
RAINWATER
HARVESTING

ELEMENTS OF RAINWATER HARVESTING

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Water is life. Being used up in a multitude of bio chemic and bio physical processes, life continues to need replenishment every few hours. To the animal world it is available from ponds, lakes, rivers etc while the plant world draws it from the soil and some from air. Human beings added wells to this list a long time back. All this water essentially comes from precipitation - rain or snow.

While about 60% of the precipitation runs back directly to the sea about 20% evaporates back to the atmosphere. The rest offers itself to be cycled through the life circuit of the flora and fauna of the land and the fresh water aqueous world, by first getting soaked into the soil, or stored in ponds and lakes.

Beside the volume of precipitation that occurs at a location, the wolume of water that gets into the soil and stays there long enough to be of use to the bio sphere depends upon

- i The texture and quality of soil
- ii The type and density of vegetation
- iii The topography
- iv The geological features

In case these factors work against, desert conditions are triggered in spite of satisfactory rainfall. Cherapunji in Meghalaya ~~is a short~~

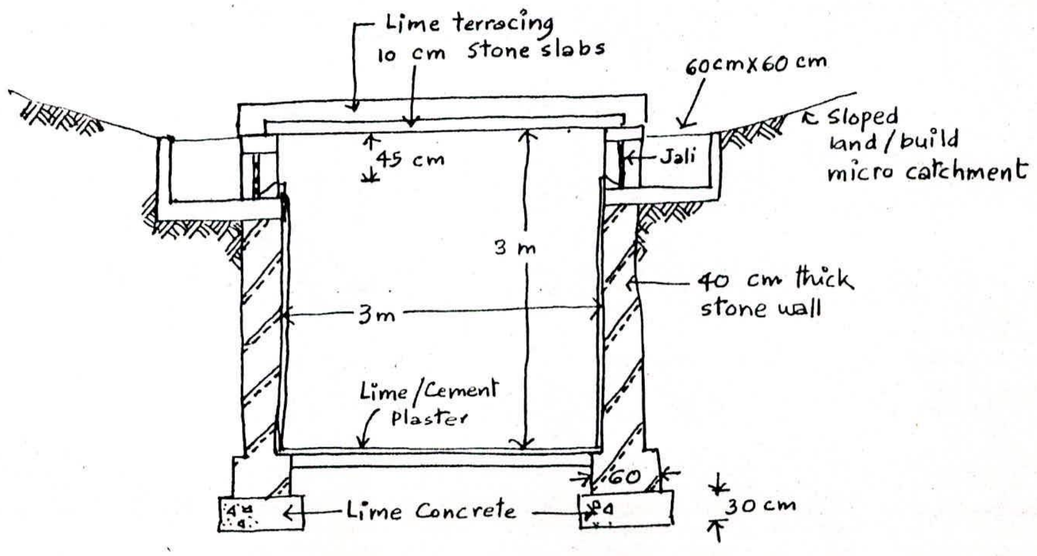
which records ~~the~~ world's highest annual precipitation, suffers from severe drinking water problem immediately after rain ceases, is a shocking example of this phenomenon.

Availability of clean and safe drinking water is an essential pre-requisite of human habitation and this water must run through the year. Problems and particularly the severe ones occur towards the far end of dry season and man has since long been alive to the potential of rain water harvesting (RWH). Many archaeological sites show up existence of RWH in the then era. RWH assisted agriculture in the Negev desert (Israel) since 3000 BC to 700 AD which level of production looks impossible today. On the island of Crete, RWH systems - collection and storage - worked in 1700 BC. The Romans improved upon this with their advances in brick and mortar construction. Their systems can be seen even now in many mediterranean locations Asian as well as European. With the use of arches, vaults and domes in lime mortar they built a vast sized cistern 140 metres by 70 metres holding 80,000 m^3 of water at Istanbul in the sixth century A.D. Around the same time they built another cistern in close vicinity with a capacity of 50,000 m^3. Both are centralized systems collecting water from roofs and paved streets and indicate a prolonged and successful operation. The Christian monks rain water harvesting

continued to use ~~rainw~~ (RWH) in monastery locations deficient in water. Examples of this can be seen in Spanish empire and they bring out a high standard of design and construction. In modern times Gibraltar continues to use RWH on a massive scale and Bermudan law demands RWH system as an integral part of every construction.

Nearer home we have Khadin methods of the Thar desert and the Ahars of the Gangetic basin known through the ages. The Haveli methods of Bundelkhand and the Eerie of Tamilnad brought perennial prosperity to their beneficiaries. They are essentially agriculture oriented but also service drinking water needs by charging the wells downstream. 'Kunds' of Rajasthan especially catered to drinking water needs. Unfortunately all these methods received a back seat in the post independence development programmes, being dubbed primitive. Wisdom is dawning once again, sensing the limitations (and in some cases failure) of the alternatives. Ralegan Shindi, a village in Western Maharashtra drought prone belt, shot up to national notice as an exporter of green fodder to needy villages nearby, thanks to RWH set into practice by an enlighted village leader Anna Hazare.

The 'Kund' or 'Tanka' method of Rajasthan is an exclusively household level drinking water RWH method. The water collected from roof and paved yards ('Pauthan') is passed through elaborate filtration into a sub surface tank generally built in stone and lime. The people value the stored water so much that the Kund is under lock and key. Cleaning the roofs before onset of monsoon is a festive ritual in some villages. With the decline in popular appeal of this 'primitive' method, in contrast to the promised panacea of centralized supply through stand pipes, several functioning Kunds underwent neglect and in some cases breakdown. Disillusioned with this, 'Kund' is catching up once more thanks to the conscious efforts of voluntary organizations like Gramin Vikas Vigyan Samiti (GVVS)



CROSS SECTION THRO' TANKA

A 'Tanka' model being promoted by GVV Samiti [redacted] Average Water consumption per household

(litres)

Wardha district

		Income Group				
Sr.No.	Purpose	A	B	C	D	E
1	2	3	4	5	6	7
1.	Cooking	38	45	45	60	60
2.	Washing Clothes	60	60	75	90	185
3.	Washing Utensils	30	45	45	90	90
4.	Bathing	75	75	75	90	185
5.	Toilet	15	15	15	30	50
6.	House cleaning	10	15	15	30	45
7.	Cattle	30	75	90	150	
8.	Gobar-gas plant	-	-	30	60	75
	Total	220	285	375	540	680

The 'Kund' and 'Tanka' methods being essentially of indigenous development, have many different location specific features and the above sketch is only one such set.

The total water required for domestic purposes (including domestic animals' drinking needs) is a very small part of the total precipitation in our country (around 4 trillion metric tonnes). The rainfall on the roof of a small house (50 m^2) is enough to look after the domestic needs of a family of five for the whole year, with annual rainfall as low as 300 mm. Obviously our work lies ~~outside~~ well within the rains, in collecting, filtering and keeping it safe from seepage and contamination for the ~~non (rainy)~~ (non) rainy day. Bhagirath, in Puranic times, invoked the mighty Ganga to quench the thirst of his land. On a much more modest scale let us try the rains, to tide over the more difficult parts of the year, to quench the thirst of our very bodies. This effort hopes to help the reader in this regard.

Domestic water consumption figures vary from place to place, from house to house. A report on a survey of Wardha district is furnished for guidance. Surveys may be set up at your location to get specific figures.

← Table

Rainwater Harwesting (RWH) can be broken down into the following functions

i Collection on a catchment
ii Guttering and downtake
iii Filtration
iv Containment
v Withdrawal (user)

The governing conditions in our country being widely different it would be wrong to precast an ideal combination. Our effort therefore would be to present tried and tested (as well as exploratory where so mentioned) techniques within each of the elements. The reader who intends to devise an appropriate system specific to his/her site, will have to assess the various alternatives and make the best selection and produce a set out of them to meet the specific needs, to have the right water at the right time in the right quantity.

Mention may be made that RWH is only one of the sides of the water story, conservation and fuller utilization the other. We would have to give up the habit of wasteful destruction we synonymize with 'decent' urbane sanitation practices like tub baths, flushing cisterns (and the sewage disposal that goes with it), washing machines etc. Recycling within the household will stretch your storage to that extent.

Table 2.

GROUND CATCHMENT RUN OFF COEFFICIENTS

Description	Run off coefficient
a. Untreated Ground	
i Soil on slopes less than 10%	0 to 0·3
ii Rocky natural catchments	0·2 to 0·5
b. Treated Ground	
i compacted and smoothed soil	0·3 to 0·5
ii Clay + Cow dung (Gobar) floor	0·5 to 0·6
iii Silicone treated soil	0·5 to 0·8
iv sodium salts treated soil	0·4 to 0·8
v Paraffin wax treated soil	0·6 to 0·9
c. Surface Coverings	
i Concrete paved	0·6 to 0·8
ii Plastic sheeting	0·7 to 0·8
iii Butyl Rubber	0·8 to 0·9
iv Brick paved	0·5 to 0·6

COLLECTION

Catchment is the area from which water is collected. In most cases drinking water is collected on roofs. A low rainfall or too small roof areas dictate additional ground catchment, a paved yard or bare ground.

Ground catchment :

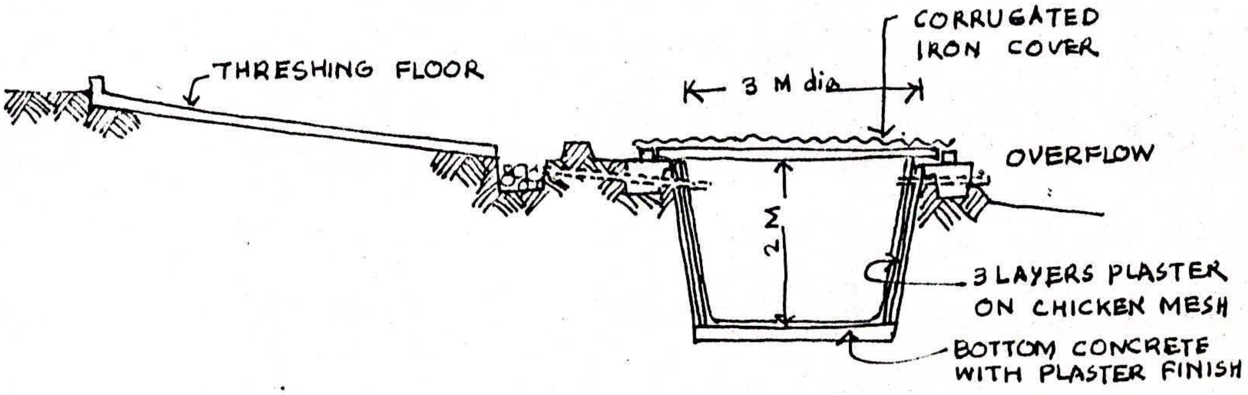
When collecting from ground, special care needs to be taken to keep the ground free from encroachment/infection at least during the period of collection. Paved yards make matters simpler but when this is not available ground treatments are known, the simplest of them the Gobar + soil plastering like the threshing floor preparation. These various surfaces would need different minimum slopes pointing towards the storage. The run-off coefficients of the surfaces follow

← Table

When one has to collect from an internal courtyard one can easily control dirt from entering into water. But when one has to collect from an unattended piece of land, far greater care needs to be exercised to ~~keep~~ ensure the potability of the stored water.

