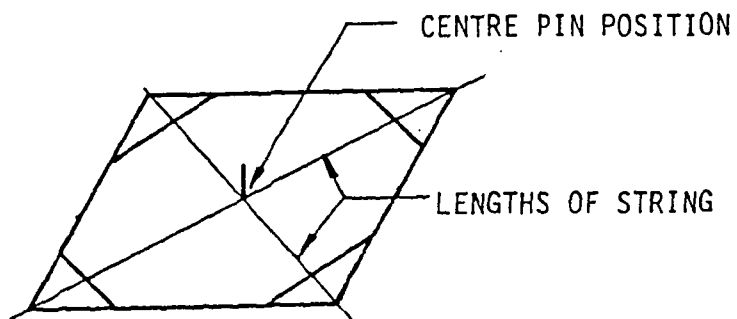
6.5 Making the Base

The timber frame for the base is made as shown in the picture below. A pin is driven into the ground to mark the centre of the tank.



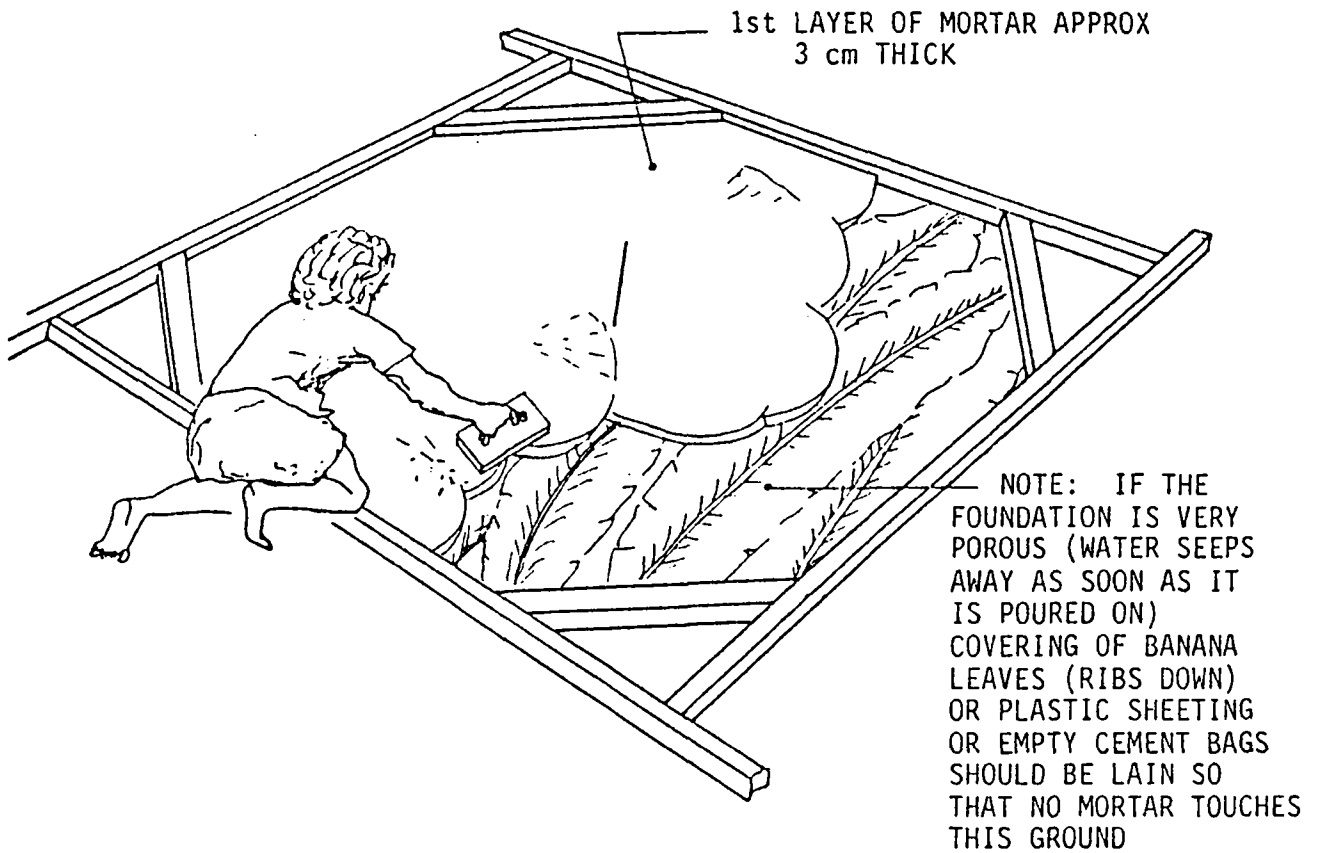
HOW TO MAKE SURE
THE BASE IS SQUARE

NOTE: TO FIND THE CENTRE (CENTRE PIN POSITION) TIE TWO LENGTHS OF STRING
ACROSS OPPOSITE CORNERS



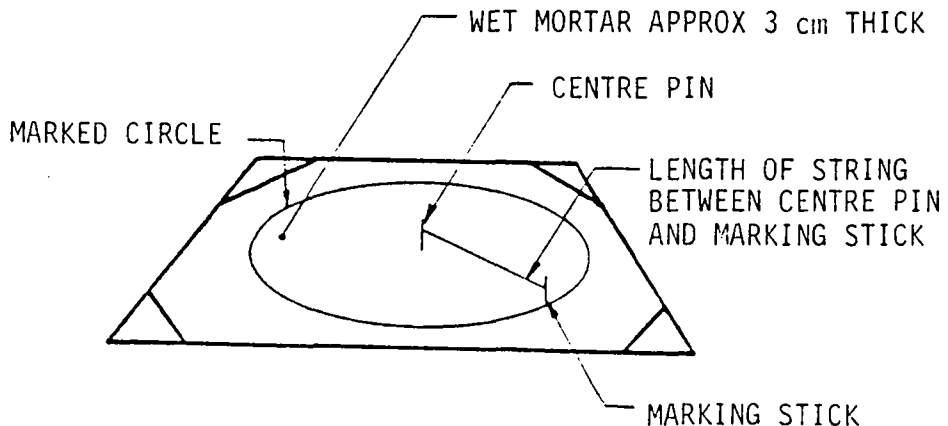
The first layer of mortar 3.0 cm thick is spread as shown in the picture and a circle is marked in the wet mortar 3.25 m diameter using a string and stick from the centre pin. The string must be 1.625 m long, this is the same as the radius of the circle and tied to the central pin.

SPREADING 1ST LAYER OF MORTAR



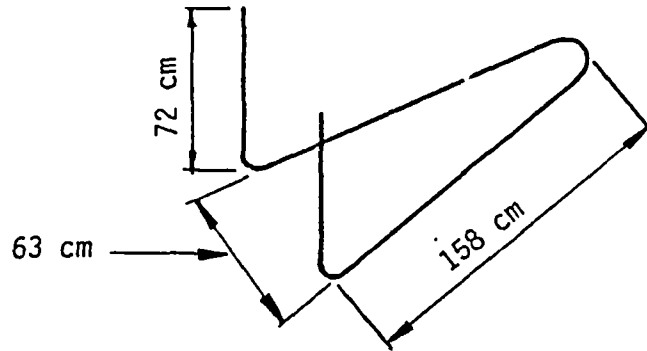
To mark a 3.25 m diameter circle:

MARKING A 3.25 m DIAMETER CIRCLE

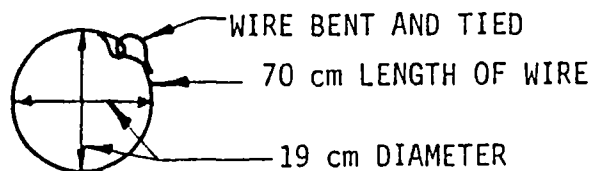
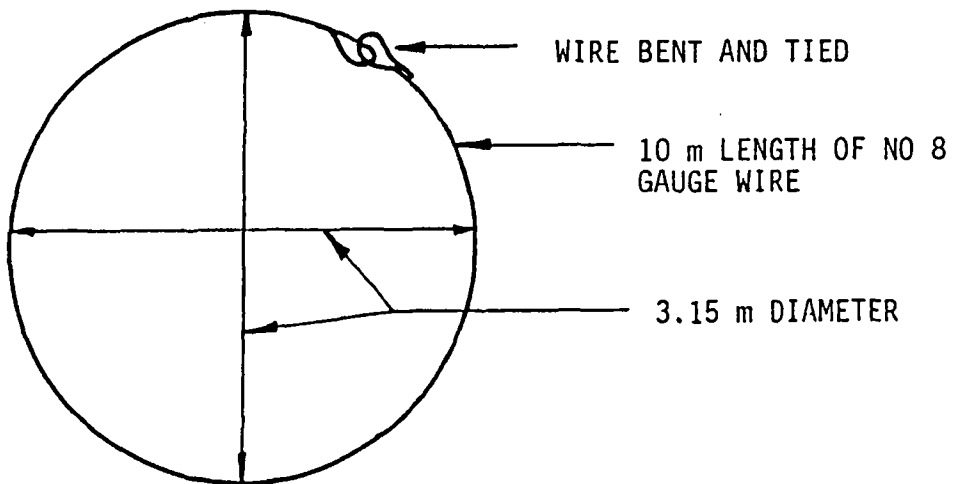


6.6 Starter Wires

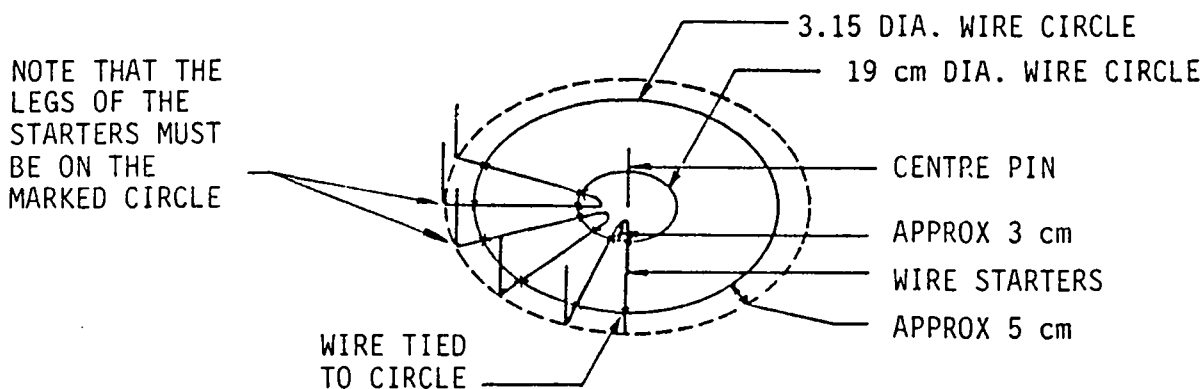
Eight starter wires made from eight lengths of No. 8 gauge wire 460 cm long are cut from the coil of No. 8 gauge wire and bent as shown.



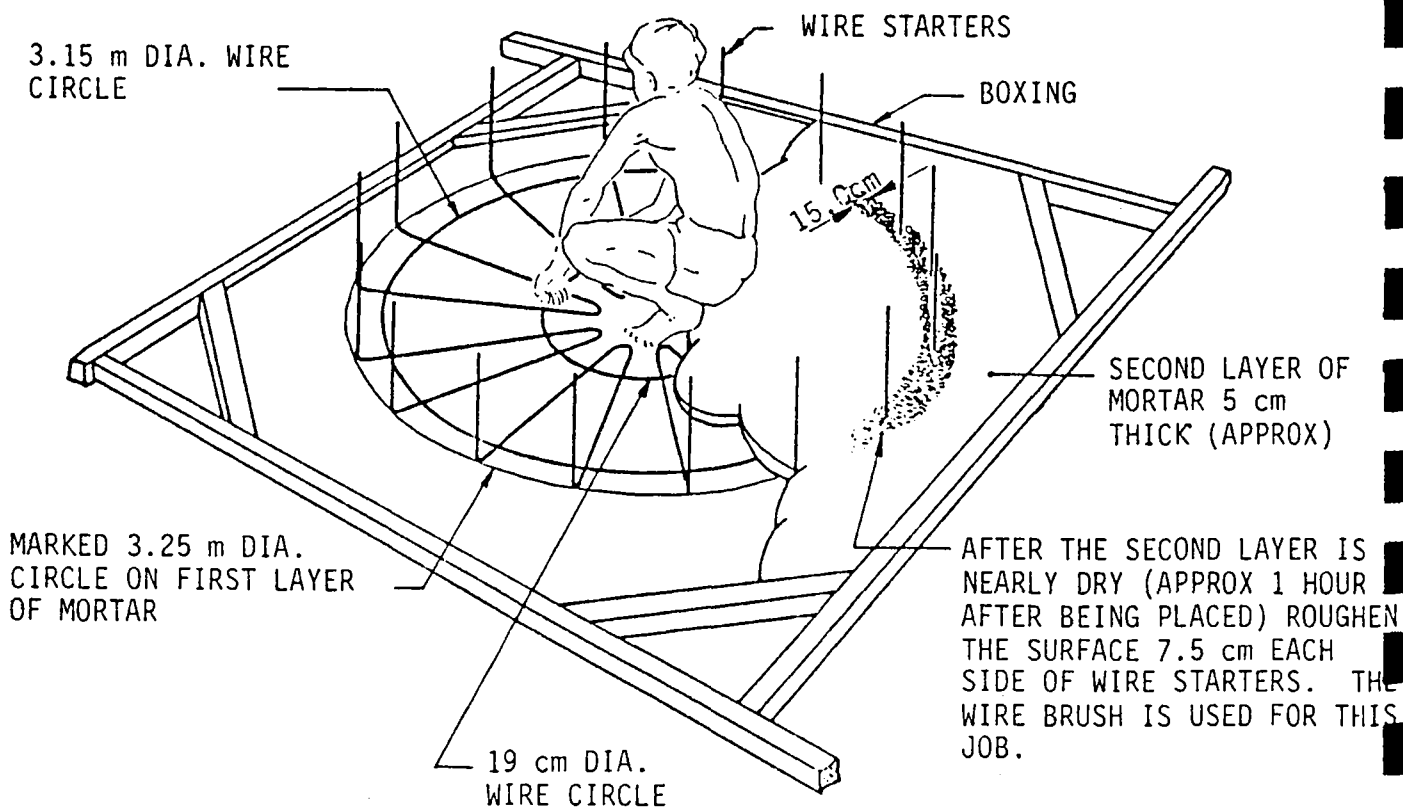
Cut two further lengths from the coil of No. 8 gauge wire, one 10 m long and the other 70 cm long and form them into two circles 3.15 m diameter and 19 cm diameter respectively.

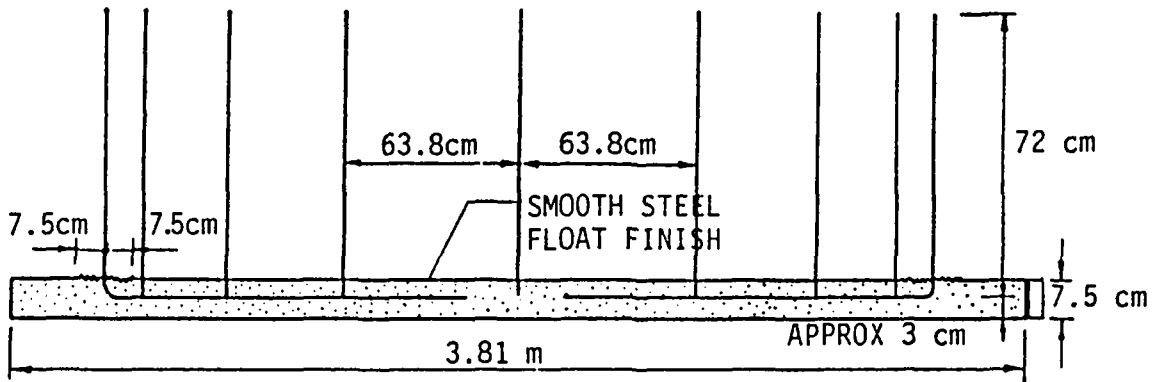


The eight starters and two wire circles are tied together as shown.



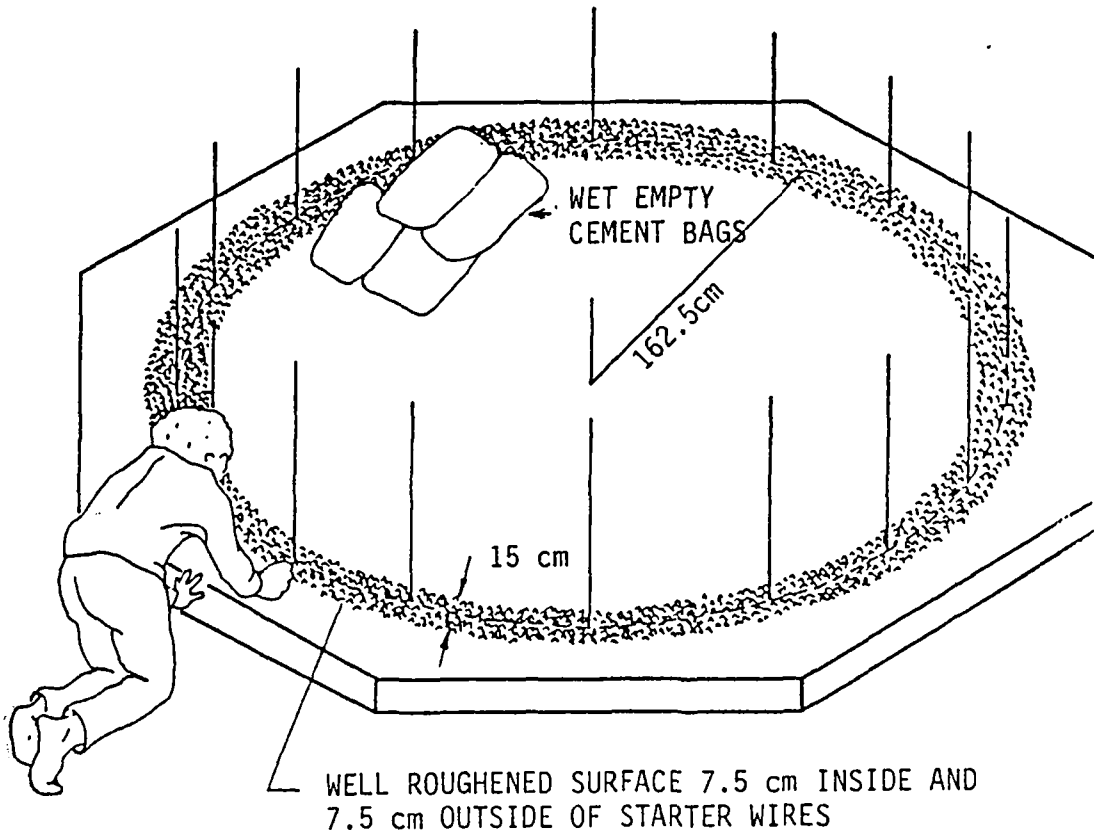
Finally, the floor, which is to be 7.5 cm thick, is completed by placing and levelling off a second layer of mortar up to the top of the frame level. The surface is finished by smoothing it with a steel float.