Preparation of ground

The ground should be cleared of all vegetation. This will have to be done on a recurring basis every year in monsoon. Similarly the ground will have to be swept



A GROUND CATCHMENT METHOD

GROUND CATCHMENT RUN OFF COEFFICIENTS

a. Untreated Ground

i	Soil on slopes less than 10%	0 to 0·3
ii	Rocky natural catchments	0·2 to 0·5

b. Treated Ground

i	Compacted and smoothed soil	0·3 to 0·5
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c. Surface Coverings

i	Concrete paved	0·6 to 0·8
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clean before monsoons. Any cracks in ground will have to be patched smooth. Any mounds etc will have to be flattened and depressions filled and the right slope built up necessary for the particular surface in mind. It would be preferable to fence off the area to keep it safe from human/animal tresspass.

The suggested chemical treatments to improve the run-off out turn are generally expensive nor do they keep the performance for long. Sodium salts do not last longer than a year, sillicone very expensive. Only paraffin wax gives a reasonable performance. The Gobar (Cow dung) + Clay ~~corn~~ mixture plastered over floor is a normal practice in Indian villages and sounds the most practical.

In spite of best care, water collected on open ground catchments usually carries contamination - further aggravated by the liabilities inherrent in sub-surface collection and manual withdrawal (where pumps are not used). Boiling and other treatments of disinfection may become necessary.

Roof catchments :

A roof being essentially designed for non-percolation and instant drainage offers ideal conditions for RWH. Most roofs would do well for us except for the non-suitability of certain roofing materials discussed below.

Roofing Materials

Non absorbent materials like concrete, galvanized iron, mangalore tiles, stone/slate slabs etc offer the easiest and most readily acceptable surfaces for RWH. Even the half round country tiles and well secured palm thatches offer no serious problem, except for the greater dirt load which would require a little more flushing. Certain grass thatches may ~~leave~~ lend the water colour and visual offence while some of them may make it non-potable, in which case proper filtration and boiling may become necessary before use.

Unsuitable Roofing Materials

- Plastic sheets are not as innocent as they look. Under ultra violet degradation they may be less so. They may leach out hazardous chemicals particularly in case of recycled plastics.
- Asbestos Cement roof collection may carry loosened asbestos fibres which are harmful.
- Lead based roofing material or surfaces may make the water quite harmful.

Run-off Coefficients - Roofs

Sloping roofs

Terra Cotta / stone slabs / slates	0·8 - 0·9
G.I. sheets / other synthetics	0·7 - 0·9

Flat roofs

Concrete	0·6 - 0·8
Brick paved	0·5 - 0·6

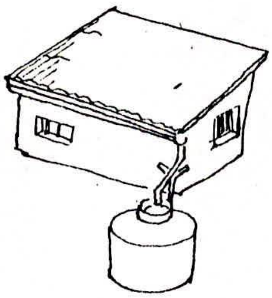
Please note that in many parts of our country roof areas exceed the storage needs and the storage needs themselves being seriously dictated by the affordability factor of the household, and the whole calculation may have to start the other way round.

Roof Forms

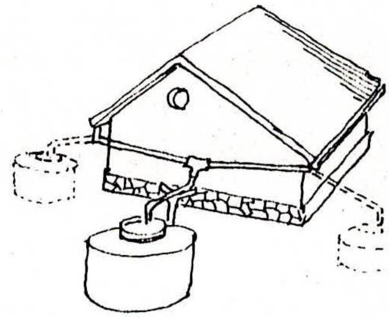
Roof forms are selected during the process of construction for various reasons of cost and convenience. However they can be adapted to RWH without much difficulty.

Single pitch : This offers the easiest collection on one side cutting costs considerably

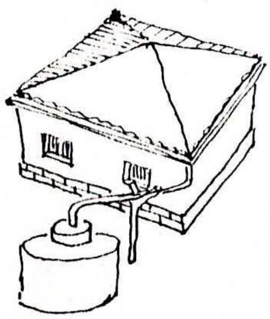
ROOF FORMS & RWH



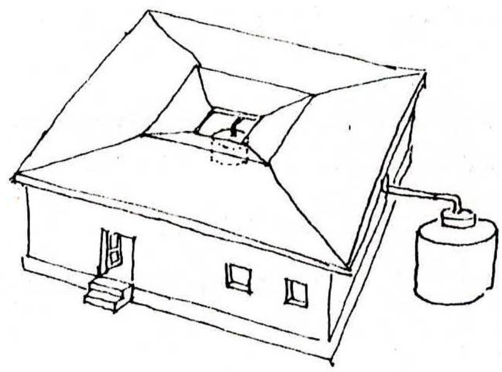
single pitch



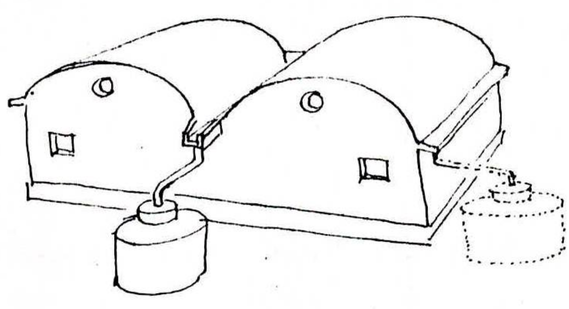
double pitch



pyramid roof



nallakethu (inner courtyard) roof



vaulted roof

Double pitch : Water from both sides could be brought together and carried to downtake like a 'Y' on the gable wall. Alternatively 2 smaller containers on either side would do.

Pyramid roof : This is one of the more difficult roof forms to collect water from, necessitating guttering on all 4 sides and sloping the gutters to the right pitch.

Nallakethu : Common in the southern parts of the country providing a well ventilated but protected courtyard for almost all the house activities, This is also very convenient for RWH. The inner quarter water can be collected in the inner courtyard along with the paved court run off into a sub-surface tank which remains well guarded. If however this is not sufficient one or more of the outer panels may be brought into service as a secondary source.

Guna Vaults : These vaults are becoming popular doing away with scarce materials like steel/timber. They are also quite easy to collect water from.

Flat Roofs : Flat roofs have been always popular in dry tropics, in mud, stone and brick jack arches. Of late RCC has extended this popularity almost all over – though at a considerable cost in money, comfort and performance not commensurate with the gains – for reasons far from technical. The roof is generally laid flat and slope has to be built in the terracing material to take the water to downtake points without forming pools. The edge of the slab should have at least a one brick tall parapet to hold back wind splashes.

Storage Size & Catchment Area Calculations

Storage size : The storage needs for domestic purpose depend upon the following

a = the water culture of the community or household to determine the daily consumption litres/person/day

b = the number of users

c = the number of service days

Thus required storage S (litres)

$$= a \cdot b \cdot c$$

Catchment Area : The catchment is a function of storage capacity in addition to the precipitation and run-off coefficient of the catching surface.

Catchment Area 'A' (in square metres)

$$= \frac{S}{RF \times RC}$$

where

RF = Annual rainfall in mm

RC = Run-off coefficient of the surface

GUTTERS & DOWNTAKE

Gutters are normally employed to carry the roof runoff and throw it away to protect the walls from damage and discolouration as also to guard the soil near foundation. In RWH, one is interested in carrying this water to collection tanks for drinking use. While in non RWH application the gutters could be considered a dispensable luxury under cost constraints, they are ~~unavo~~ a necessity of RWH system

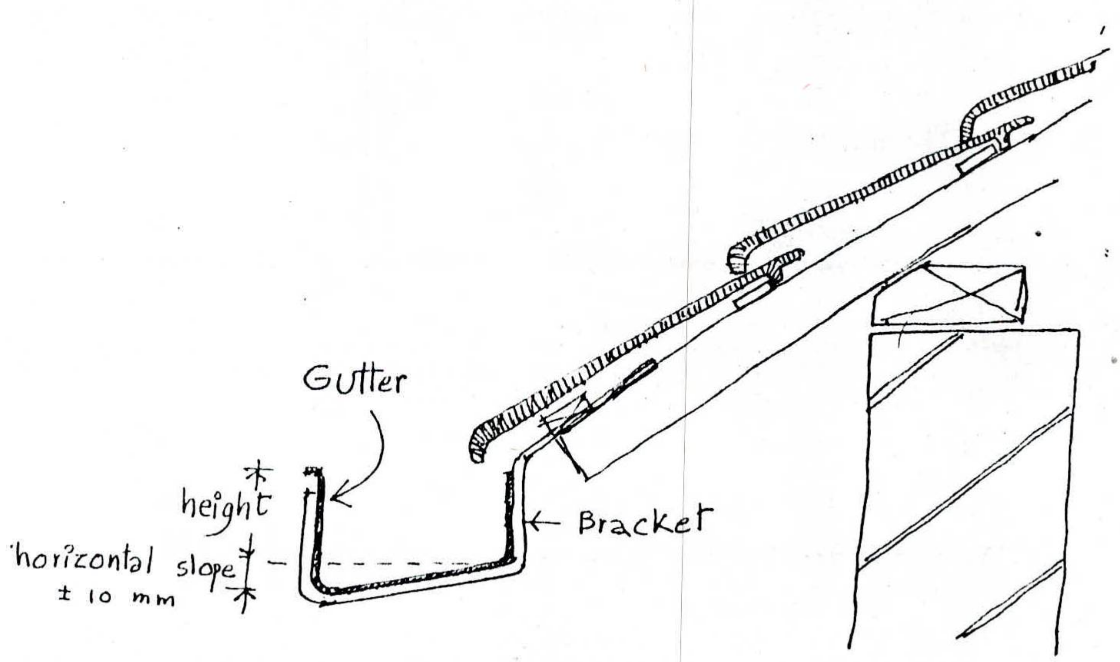
The non-criticality of gutters under general non RWH engineering practice, has rendered it a rather unimportant hardware item and thus receives scanty supervision. The same in legacy comes to RWH but it would be a serious mistake to treat so. We may take the roof as a given factor but not the gutters which must receive our close scrutiny

Dimensions of gutter

The general rule is to provide a cm^2 of gutter cross section for each m^2 of serviced roof area. In addition the gutter should be strong enough to take the weight and turbulence of the passing water during heaviest of showers. Gutters are usually fabricated out of galvanized iron and the recommended sizes and thicknesses follow

Serviced Area of Roof m^2	Gutter Dimensions mm Half Round diameter	Rectilinear	Thickness of G.I. sheet mm
less than 25	80	40 X 65	0·65
25 - 40	105	50 X 85	0·65
40 - 60	125	60 X 100	0·7
60 - 100	150	75 X 110	0·7
100 - 150	190	90 X 140	0·7
150 - 250	250	115 X 190	0·8

Brackets : Besides the thickness of the guttering material, the strength and the method of securing the brackets to the principal structural elements is very important. The smallest gutter may carry 30 kg of water ~~for~~ while the largest around 220 kg, for every metre length at full load and the cantilever supports have to be very good to carry this load. The G.I. sheet thicknesses have been worked out for being supported at the max. of one metre centre to centre by such strong brackets. If the brackets fail or sag under load, the gutters would fail/sag similarly and the water would go waste beside other damage.



Gutter
height
Bracket
horizontal slope
± 10 mm

Slope of Gutter : The gutters should be sloped towards the downtake so as to ensure a fluent flow. Care should be taken that there are no depressions or sags which may form puddles which may harbour dirt / algae or breed mosquitoes. The recommended slope for G.I. gutters is 3 - 5 mm per metre length.