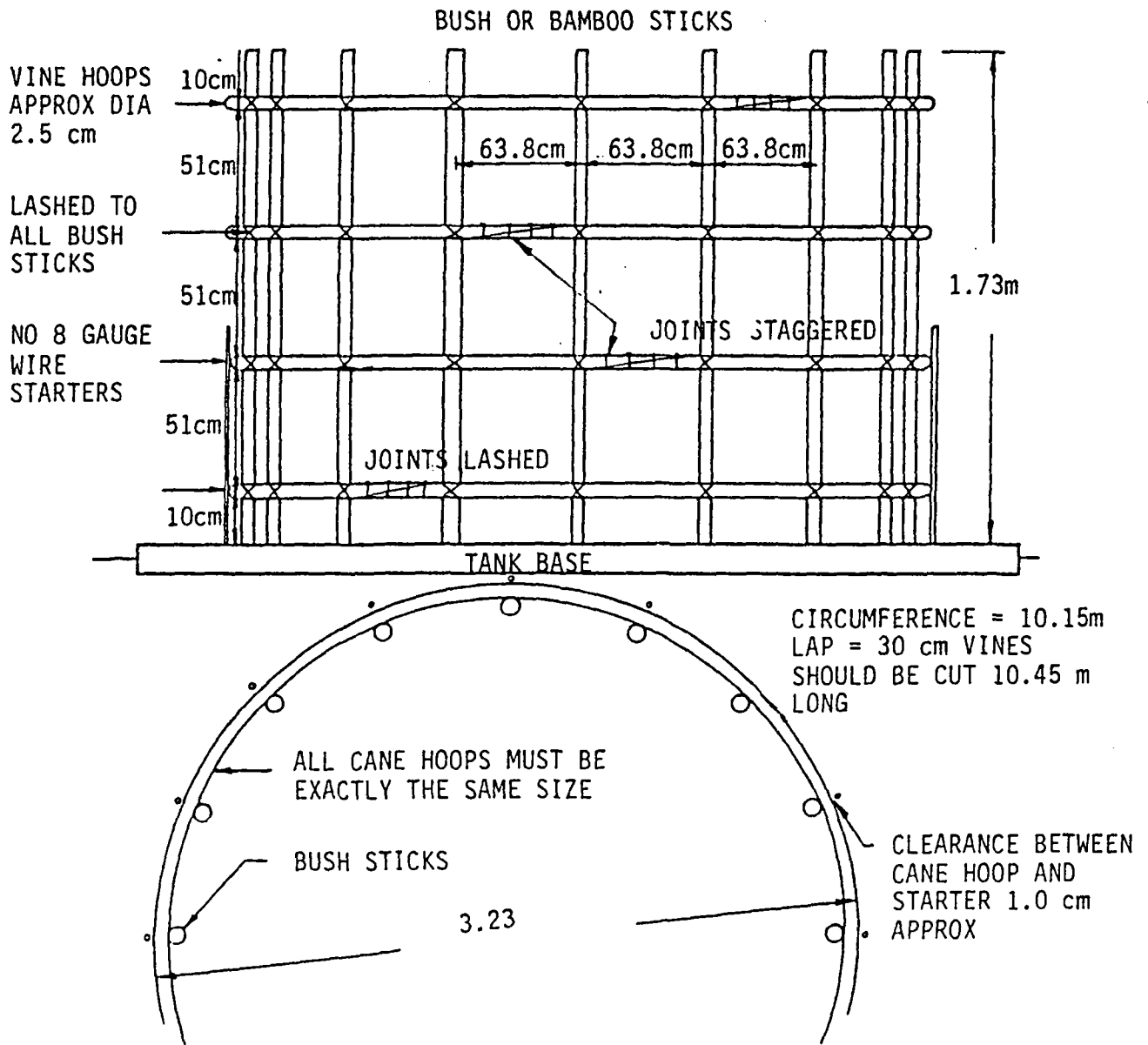
6.7 Removing Boxing

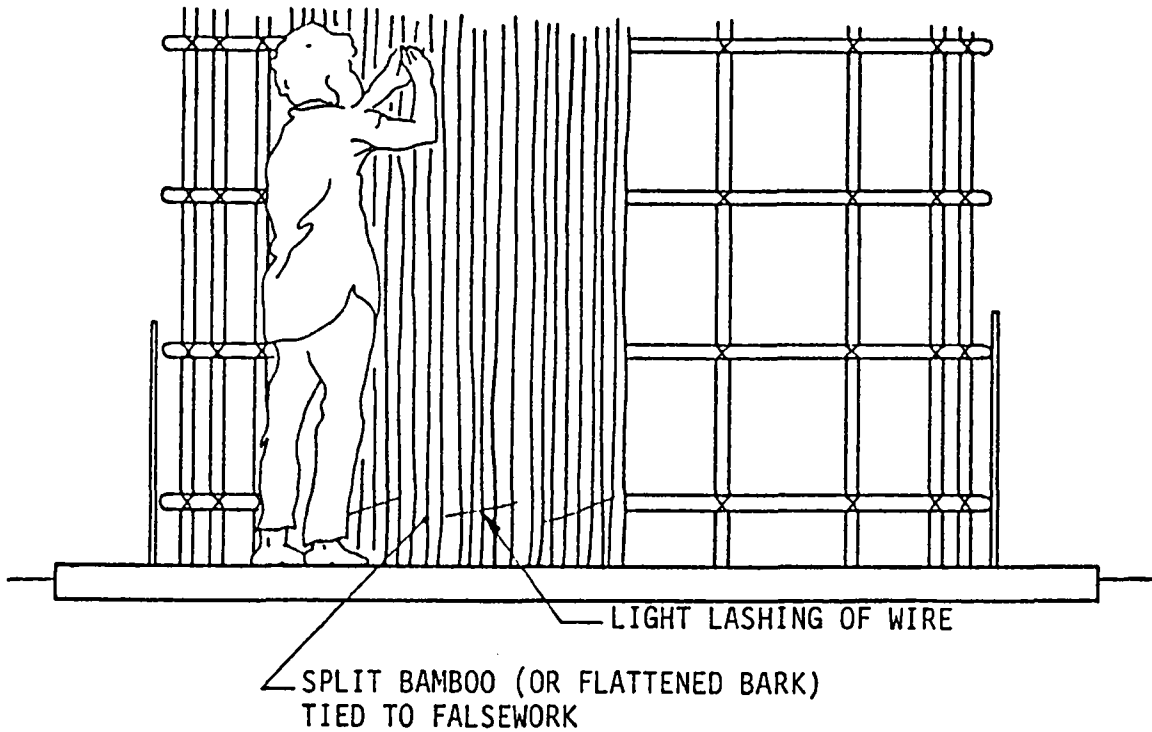
Twenty four hours after the mortar has dried all the boxing is carefully removed. Keep the base covered with empty cement bags to allow it to dry slowly.



6.8 Falsework-Formwork

Sixteen bush sticks or bamboo poles are needed next. They must be cut 1.73 m long. Also four lengths of approximately 2.5 cm diameter vines are needed to make four hoops for the main tank framework. These vines must be exactly the same size (10.45 m long). The ends of each length of vine are tied together to make four hoops exactly 3.23 m in diameter. Bush sticks and vine hoops are lashed together as shown. The complete falsework is placed on the base as shown below.