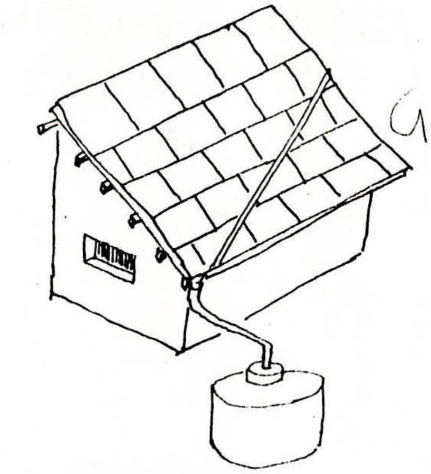
For long roofs this slope may lead to a big gap between the eaves and the gutter (30 metre long roof may mean a gap of 9 to 15 cm) and in that case the gutter may not be able to trap the entire range of dripping angles. This problem is usually avoided by placing a downtake at every 10 metres or so, and the gap brought down to manageable limits.

It would be also important to note that rectangular gutters should be sloped slightly outwards (about 1 c.m.) to ensure faster and total drainage

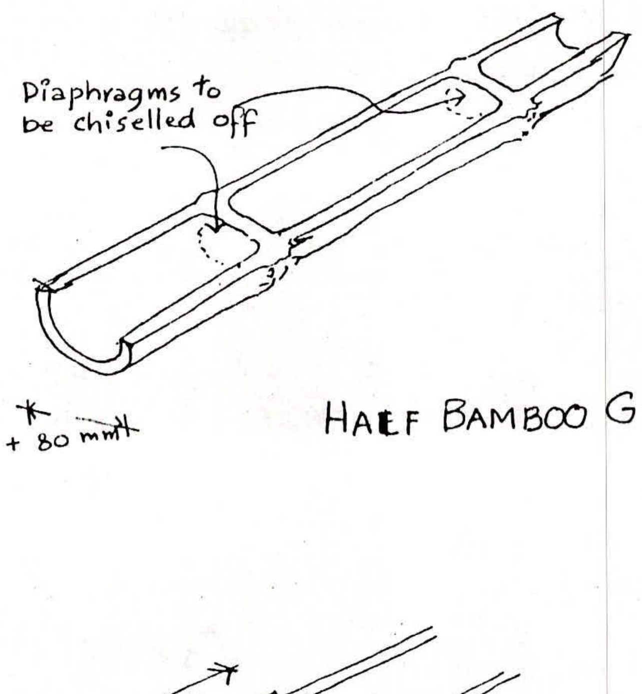
figure ←

Alternative Materials

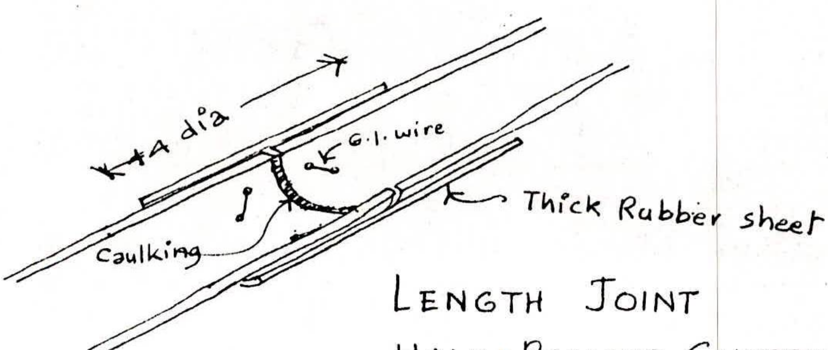
Although G.I. gutters may be more favoured cost and availability constraints may point to the alternatives



stone glide



HALF BAMBOO GUTTER



LENGTH JOINT
HALF BAMBOO GUTTER

Glide

This is a very simple and inexpensive method. But it is applicable only to flat surfaces i.e. stone, concrete or slate. A narrow stone ledge is placed and joined in mortar across the slope at an appropriate angle to guide the water towards the downtake

figure ←

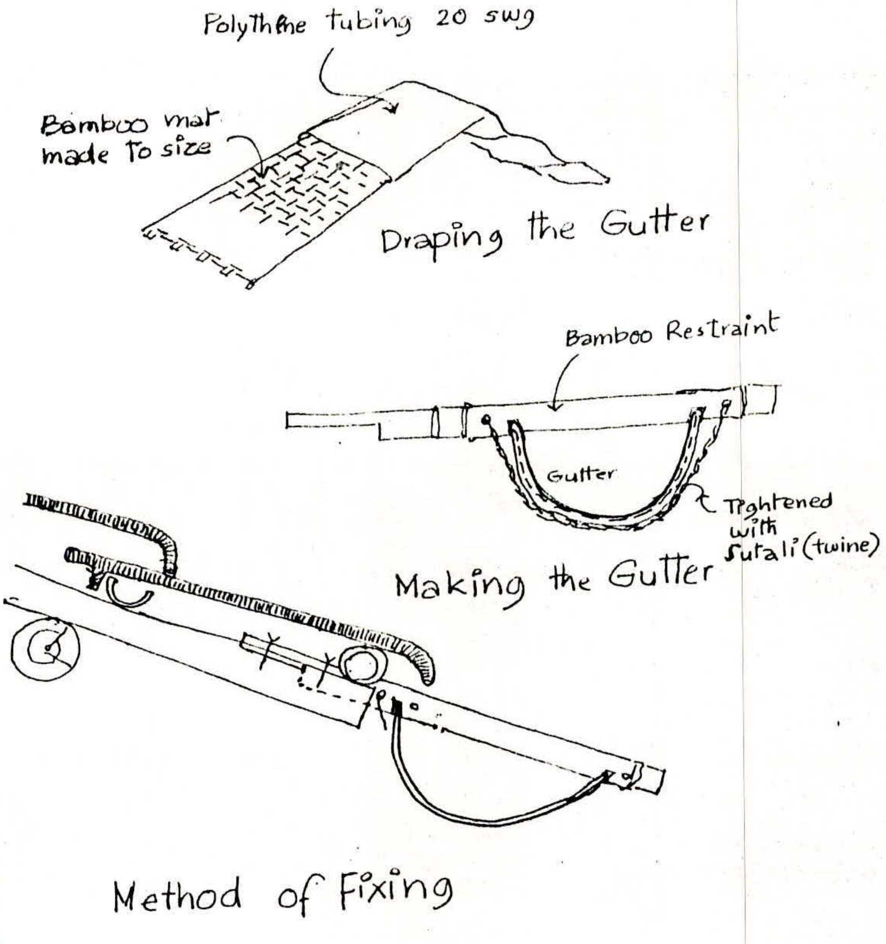
Bamboo Gutters

Gutters can be easily made out of bamboos, if bamoos of diameters +80 mm are available in close vicinity. Lengthwise joints can be made by cutting bamboos (of matching size) to true face by a hack saw. Use rubber sheet (from old motor tubes) as a jointer from underneath. Secure the rubber sheet to both the bamboos by G.I. wire. The butt joint should be caulked and sealed with hot bitumen. alternatively the joiner piece could be another bamboo of matching over size.

Figure ←

Bamboo Mat Gutters

When bamboos of required diameter/length are not readily available, gutters could be made



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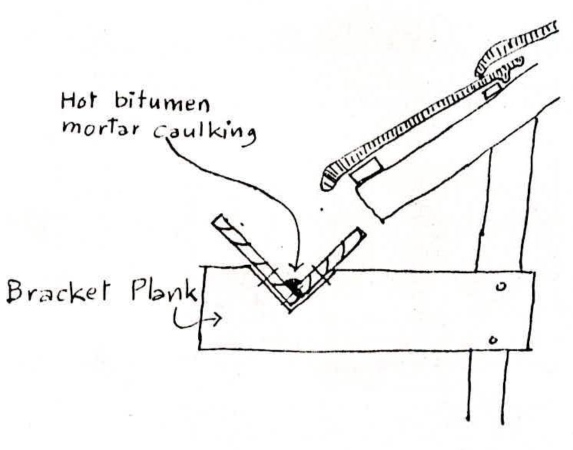
BAMBOO MAT GUTTERS



WOODEN GUTTER

out of polythene sheet draped bamboo mats. Mats should be woven to appropriate width - calculated from the diameter of the required gutter. After draping, the two surfaces of polythene sheet pipe should be welded by heated iron at suitable points. This sandwich should be then mounted on the bamboo restraint c brackets and fixed to rafters of the roof.

figure ←

(Please note that this is tried only at one place as an ordinary non RWH gutter but found promising)

Wooden Gutters

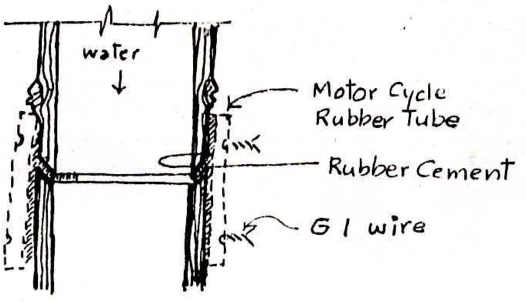
Gutters could also be made out of timber planks where available in lengths at low cost. A 'V' shaped notch is cut into the bracket planks and the length pieces nailed together as well as to the bracket. The groove between the planks should be caulked and sealed with heated bitumen sand 1 : ½ mortar

figure ←

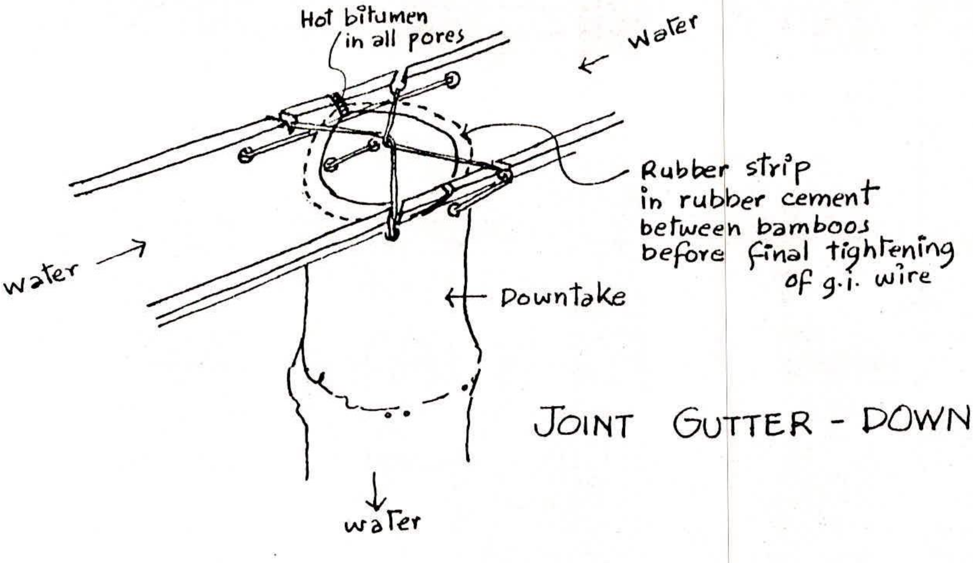
BOX

Treatment of Bamboo and Timber

Untreated bamboo and timber have a very short useful life if exposed to sun and rain as is



DETAIL OF VERTICAL JOINT



JOINT GUTTER - DOWNTAKE

bound to happen in this case. Drinking water use rules out tried and tested creosote / chemical / heavy metal treatments. The bio materials could be seasoned with water / steam / smoke and covered with a lead free paint fit for exterior use.

Traditional Bamboo Seasoning - A method

If bamboo plants are in the vicinity of the project, + 3 year bamboo culms should be felled in the dark half of the lunar month and dipped into water (full surface needs to be covered with water all the time) for a minimum period of one month. Immediately on removal from water the bamboos should be stacked vertically in shade for a minimum of 7 days for air drying. Paint etc should be applied after full fabrication and erection, in situ.

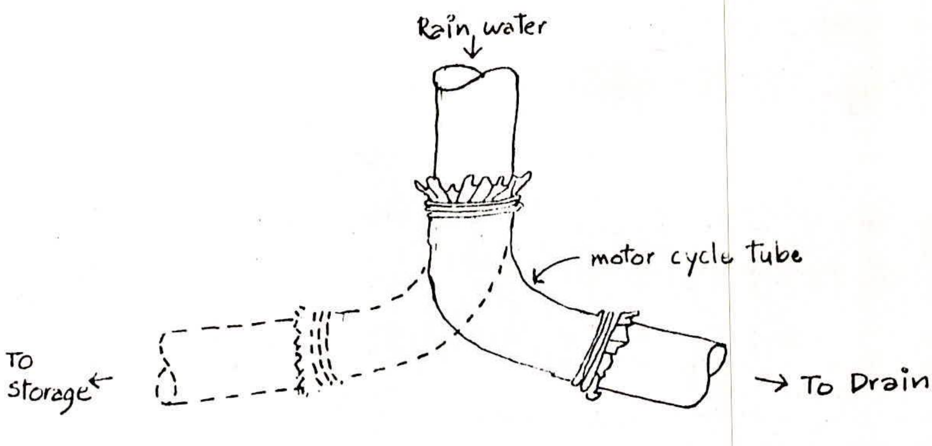
Box

Bamboo Downtake

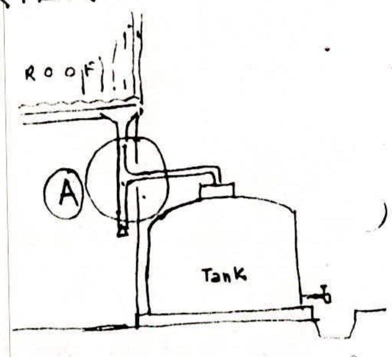
Whole bamboos can be used as downtake after burning off the nodes, if bamboos of +100 mm dia are available ~~in~~ at right price.

(Here are some exploratory suggestions not tried anywhere so far to the knowledge of us)

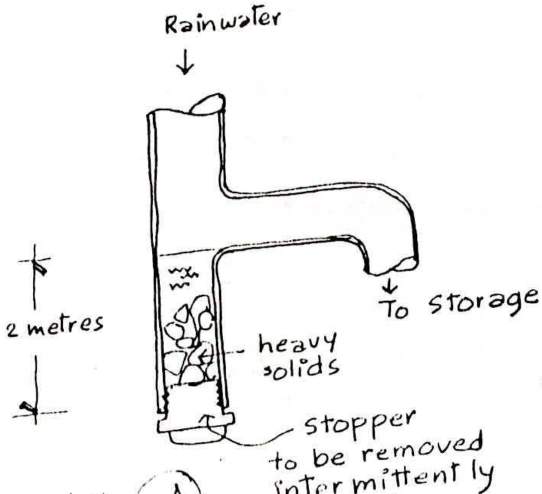
figure ←



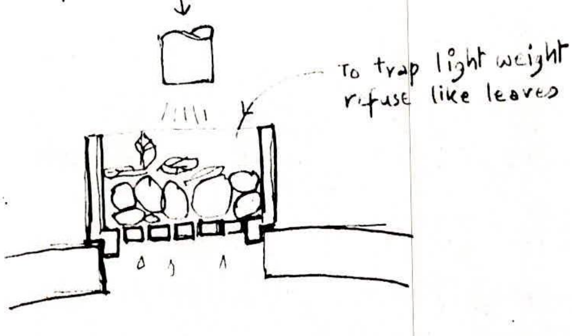
SIMPLE MANUAL DIVERTER



THAILAND TRAP



DETAIL A



DIVERTERS

In our country, roofs remain dry for long before it rains again. A lot of dirt, dust, leaves, bird/animal droppings etc accumulate on the roof during this period. The first showers send down a muddy flow laden with this refuse. This cannot be allowed to go into storage. A generally observed precaution is to get the roof surfaces broomed and swept before the rains which gets rid of most of this dirt but this is usually not enough and the first flushes still need to be rejected.

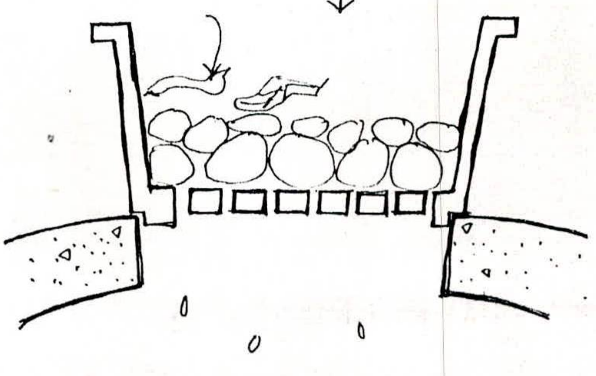
A very simple manual diverter can be made out of old motor cycle tube as shown in the sketch.

figure ←

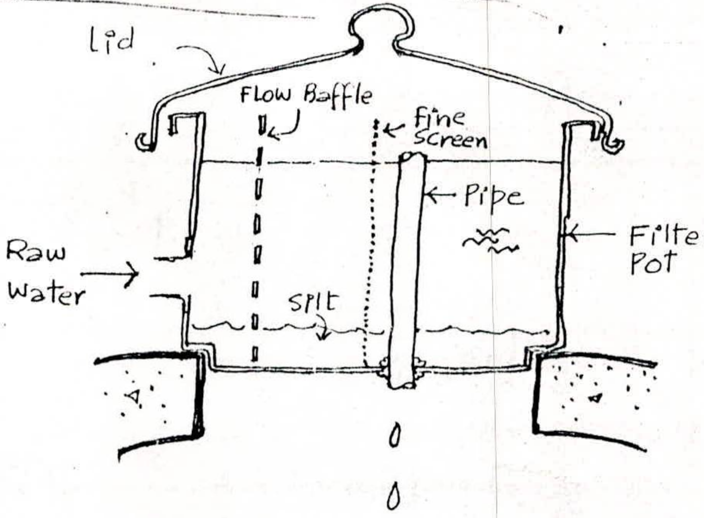
An Ingenius method was developed in Thailand to get rid of dust and heavy dirt automatically as shown in the sketch.

figure ←

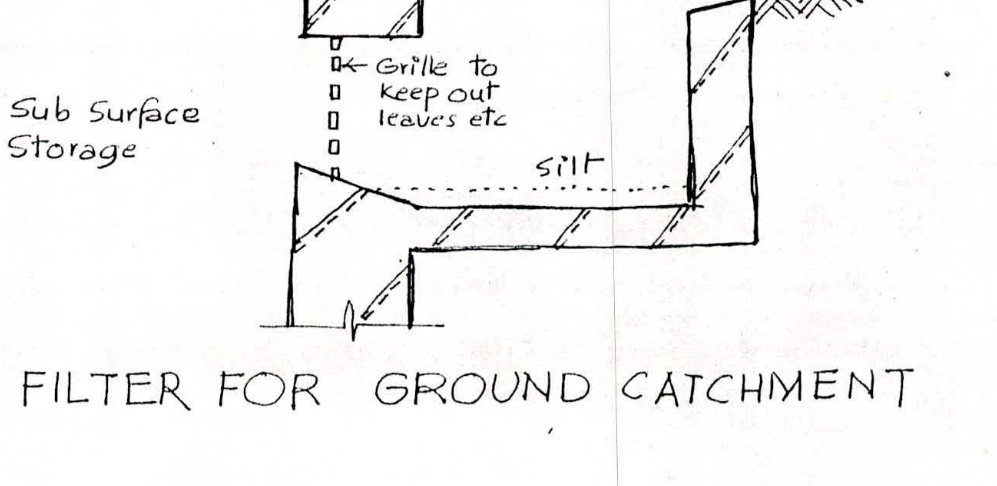
As a general rule simpler methods are more reliable as attention level drops after the first zeal (which may last a season) and any single link not functioning at its optimum may jeopardize the whole system. Besides this, they are usually expensive and could be bartered for a few m^3 more of storage.



COARSE FILTER



DETAIL FILTRATION



FILTER FOR GROUND CATCHMENT

FILTERS

Filters are an absolute must for all drinking water storage systems not only on ground catch but also for roof catch. They are best mounted on the storage container to disallow any further entrants into the water.

This simple coarse filter is meant to keep out leaves and other large sized refuse.

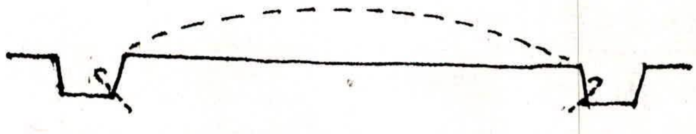
fig ←

This one keeps out light as well as heavy solids and silt. The flow baffle arrests the speed reducing the possibility of dirt gate-crashing while the fine sieve keeps out floating fines. The standing pipe allows only super-natant water in the storage leaving the silt in the filter pot to be removed from time to time.

fig ←

Ground Catchments necessitate ~~demand~~ slightly different types of filters.
This filter often employed in Rajasthan keeps out Large leaves and silt but allows floating fines.

fig ←



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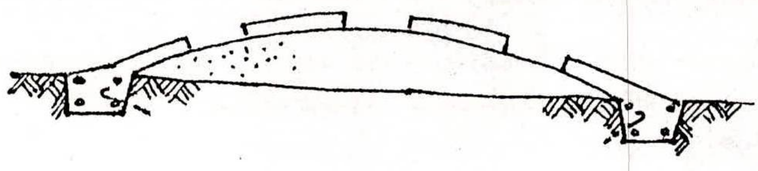

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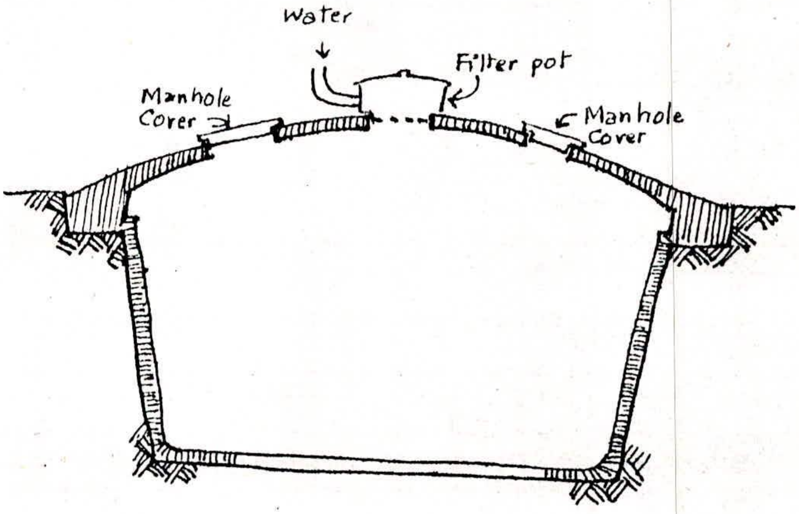