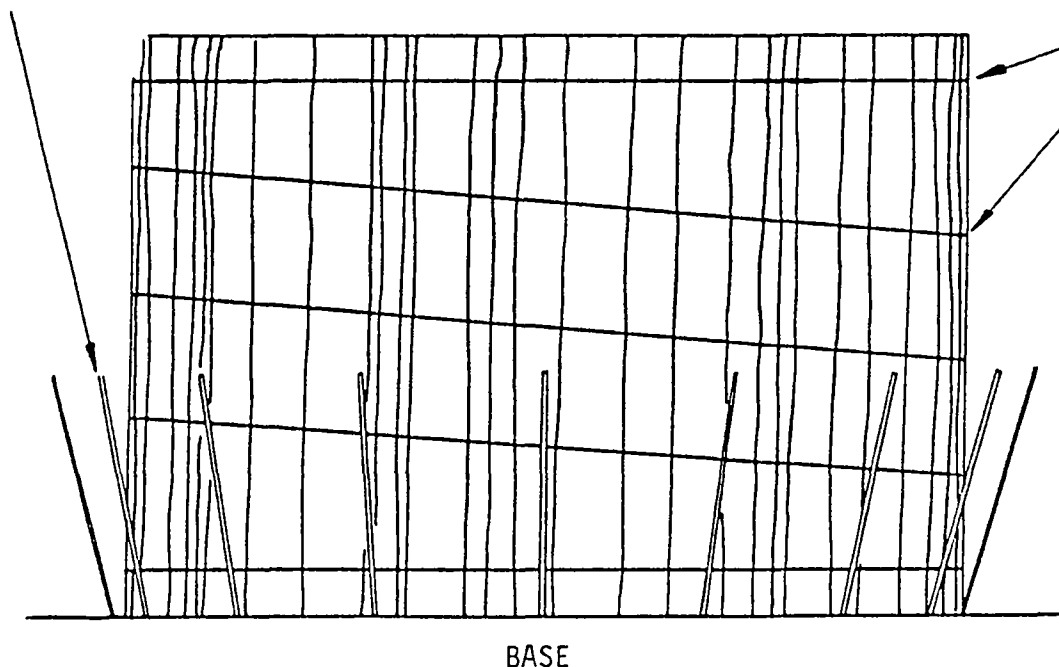




Flattened bark or split bamboo is now placed around the falsework with light lashing or wire to hold it in the right place (as above). As soon as this is all in place five hoops of No. 8 wire are pulled around the bark form and fastened off (as below) to hold the formwork tight.

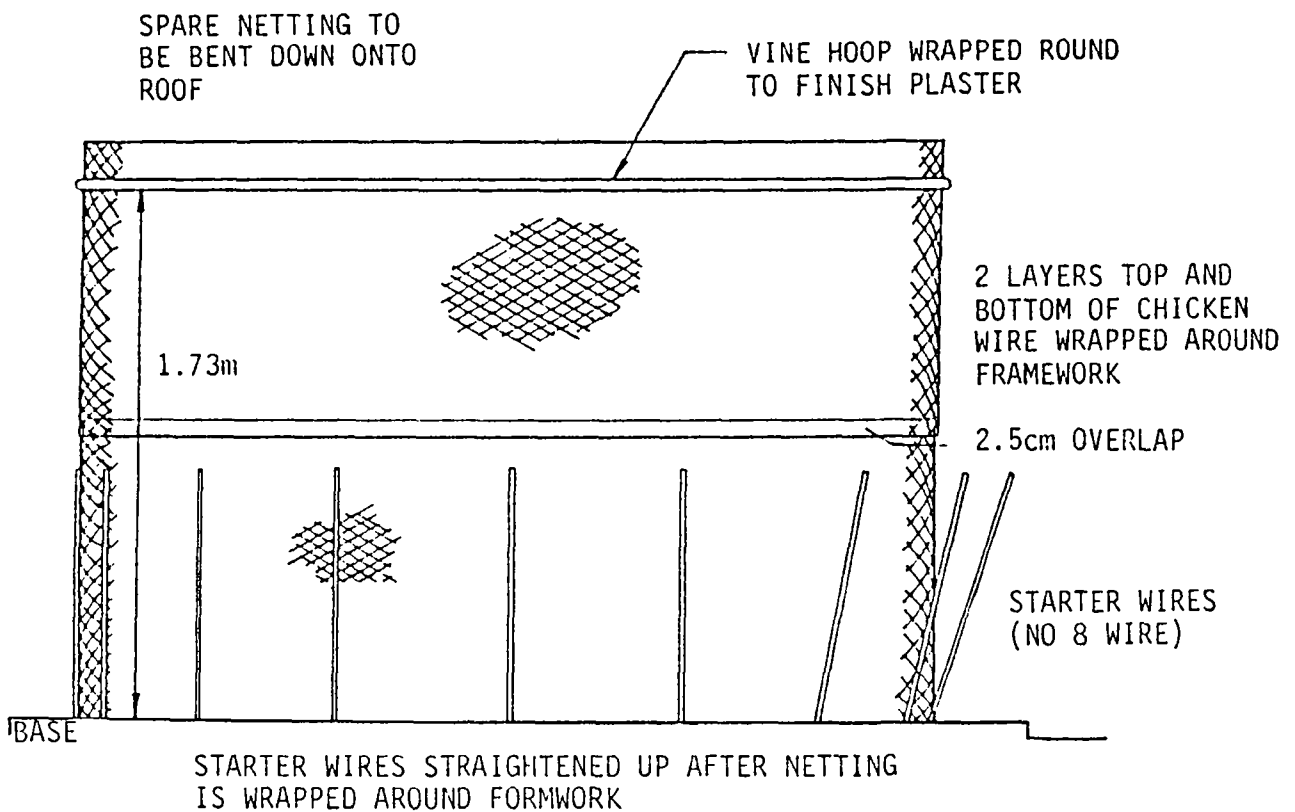
STARTERS OPENED OUT
LIGHTLY TO HELP
CONSTRUCTION

5 HOOPS OF NO 8
WIRE WRAPPED
AROUND TO HOLD
ALL TOGETHER
TIGHTLY



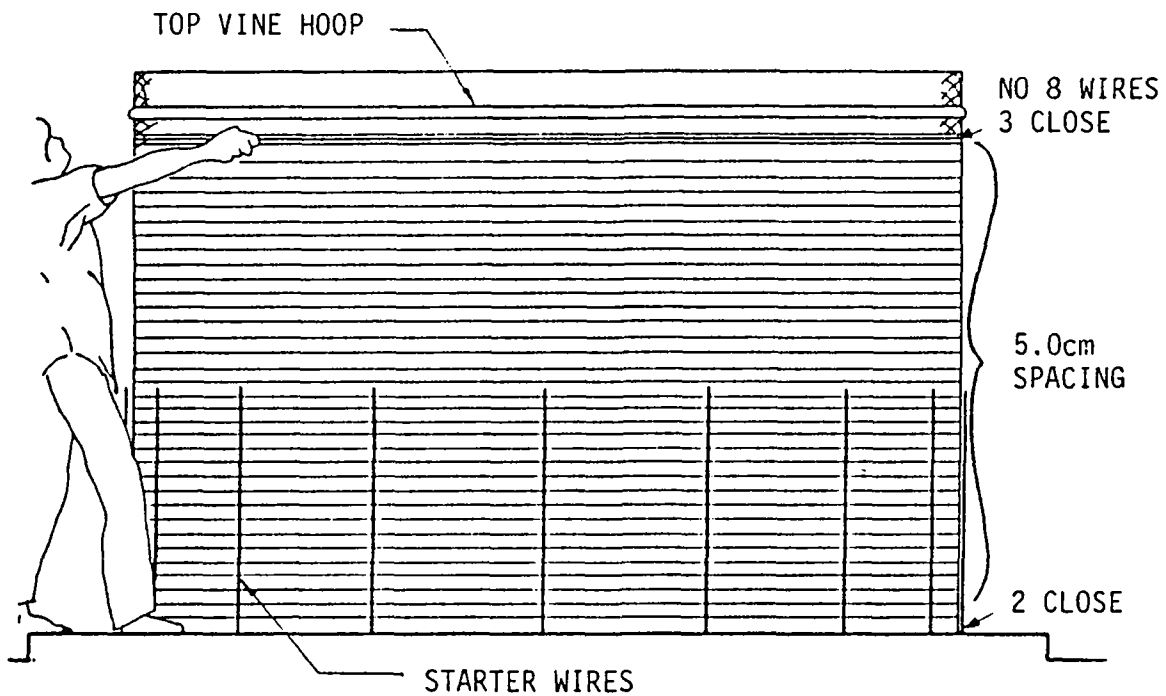
6.9 Wrapping the Chicken Netting

The chicken netting is then unrolled on a piece of open ground. A length of cord is used to measure the distance around the tank and then to mark the netting. There must be about 15 cm added to the distance around the tank to allow the chicken netting to be lapped and tied off. The first length of netting is marked, cut and then wrapped around the tank to check that the length is right. The first length is located round the bottom of the tank. Then three more lengths are cut from the roll of netting. The next length goes round the top, the next round the bottom and the final length round the top (see below).



A vine hoop is now placed around the tank at 1.73 m height above the base. This hoop is used to finish the wiring and to form the top edge for plaster. The laps and netting are then pressed flat to reduce the thickness of the mesh as much as possible.