(3)

UNDER CARVED CONCRETE TANK

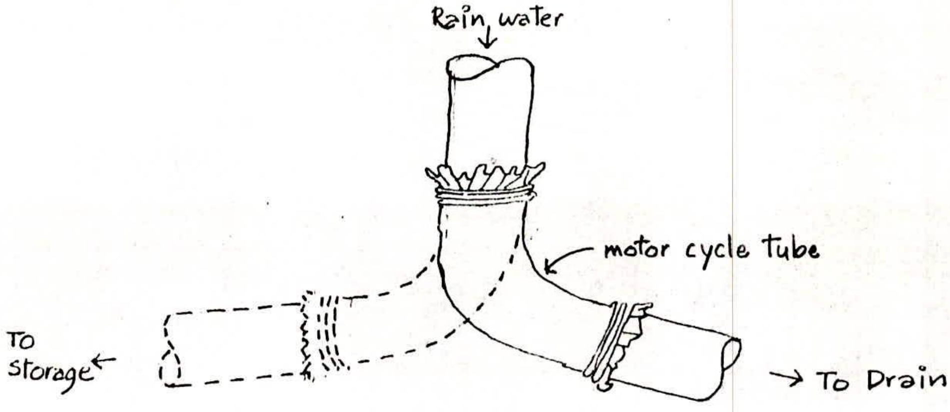
Automatic Foul Flush Rejector

This is a very interesting method particularly suitable for community projects. It allows collection of unwarned rains, getting rid of foul flush automatically.

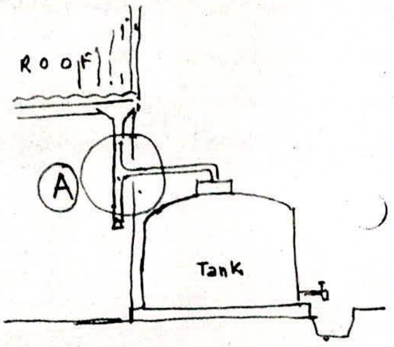
(fig)

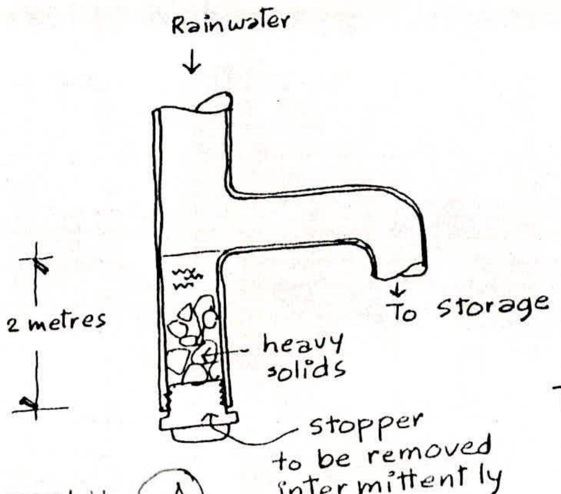
It works on the basis of a wooden float which tilts away ~~on its~~ the diverter as the foul flush receptacle gets filled with water, as indicated in the sketch.

The diverter is a channel – assymetrically positioned on a fulcrum ~~normally~~ tilted towards the container. The wooden float on the rejector side has just enough weight to keep the channel tilted towards the rejector. When water gets filled in the foul flush receptacle, the wooden float gets lifted up along the rise in the water level, finally tilting away the diverter towards the container.



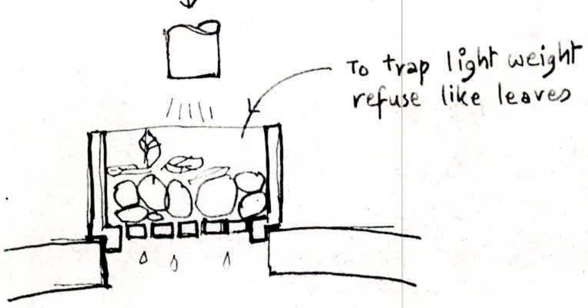
SIMPLE MANUAL DIVERTER





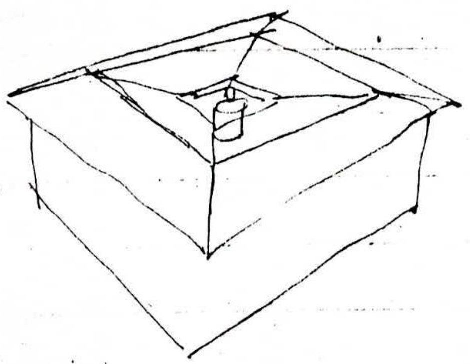
THAILAND TRAP

DETAIL A

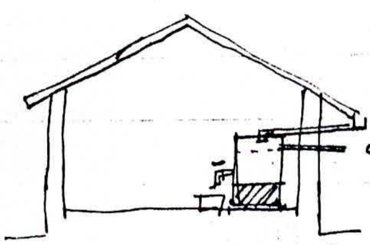


Instant Harvesting

In some parts of the world, particularly in island conditions, it rains throughout the year, ~~or~~ nearly every day. However not all these locations are free from water -and particularly drinking water- problems.

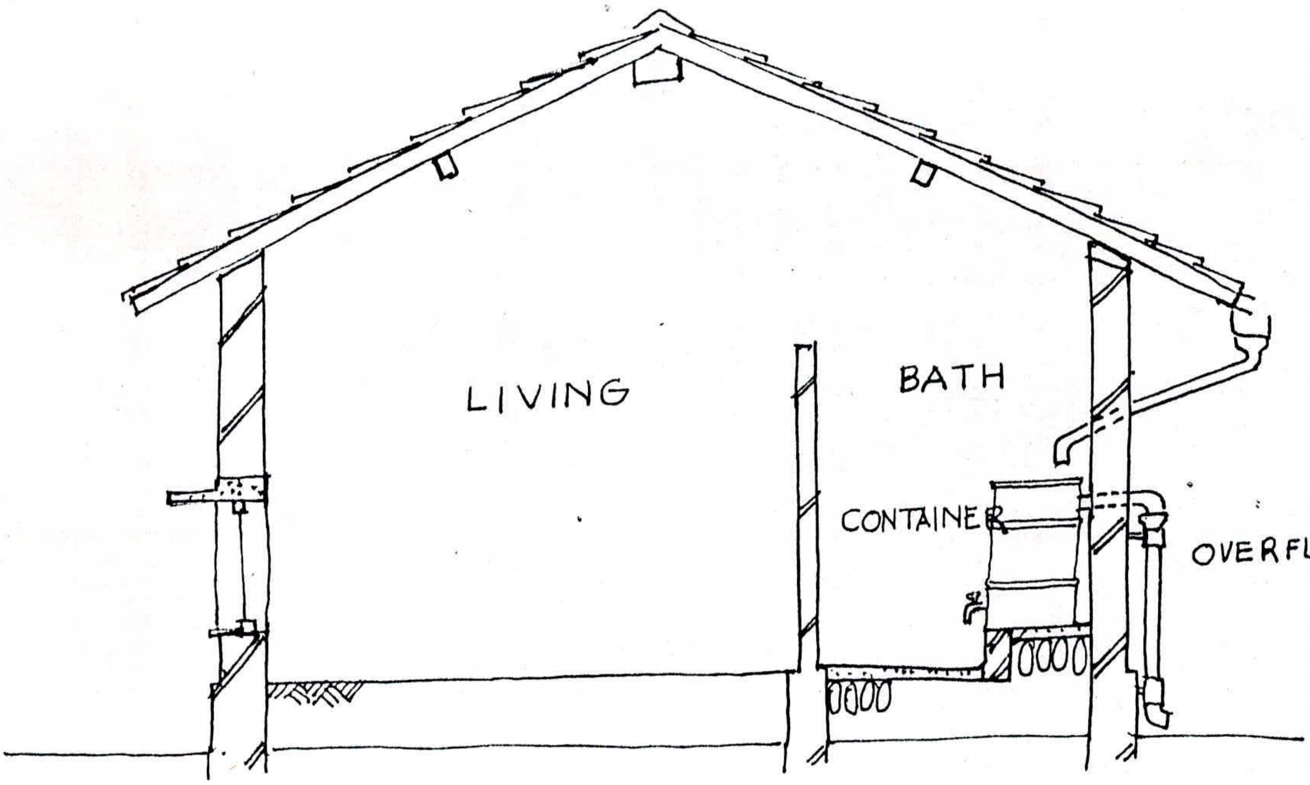


In such locations, a drum or a group of Ranjans (Terra Cotta pots) could be kept just under the gutter downtake to collect water.

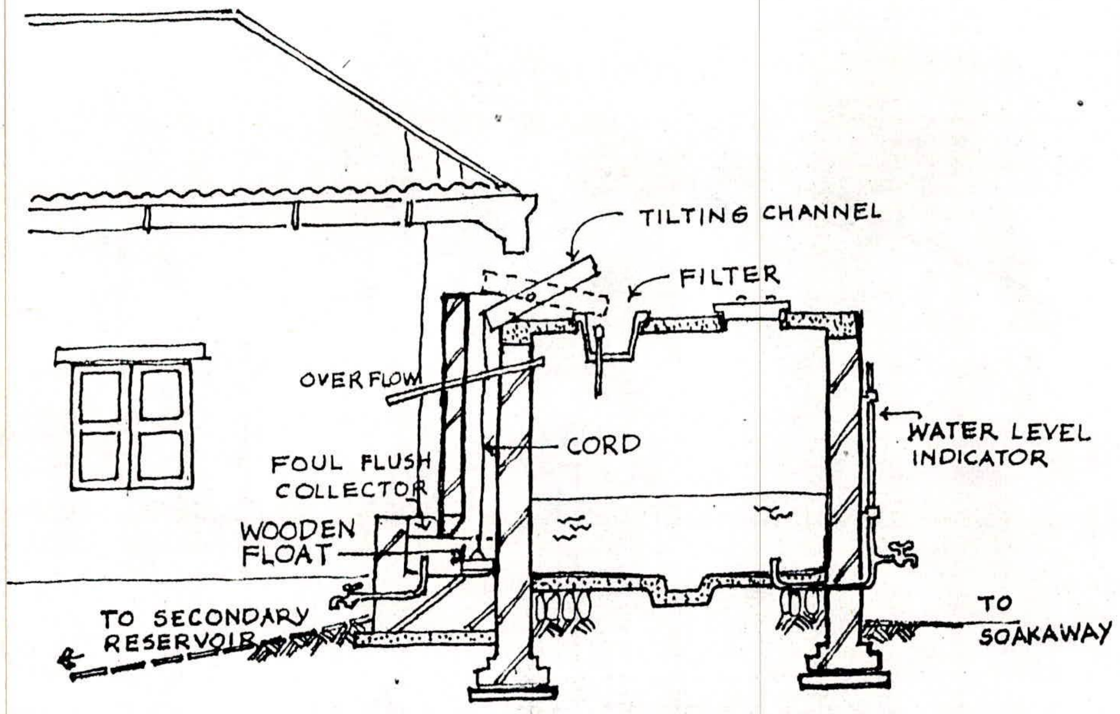


A further improvement could be to ~~place~~ carry the ~~drum +~~ down take to a water storage drum inside / or outside the house, with overflow throwing the water out of the house