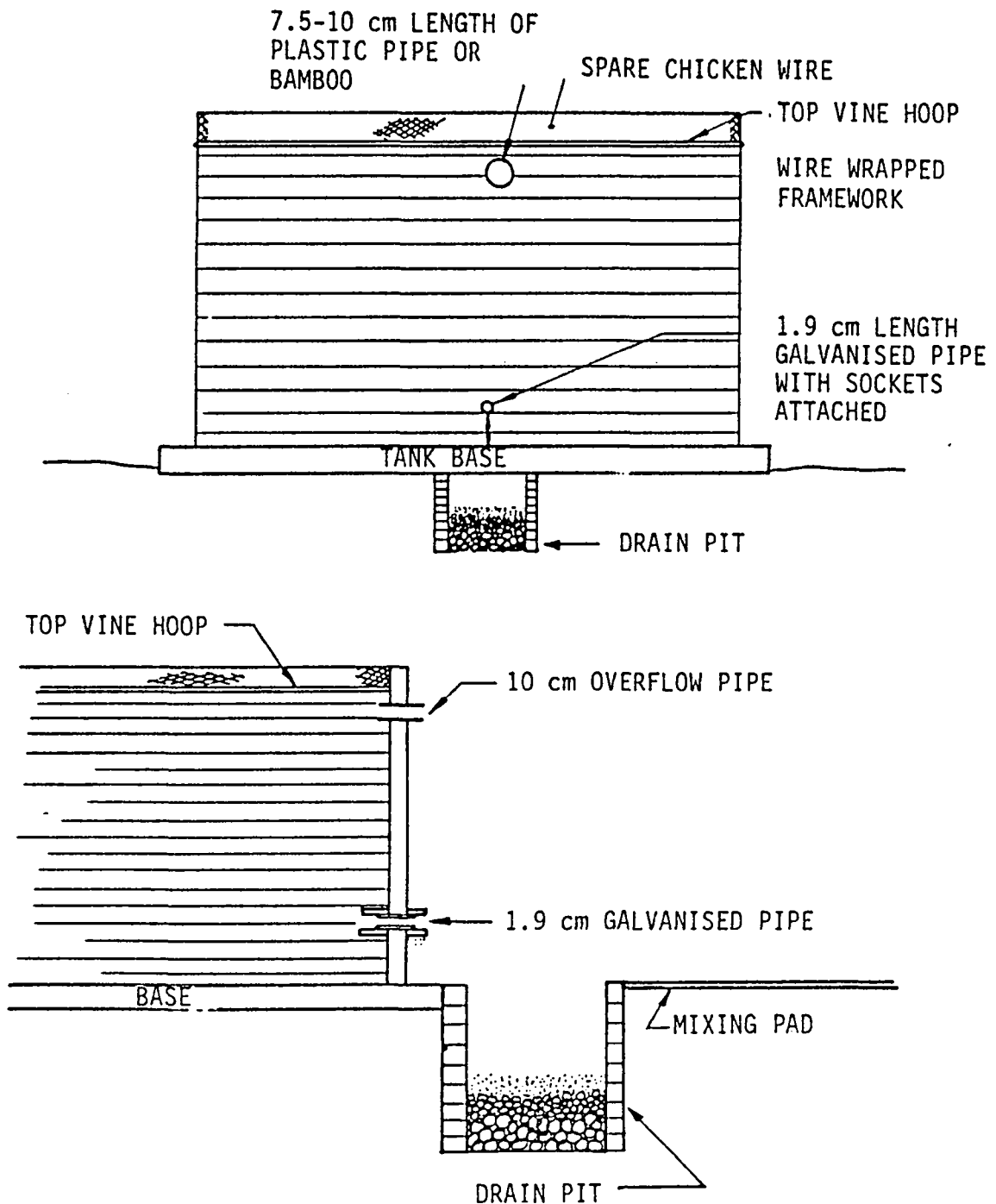
6.10 Wrapping the Wire



The end of the No. 8 wire is now attached to a starter bar. Firstly, two close coils are wound around the base and wire is then progressively wound around the tank up to the top. While the coil is being rolled around the outer netting, two men follow the first man, one keeping the wire tight and the other man helping, and keeping the wire loops 5 cm apart. Wire is wound on to the tank in this way until the top is reached and then wiring is finished off with three tight winds close together, under the top vine hoop. The end is then hooked and fastened to the netting.

6.11 Overflow Pipe and Tap

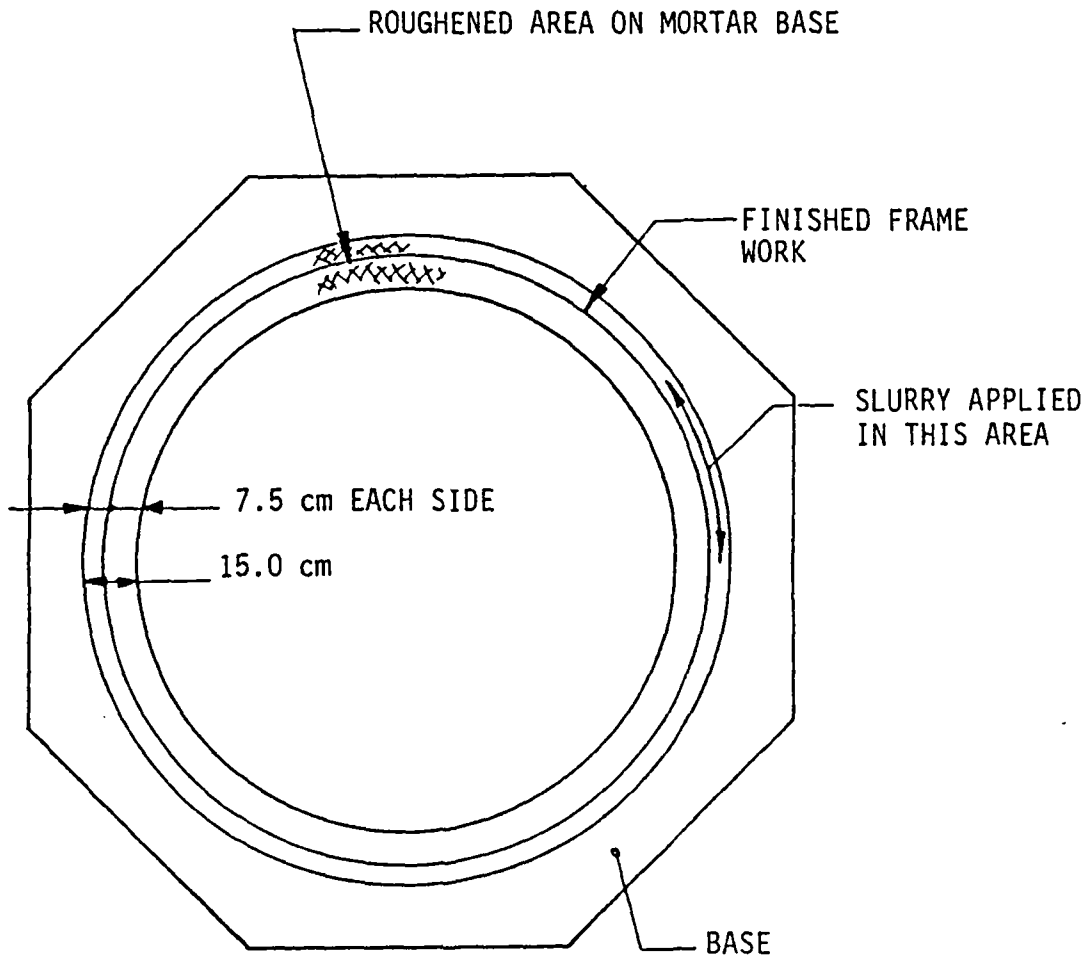
Push the length of 1.9 cm galvanised pipe with sockets attached through the formwork in the correct position for the tap and also push a length of plastic pipe or bamboo (around 10 cm in diameter) for the tank overflow. Positions for the tap and overflow pipe are shown below.



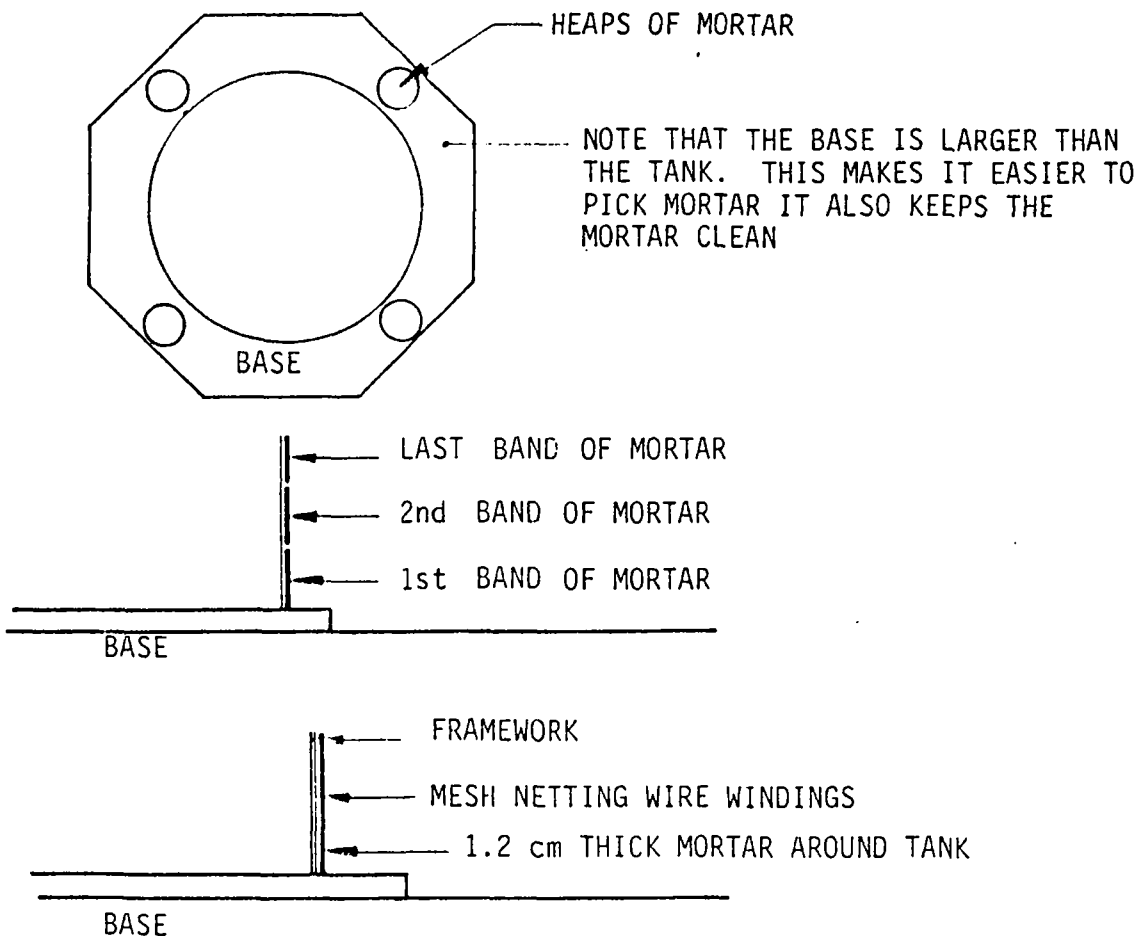
6.12 Wall Mortar

Day 1 : We are now ready to commence outer wall construction.

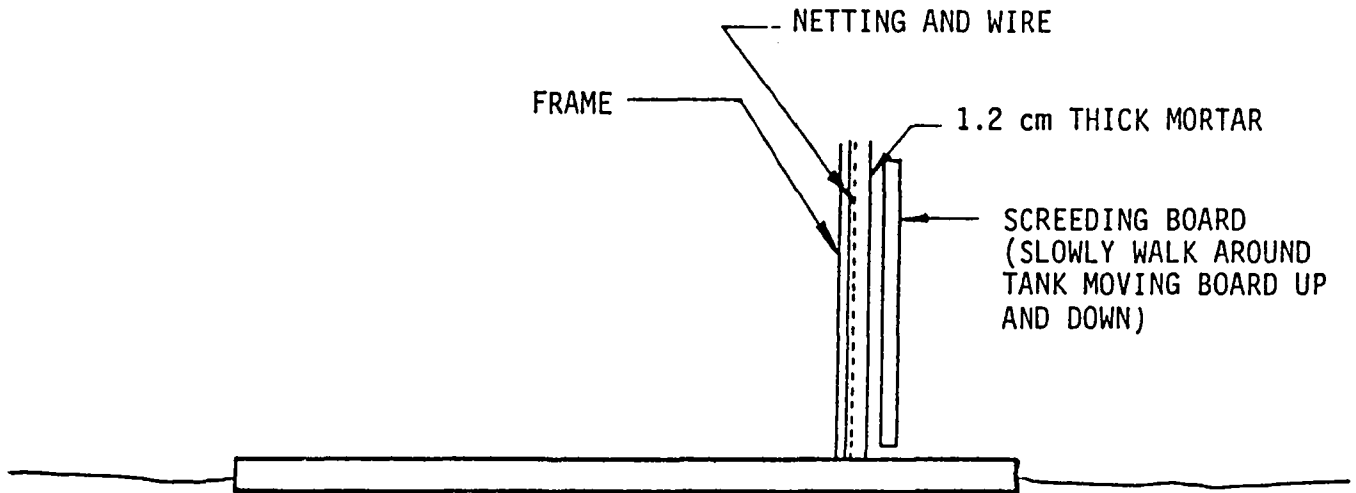
This work should start early in the morning. Mortar is now mixed and left ready on the mixing pad. At this time a rich cement and water slurry is mixed up in a bucket using about half a shovel of cement. A few coconut leaves or similar leaves are held together doubled over and then tied to form a good switch or brush. This is now dipped in the slurry mix and used to put a good coating of it onto the base of the wall over the roughened concrete.



Heaps of mortar are placed at convenient places around the outer base. The men put on plastic gloves or other suitable hand protection and pick up the mortar with their hands and force it into the chicken netting and wire at the base of wall and up the wall to about one third of the wall height right round the tank. Then the next third of mortar is applied and last of all, the final third of mortar up to the level of the top cane hoop. Working on without stopping, the wooden floats are now used by the men to pick up and put on extra mortar to fill in the hollows. They should work sideways around the tank to make a good surface finish without hollows or lumps. The mortar of this first layer should go through the netting mesh to the bark layer and it should be approximately 1.2 cm thick over the wire windings.



Now a screeding board is used to pick up any high spots and hollows. The screed board should also be worked sideways around the tank as shown below. Wooden floats are used to finish this first coating and give a rather rough surface finish.



At this time great efforts should be made to keep sunshine, wind and rain from the surface. Some water should be applied late in the day by gently splashing it on by hand from a bucket.

Day 2 : A second layer of mortar is placed on the outside of the first layer. It should also be 1.2 cm thick and should be done in the same way as the first layer, not forgetting the water at the end.

Day 3 : The bush sticks, hoops and bark or split bamboo are now removed from inside the tank and the whole wall surface inside the tank is then chipped and wire-brushed to remove any loose material.

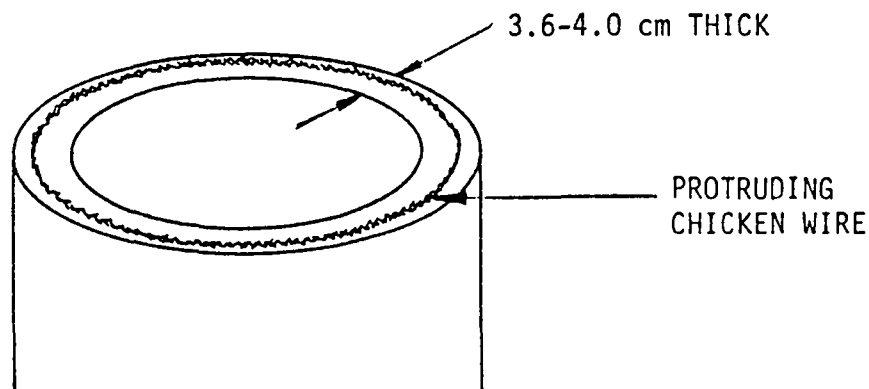
The cleaned inner wall is thoroughly wetted all over and a cement slurry is applied around the roughened floor area and wall (as was done for the outside wall).

Now a mix of mortar is made using slightly more water than before for the outside of the tank. This will produce a thinner mixture, it will be easier to apply to the very rough surface and it will run into all the cracks and holes.

Then the mortar is applied 1.2 cm thick to the inner surface of the tank in exactly the same way as it was applied to the outside with special force being used on the floor/wall joint. The finish between the inner wall and floor should be rounded.

The mortar is now finished off with the wooden floats and tidied up in the same way as was done on the outside, paying particular attention to getting a good covering on the inside at the floor/wall joint.