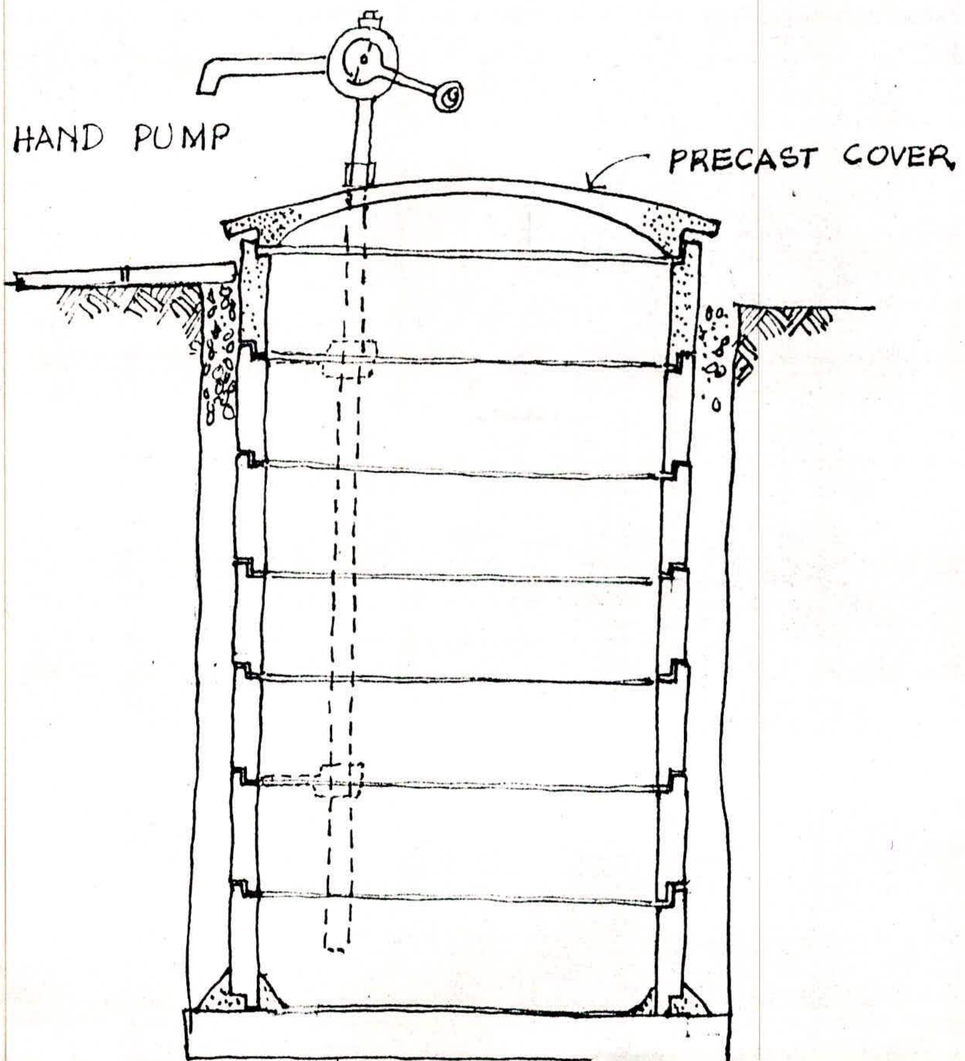
Since instant water harvesting may not remain free from contamination care would have to be taken to keep a continuous check on quality of water ~~t~~ and throw off bad water as and when necessary, to be able to collect the next rain.



INSTANT RW HARVESTING



AUTOMATIC FOUL FLUSH REJECTOR



STORAGE CONTAINERS

A container is the most expensive and also the most crucial component of the RWH system. This is particularly true in climates like India where collection and withdrawal may be six months or more apart in time. Till then the tank has to keep the water from such formidable enemies like leakage, evaporation, sunshine and contamination.

The high cost of containers has fuelled research in alternatives-low cost options. But serious break through is yet not in sight. The enthusiasm generated by bamboo reinforced tanks of YDD (Indonesia) ~~had~~ was short lived and led many low budget enthusiasts to frustration. The cement jars failed by leaking bottoms in many instances. Caution may be exercised in promoting only well tested technologies for storage containers.

A set of critical requirements common to all kinds of containers would be

- A secure man-hole cover to keep out contaminants and sunshine
- An inlet filter

- An overflow arrangement
- A sump (and clean out arrangement for flushing for over ground tanks')
- An extraction system that keeps out contamination
- A soakage system for the spilt water

Some elements would add to the utility of the system

- A water level indicator
- Foul flush rejection system
- A lock on the withdrawal end
- A secondary sub surface tank (in case of over ground tanks) to collect the spilt water and overflow for cattle or plant watering

TYPES OF CONTAINERS

1. BLOCK/STONE/BRICK & MORTAR

These materials are commonly used all over the country and the skills easily available. Appropriately dressed stone/laterite blocks would make the construction even easier. An interlocking brick design has been reported from Thailand but is yet to make grede as a field success. The roof of the tank can ~~also~~ be built in RCC, stone slabs, or in brick dome as per availability of skills

Supervision towards well proportioned mortar, ~~and~~ waterproof plastering to inside surfaces and thorough curing normally ensures success.

ii REINFORCED CONCRETE TANKS

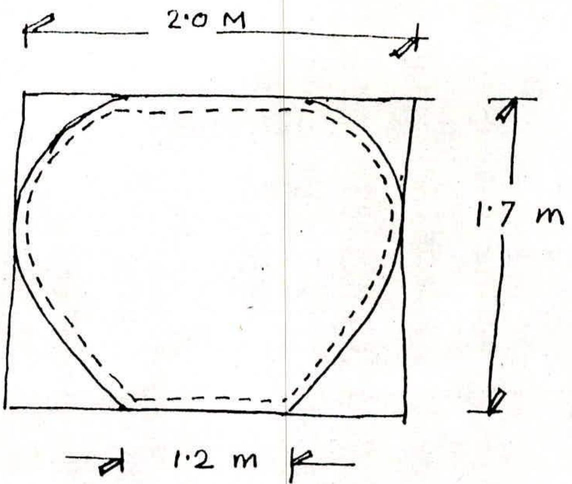
These are even more expensive but may be convenient in precast or partially precast (like well-rings) form. Centrifugally moulded (hume-pipe) RCC pipes too can be adapted to make precast storage tanks.

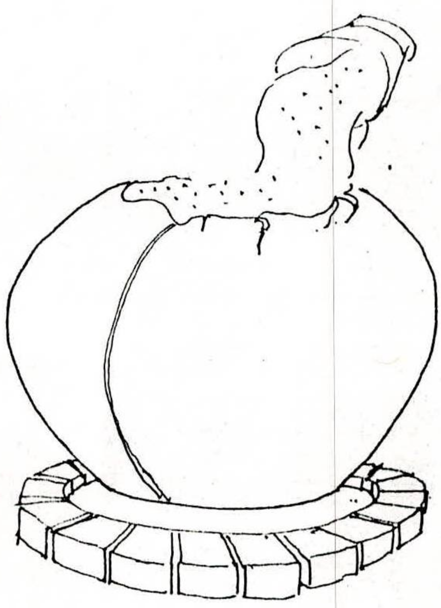
iii MOULDED PLASTIC TANKS

These are about the most expensive. But their watertight lightness may outweigh cost considerations in certain difficult locations. But they are ~~but~~ susceptible to vandal and rodent attacks. These tanks have attained phenomenal popularity as drinking water storage tanks in recent times and are available in most towns of the country.

iv PLAIN CEMENT JARS 1·0 M^3

A very interesting method has been evolved for making cement mortar jars upto 2 M^3. Two pieces of gunny cloth (fresh or out of used sacks) should be cut and stitched to each other as shown


2·0 M
1·7 m
1·2 m



After stitching the bottomless bag, it is turned inside out to provide a neat surface for plastering over it.

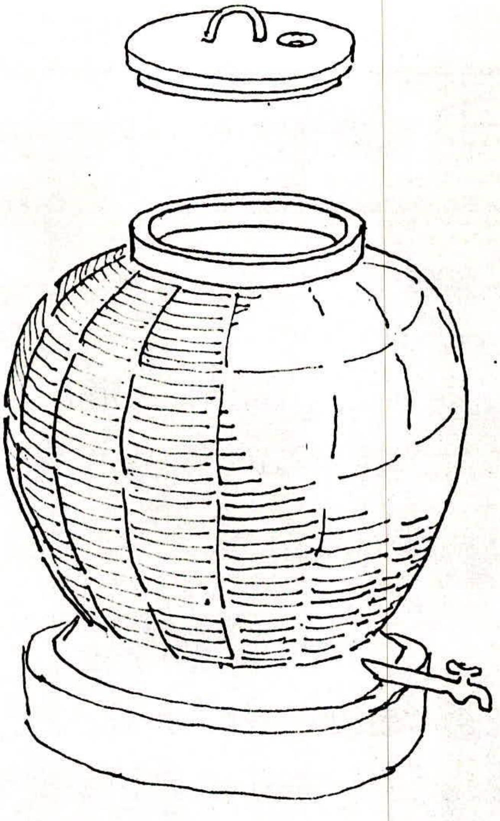
2) To make the bottom of tank, mark out 1·0 m dia circle on the ground. Place half bricks or some other material available at the site to contain this circle. Place polythene / paper sheeting over this inscribed circle to break contact with the jar to be made over it. Mix 1:2 cement sand mortar thoroughly mixed dry and water 0·6 parts by weight of cement added thereafter and lay this on the circle to a thickness of 15 mm.

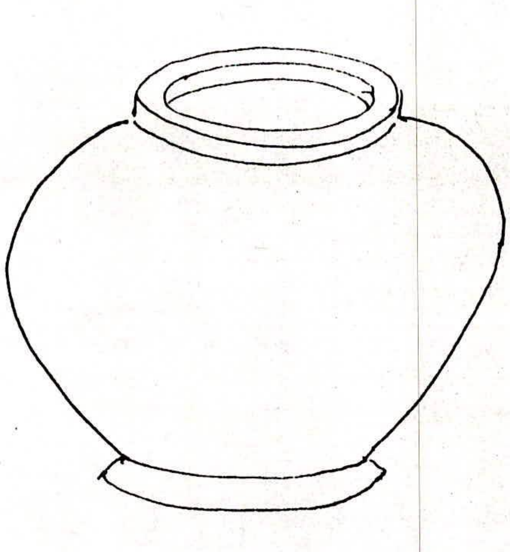
fig ←

3) Before the cement plate sets - but after initial drying - place the sacking bag narrow end down and start filling the sack with saw dust / sand / rice husk. Make sure the mortar base sticks out from under the ~~skel~~ sack as shown in the sketch and tuck the edges of the sack between the filling and the base to be held down by the weight of the fill, with sufficient and uniform margin all around.

fig ←

4) Fold the top and tie it closed. Smooth and press the sack into a regular shape. Make a wooden ring (or a precast one in cement mortar) 80 cm external dia to work as formwork for casting the lips of opening.