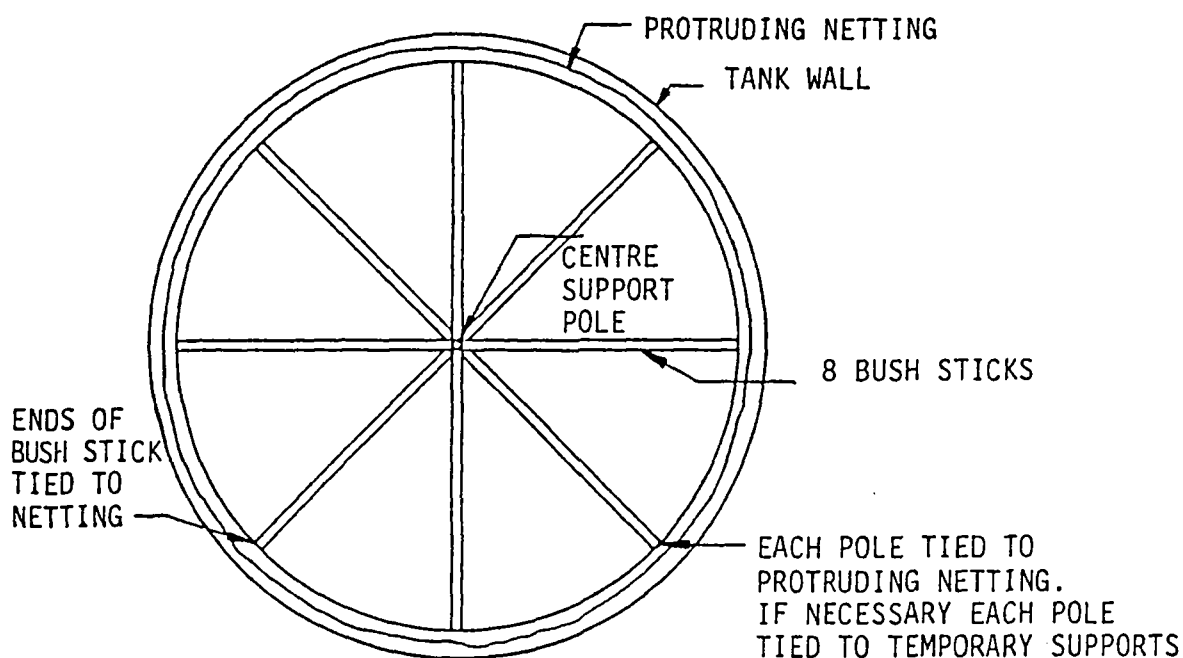
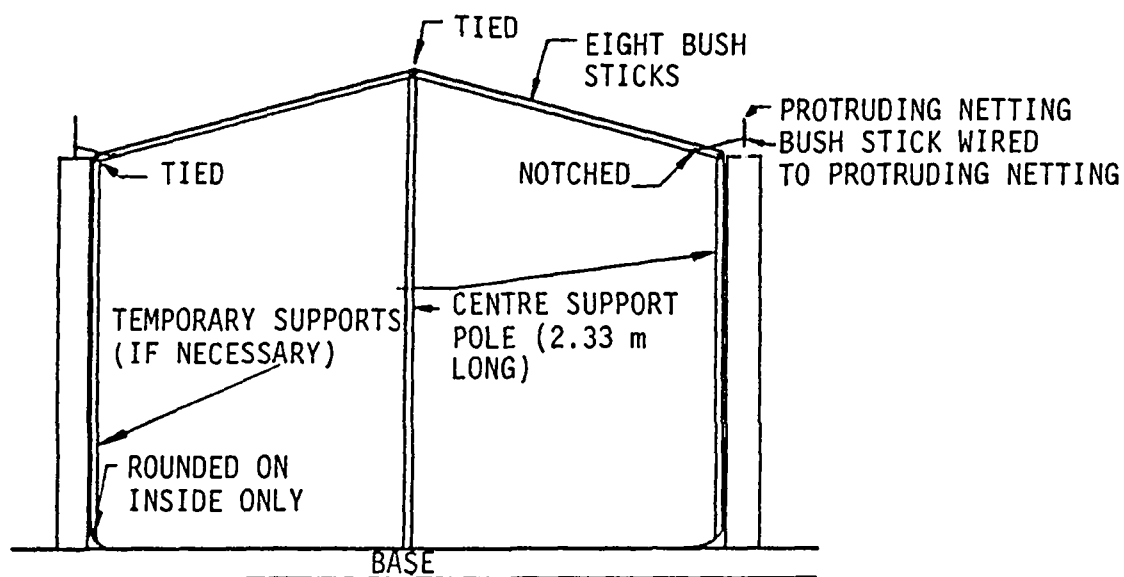
Day 4 : The next day a coat of cement slurry is applied all over the inside surface using pieces of sacking or coconut fibre until the surface is filled up and smooth. Final wall thickness should be not less than 3.6 cm and not greater than 4.0 cm as shown below.



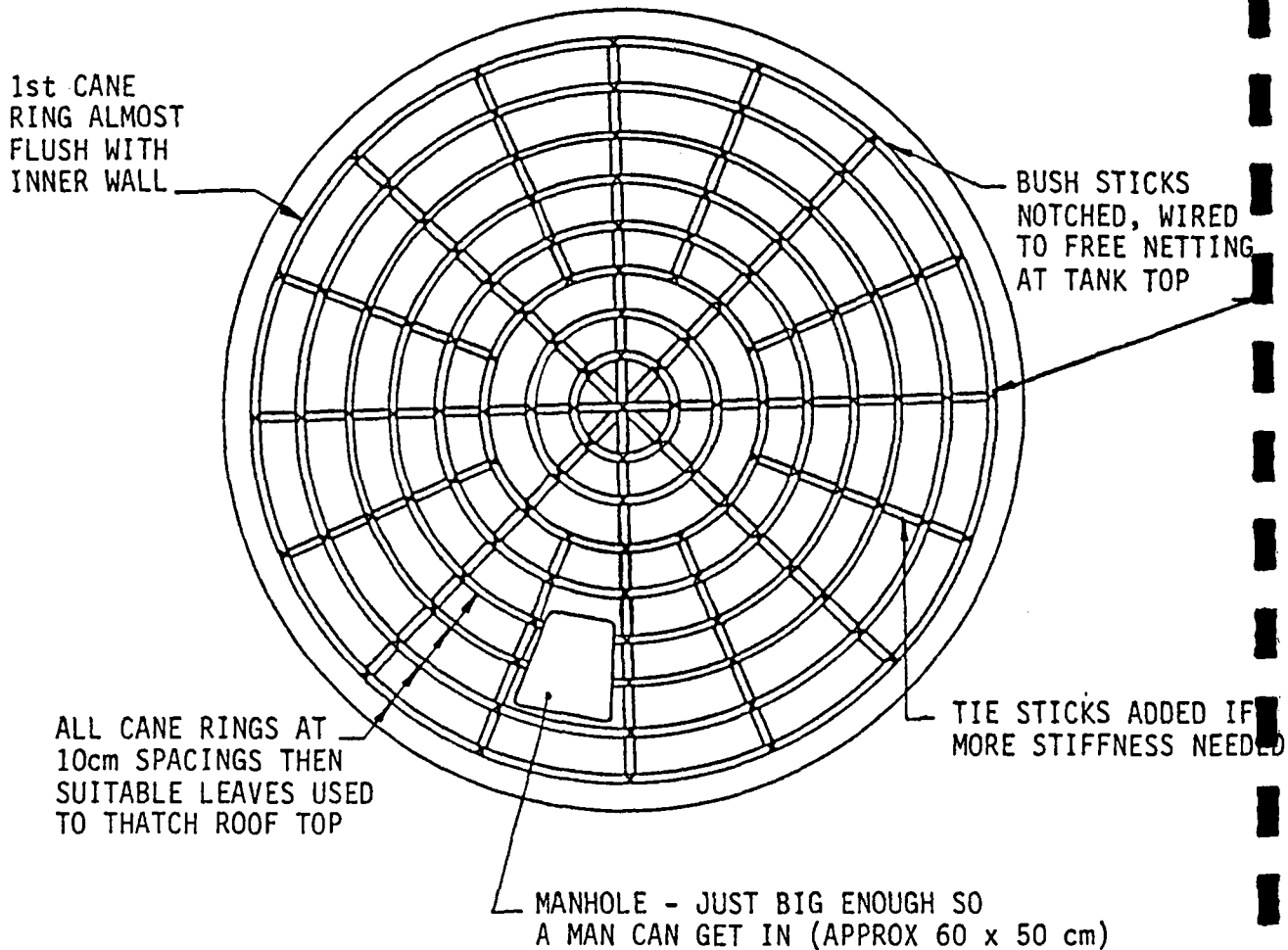
6.13 Roof Framing

Framing for the roof can be started the day after finishing the inside of the tank.

Eight bush sticks or bamboo lengths should be cut to fit over a central pole and fixed firmly to this pole. Each stick should be notched underneath at the wall end to take the tie wire. They should be tied to the netting where it comes out of the mortar.

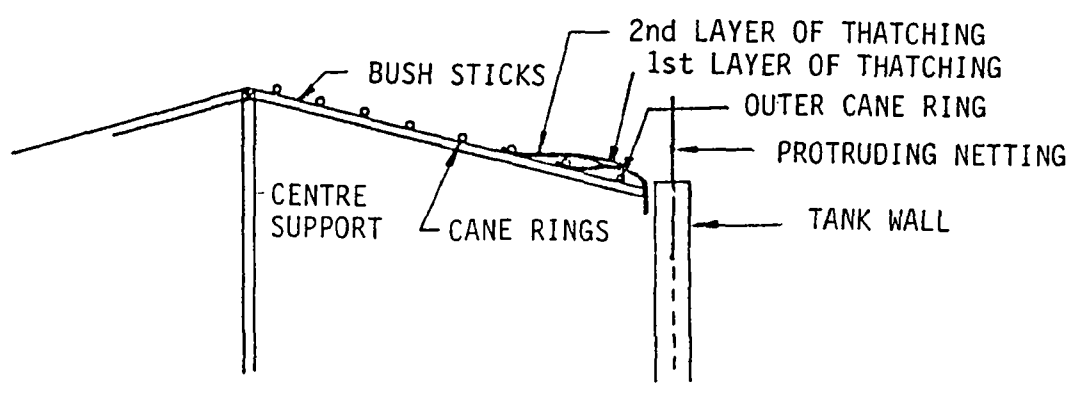


Cane is then put on top to make rings or spirals at 10 cm spacing and is tied firmly to the bush sticks, as seen below. More bush sticks can be added if needed to hold the cane in position.

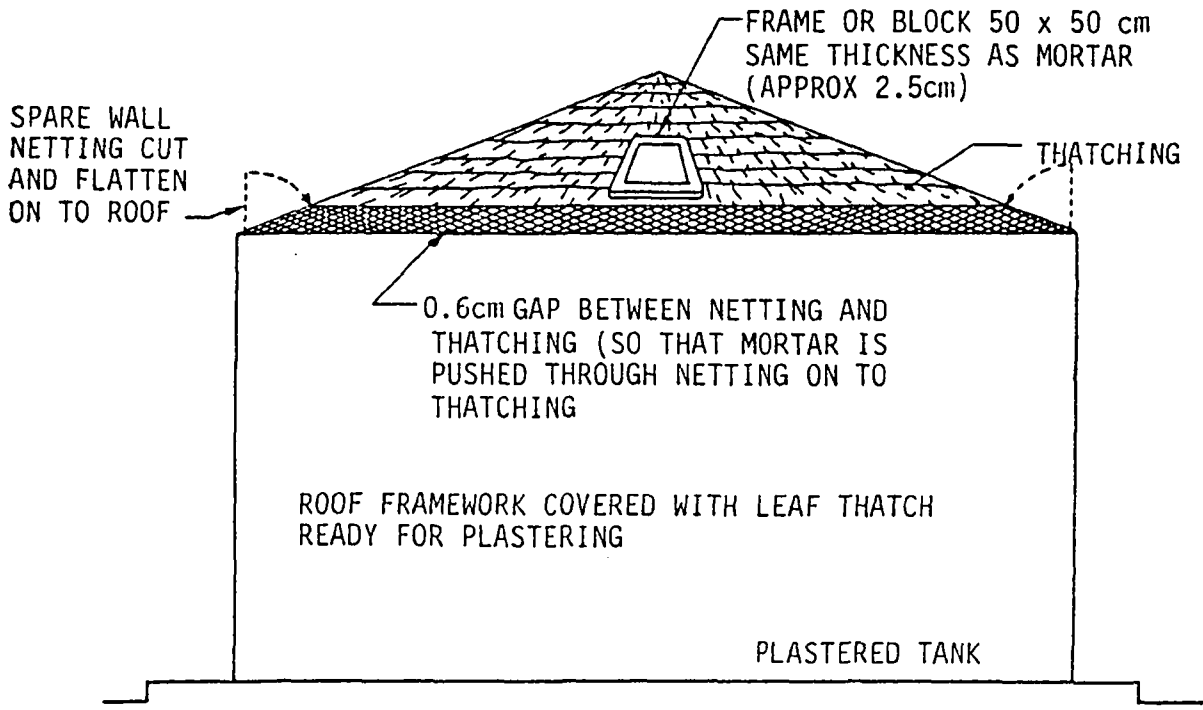


6.14 Roof Thatching

Thatching is now done using good leaves. Start underneath the second-to-outer ring then go down between the wall and outer ring and continue around the roof. Repeat the thatching from the third-to-outer ring and gradually work up to the top ring. The hole at the roof peak is covered with some open cement bags. The thatching provides a mortar proof inner or form.



Now a simple framework is made around the manhole to stick the mortar to. The spare netting sticking above the mortared walls is then bent over and flattened down on to the thatching, as below.



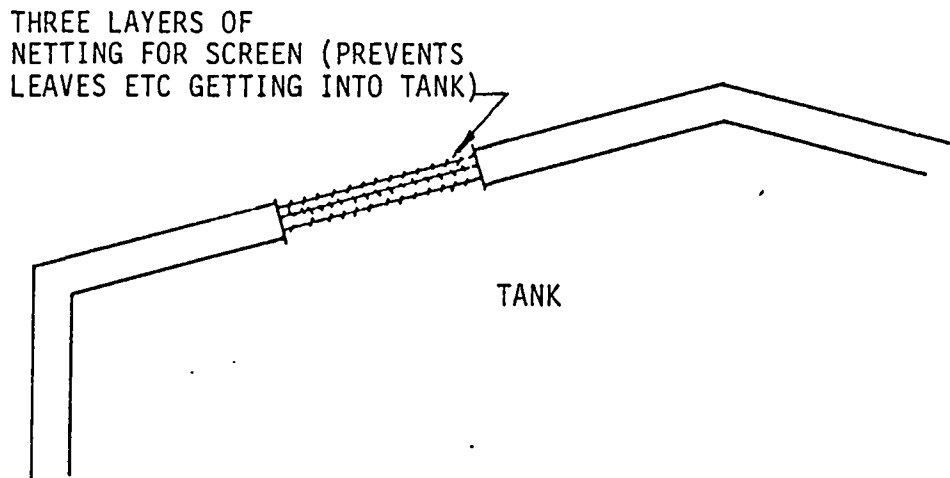
6.15 Roof Mortaring

The first layer of mortar is put on the thatching and shaped with wooden floats. The first layer is 1.2 cm thick, and the surface is left rough. Next a single layer of chicken mesh is laid on the mortar while it is still wet. Then a second layer of mortar is placed also to 1.2 cm thickness and floated smooth using wooden floats. Steel floats should not be used.

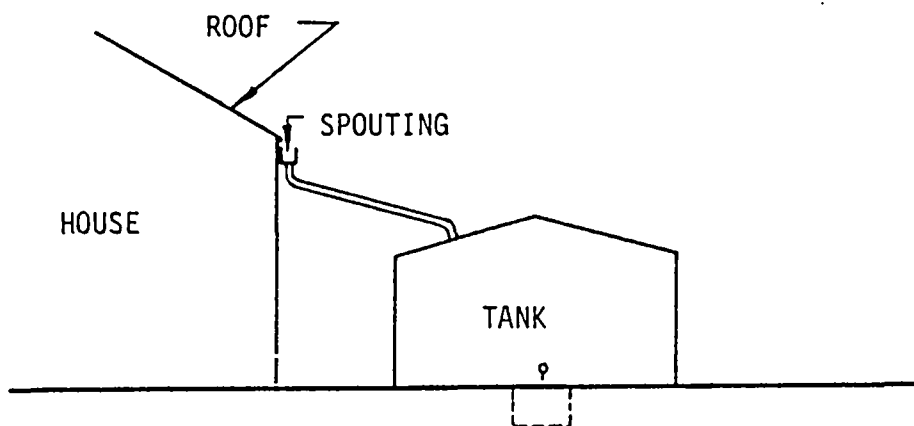
The inner formwork and central prop should not be removed until the roof mortar has cured for one week (seven days). Keep tank damp for this time.

7. WATER INLET

Make a screen using three layers of netting and fit the screen over the manhole (prevents leaves, etc getting into tank).



Connect pipe from roof to the manhole in the tank.

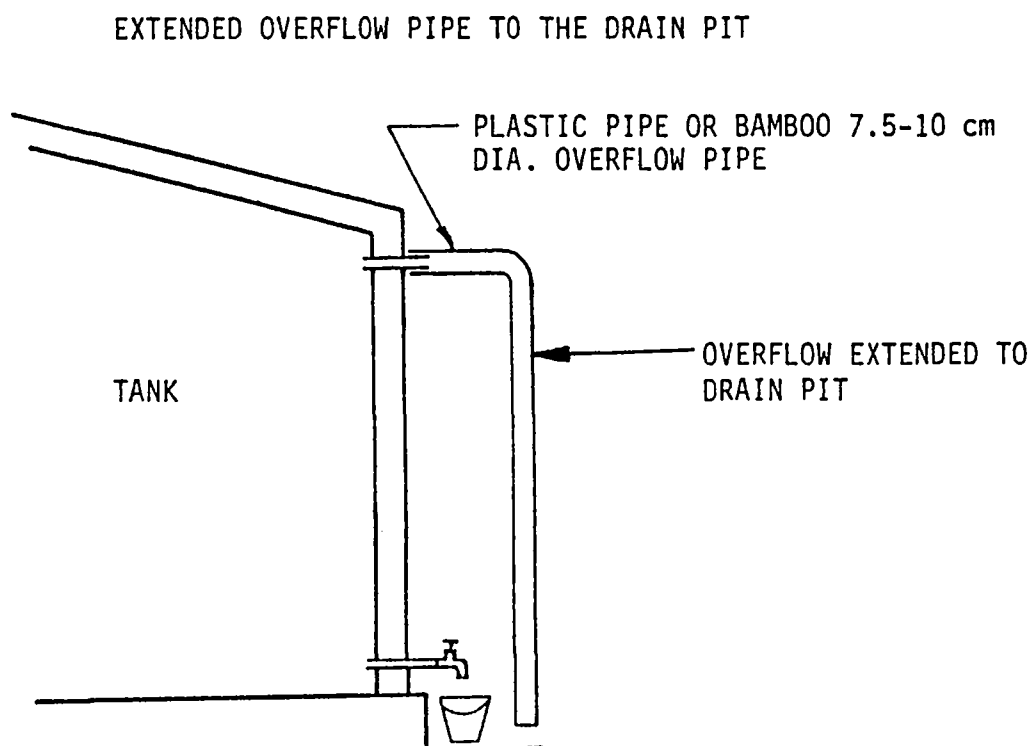


8. OUTLET TAP

Fit tap to suit local requirement.

9. OVERFLOW PIPE

Extend overflow pipe to the apron slab.

10. FILLING TANK

We are now ready to fill the tank. It can be filled naturally from the roof run or filled by pump or bucket from some other suitable water supply.

If leaks appear after filling, mark the leaks and empty the tank.

Use cement slurry to cover the inside wall of the tank where the leaks have been marked. Two or three coatings may be required.

Periodically it may be necessary to drain the tank and remove any sediment from the bottom. The tank should be drained to the tap level with the tap. Then men will have to climb inside the tank and clean out the remainder by hand using sponges and buckets.

All grit and slime should be thoroughly removed from the walls and base with a scrubbing brush.

11. FINISHED JOB

ROOF AND
ALL OF WALLS
ROUGHCAST
APPEARANCE