'GHALA' TANKS

'Ghala' means granary basket in Kenya. Cement mortar is plastered on this basket to store water in that.

In Kenya a Ghala is traditionally woven out of a woody shrub growing wild. Baskets could also be made out of bamboo for this use. Any strong basket would do for this purpose. In making the basket, the bottom should be ommitted to ensure a better structure.

METHOD OF CONSTRUCTION (2·3 M^3 capacity)

1. Construct a stone foundation 2 metres dia and 20 cm deep. Level the top to receive concrete.
2. Place water pipe with socket etc as shown in the sketch
3. Lay 5·0 cm thick concrete 1:2:4, working around the pipe arrangement and embedding it in the process.
4. Before the concrete hardens place the bottomless basket ~~on~~ centrally on that. The basket should sink into the concrete to 15-20 mm depth. Go on to build a retaining toe rim at the base, to hold the basket firmly in place and allow the whole thing to harden.
5. Start plastering the inside of the tank from

bottom up, dashing hard on the weave so as to work into it and smearing the 1:2 mortar first coat 15 mm thick. Take care to bond the sides with the base and smoothen the sharpness with fillet. ~~if~~

6. Immediately after drying of the first coat, scratch it lightly and apply the second coat to another 15 mm thickness. The outside may now be plastered similarly in two coats. Mould the lips.
7. Cure the tank by draping wet sacks around the tank after the cement sets. After 12 hours, fill the tank to quarter capacity.
8. Cast the lid in ferro cement or reinforced concrete to a thickness of 3-5 cm depending upon the size of the opening.

UNDER-CARVED CONCRETE TANK

This is another interesting method suitable for soft soils. It is constructed roof down, without normal formwork.

$18\ M^3$ CAPACITY TANK

1. Excavate a trench 30 cm x 30 cm in cross section, to a circle of inside diameter of 3·6 metres. Tamp up the soil and plaster the sides with clay and cow dung slurry. Keep the excavated material on the inside circle Tamp it up to form a mound

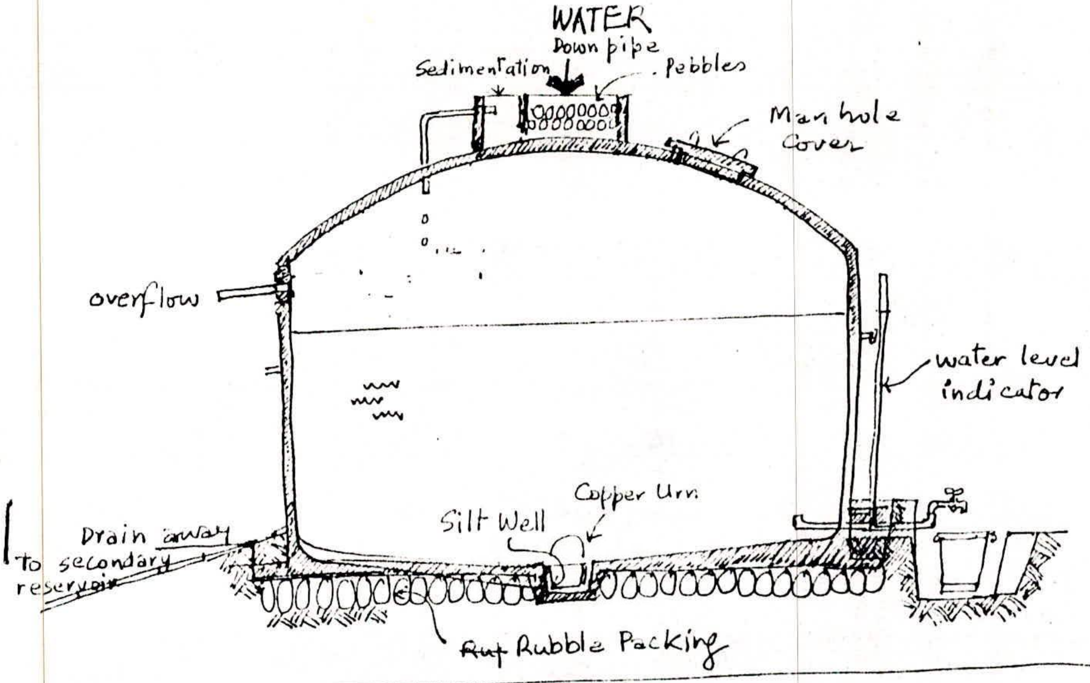
fig ←

2. Lay beam reinforcement cage in the circular trench and cover the mound with dome reinforcement positioning two manholes 45 cm diameter, one on each side and a water inlet arrangement at the crown. Take care to keep the whole of iron 2 cm clear of ground. Lay 1:2:4 cement concrete. Cure well.
3. Two weeks after this, carve out the soil from under the dome to a depth of 3.5 metres. The dowels anchored in the ring beam will be visible on the side and this is an indication of caution too. Dress the soil ~~under~~ beside the beam to leave the support intact. Build the walls in ferro cement anchoring it into the dowels on top and the floor at bottom. Lay concrete on the floor, embedding a reinforcement cage and incorporating a sump.
4. Plaster the sides, ceiling and the floor in that order, applying two coats covering up any minor depressions / bulges. Cure well.

FERRO CEMENT TANKS

Ferro Cement comprises of cement and sand mortar with steel reinforcement. Absence of coarse aggregate enables thinner sections with higher impact strength accruing from close weave meshes. The concept and practice is even older than reinforced concrete but has fallen out of favour for being labour

DIAGRAMATIC SECTION THROUGH
TYPICAL FERRO CEMENT TANK



intensive.

In 1847, barely a decade after portland cement was patented in England, a Frenchman J.L. Lambot filed a patent to produce wire reinforced cement boat. In 1867, another Frenchman J. Monier displayed wire reinforced cement pots at a World exhibition at Paris. (This J. Monier went on to become famous as father of reinforced concrete). P.L. Nerwi an Italian engineer of more modern times, built his famous Turin Exhibition Hall with spans as large as 91 metres using a combination of Ferro-Concrete and Ferro Cement, in post war Italy.

Salient Features

- Can be worked to much lower thicknesses still retaining imperviousness to water (15-20 mm as against the minimum of 60 mm in case of ferro concrete) and impact strength.
- Lighter and transportable
- Repaired easily
- Over all costs per litre nearly same as for ferro concrete, needing more on laboure but less on materials
- Can be prefabricated or cast in situ. Has been recently adapted to large scale semi-mechanized partial pre-fab by Structural Engg. Research Institute Ghaziabad
- Costs Rs. 1·20 to 1·80 per litre now.

Schedule of Material Consumption

Item of Material	Size of Ferro Cement Tank		
	10 m3	20 m3	30 m3
1. Portland Cement (bags)	28	46	68
2. BRC Weld Mesh 6"x6", 7'x150' (rolls) N° 65 or 66 (m)	20	30	40
3. Chicken Mesh 1" size 3'x100' (rolls)	1	2	2½
4. Binding wire 16 swg (kg)	6	10	13
5. Clean sand (m3)	1·5	2·5	3·0
6. Coarse Aggregate 20 dia (m3)	0·8	1·3	2·0
7. Water Tap (Unit)	1	1	1
8. Copper Urn (No)	1	1	1

Taking into account the rather low exposure of our building artisans to this useful technology it has been decided to detail this rather elaborately, for cylindrical tanks.

Dimensions for ferrocement tanks

Dimensions	Capacity 10 m³	20 m³	30 m³
Internal Diameter	2·66 m	3·76 m	4·60 m
Foundation slab diameter	3·02 m	4·10 m	4·95 m
Diameter of the mesh circle	2·72 m	3·82 m	4·66 m
External diameter	2·76 m	3·86 m	4·70 m
Height of the ~~structure~~ side walls	1·80 m	1·80 m	1·80 m
Level of overflow	1·65 m	1·65 m	1·65 m
Mesh circumferences incl. 30 cm overlap	8·85 m	12·30 m	14·94 m

From among the list choose your size if possible. This will give you a ready made list of materials.

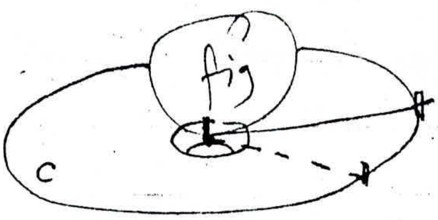
Table

←

Preparation of Ground

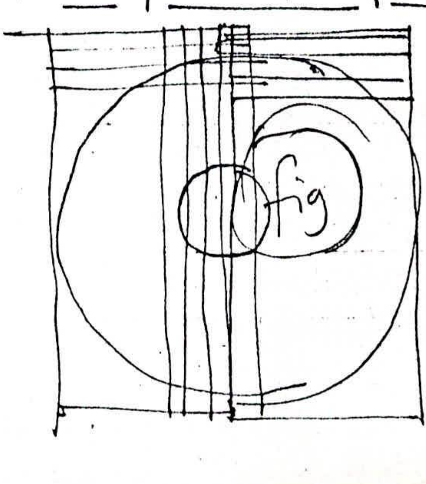
Like all ~~sub~~ surface tanks one has to take care to provide strong foundation, in the case of Ferro Cement ~~bd~~ tanks. Select the location of the tank from the view point of proximity to catchment. If this happens to be on sloping ground you will have to level this. Mark out an area approximately ·1·5 M larger than the diameter and level it. If the ground happens to be rocky, remove the soil between the rocks including loose stones. fill up these gaps with lean concrete and level it.

On the levelled ground mark the foundation slab circle. To mark out circle use a string and two pegs as shown in sketch. Remove top soil. If this is more than 10 cm, continue removing till exhaustion of top soil and fill back with hard core. If available, fill up this now with water and allow it to stay overnight, Ram the filling next day to obtain a sound bed to lay concrete upon. Mark out the trough for urn and excavate and shape it properly.



Preparation of Reinforcement

On a flat area near the tank, mark out a circle with the foundation radius. Lay the mesh on the circle as shown in the

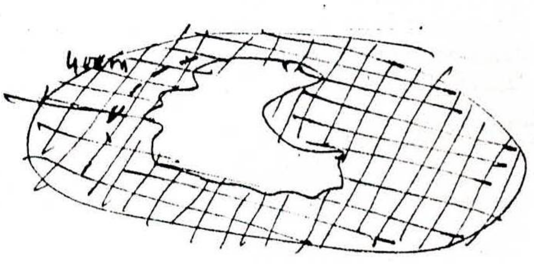


sketch and mark the cutting points to make the whole circle. Trim off the corners and save the pieces for future use. Make sure the two pieces overlap at least one square. If any part of the circle remains yet uncovered, fill it up with one of the pieces. Trim off again and tie with binding wire to make the circle true and complete. Mark out the urn receptacle, cut off the circle and tie trough shaped mesh in place.

Preparation of the floor

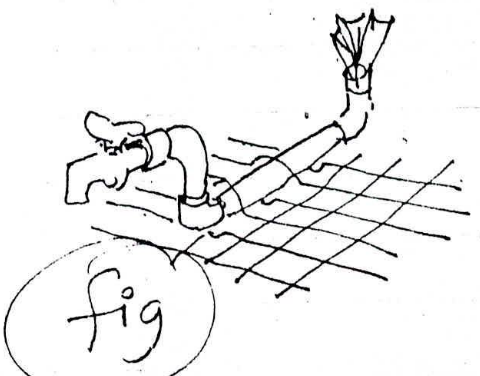
Prepare a mixing bed with bricks or iron sheet etc. Mix cement, sand and aggregate 1:1:2 in dry state, on this bed. Thoroughness of mixture can be ensured by achieving uniformity of the colour. Now add water carefully to this mix. The quantity of water should be just enough to make ~~the~~ ~~ma~~ it workable. If your material flows off the shovel or gets separated, it means your concrete is too wet. This excess of water means porosity and weakness of your final product. Carry this concrete to the tank site.

Fill this concrete on the prepared sub base to a depth of 5 cm and ram it. The right kind of stiffness in concrete will need good ramming. Pour more concrete and ram it to a compacted thickness of 5 cm. Place the reinforcement on this. Mix another batch of concrete and place it on the mesh 40 cm inside the diameter on all sides, to a compacted



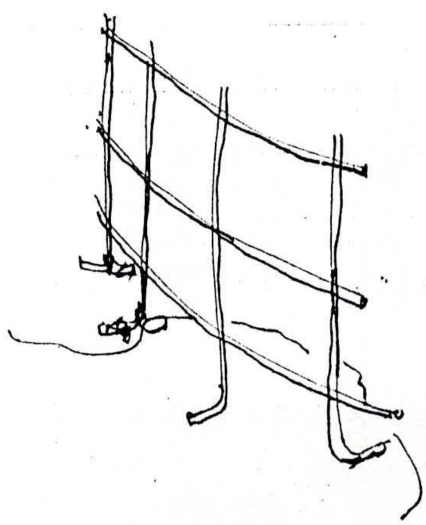
thickness of 5 cm.

Take the outlet fixture and stuff some paper into the open end to prevent mortar or other dirt choking it during construction. Fix this ~~part~~ on the side of desired outlet and tie the pipe to the reinforcement, with alternate mesh wire on top and bottom of the pipe as shown in the sketch.



Preparing the Wall Reinforcement

Find the length of reinforcement in the table under BRC mesh. Cut the material to form the cylinder with the ends overlapping at least two squares min. 300 mm. Tie the overlaps securely.



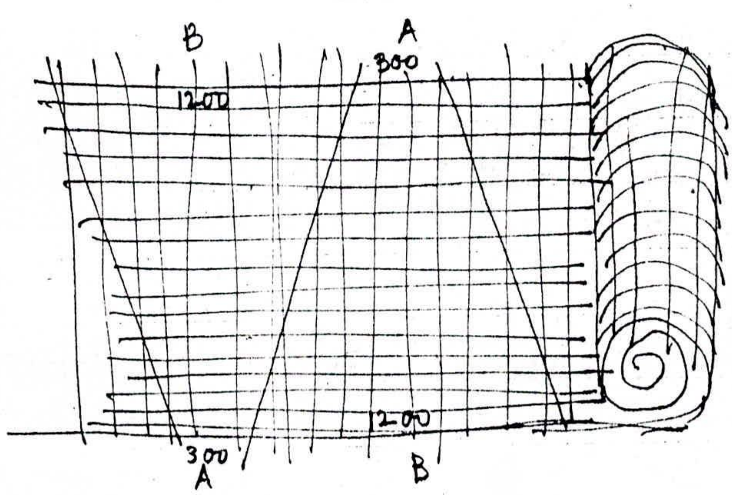
Bend the vertical wires of the cylinder at perpendicular to its surface on either inward and outward side alternately, on the floor side as shown in the sketch.

Place the cylinder on the mesh to form a true cylinder and

and tie it securely to the mesh below. Prepare another batch of concrete and place it on the floor to complete the foundation diameter to a compacted thickness of 5 cm, making the overall thickness 10 cm. Cover the inside and outside of the circle ramming carefully and firmly without working on the wall reinforcement. ~~Cover~~ Place covers on the concrete to prevent evaporation and allow it to cure overnight.

Next morning, removing the cover splash water all over the concrete surface, now keeping it moist throughout.

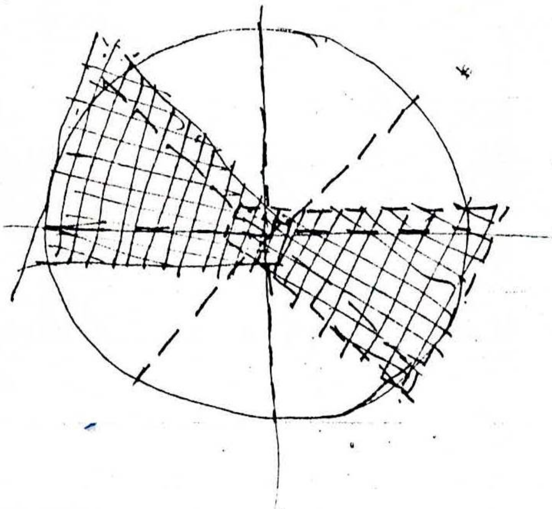
Preparation of Tank Roof Reinforcement



Plot a circle with the radius of the tank wall on a nearby piece of ground. Place a wooden or concrete block about 45 cm tall at the centre of this circle.

Open out the BRC mesh and mark out 8 trapezoids to ~~st~~ complete the circle with min.

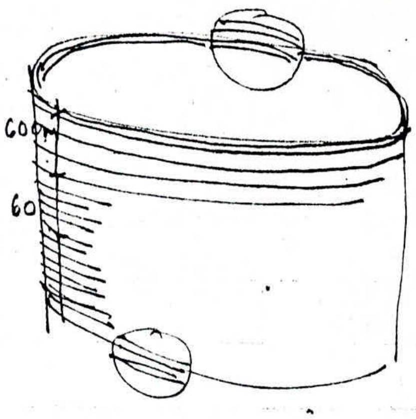
20 cm overlap. The trapezoids could be cut as shown to avoid wastage. Place the trapezoids on the circle with the smaller portion at the centre on the block. Tie the pieces together ensuring 20 cm overlap. ~~Ex~~ Make sure of the rigidity of this by lifting without loss of form. Trim off the triangles. Tie chicken mesh all over.



Further Work on the Tank Wall

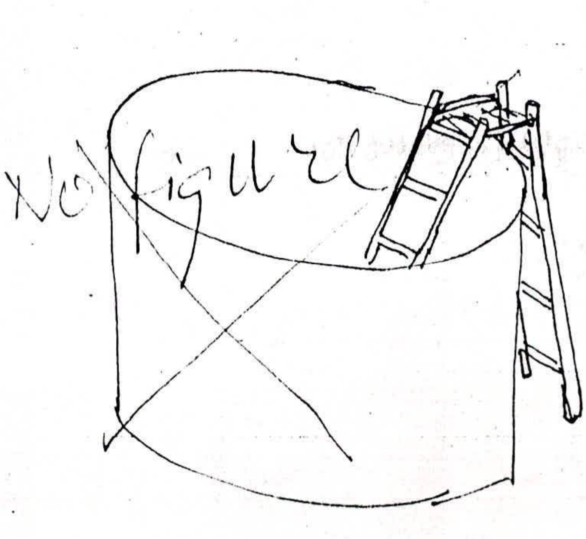
Take wooden planks 3 nos and fix them on diameters just below the top of the cylindrical ~~shape~~ mesh. This will provide the rigidity necessary for the work ahead. Now take the chicken wire roll and start wrapping it ~~upon~~ around the cylinder, pushing the top edge of the chicken mesh over the free vertical end of the mesh. While encircling, tighten the mesh in both vertical and horizontal directions, with one or two helpers, one holding the roll and the other two tightening and tying with binding wire. Overlap the chicken mesh at least 20 cm. Depending on the available width of chicken mesh, it may take three or more layers. Take care to provide 20 cm overlap in all directions. Tighten up

all sags and ~~bulg~~ bulges.
Now take the 16 swg binding wire roll and wrap it around the cylindrical cage four times around the top. Proceed to spiral the wire around the cage at a pitch of 10 cm for next 60 cm height, pulling it very tight. Proceed to next 60 cm height at a pitch of 8 cm. Now adopt a pitch of 5 cm for the remaining height. At bottom again wrap the wire around four times. If at any stage the roll is exhausted tie the end tightly to a vertical mesh with pliers and start the next roll.



Wrap loose sacks or other such material around the outside, ~~stich~~ stitched to each other and tightened further to the cage by wrapping sutali (string) at a pitch of 5 cm all over.

Now prepare a laddder which will allow men and materials to move in and out of the cage without causing any damage/ vibrations to the



structure. Inside and outside there should be enough ~~spa~~ working space between the ladder and the cage. Now remove the timber planks. This may result in the loss of shape of the cylinder and this should be corrected by guy wires on the outside. The binding wire can be used for this purpose, one end tied to the cage and the other pulled with just the right strength, securing it to a bamboo peg driven deep into the ground.

Plastering the Tank from Inside

For plaster also, thorough dry mixing and optimum water content are essential to strength and impermeability. It is also necessary that the whole of inside plastering ~~must~~ must be completed in one operation to reduce the likelihood of cracks. It may be wiser to have two plasterers carrying on the plastering from opposite direction to finish to a common point. Start from the bottom, smearing and pushing the plaster through the wires, going up till you reach the top horizontal wire. Fix ~~outlet~~ overflow pipe during plastering at 15 cm below the top. Do not smooth the plaster. Cover the plaster with plastic / gunny sacks at the end of the work to prevent drying. This plastic could be hung from the top vertical wires of the cylindrical cage. Do not forget to keep the floor ~~wet~~ covered with wet gunny bags. The floor concrete should not be allowed to become dry.

Remove the plastic cover only immediately before applying the second coat on the next day. This mortar can be a little wetter to allow it to be smoothed but should not become shiny. The wall thicknes should be 5 cm overall, only 3 cm of that should be inside, covering sags and bulges. Again take care to finish the second coat in one operation, if necessary with two plasterers. ~~After~~ Use only wooden float. Cover the work with plastic immediately after the work.

Now remove the cloth from outside and apply plaster to a thickness of 1 cm, filling the sags and levelling them with the bulges, without using float. Cover the plaster again till next day.

Apply second coat of plaster from the out side next morning and float it to a smooth plumb wall.

Prepare cement slurry with equal proportion - by weight - of water. If possible apply this ~~slurry~~ slurry on the inside plaster ~~the~~ on the same day of applying second coat. If this is not possible splash water to wet the plaster thoroughly and apply with a steel trowel, leaving the bottom 15 cm height uncovered for receiving round skirting. Cover the finished surface again. Clean the floor, ~~of~~ removing mortar and other debris, splash with water to keep it wet.

Next day, clear the floor again

washing off all dust and silt and mop it up if necessary. Prepare a stiff 1:3 cement mortar and lay it on the floor, 4 cm thick on sides reducing to 1.5 cm at the urn receptacle. Finish the plaster with a wooden float. Give the plaster a few hours before you start the next job.

Now lay wooden planks on the plaster below to enable you to work without damaging the green work. Prepare 1:3. stiff cement mortar and fill up the corner between the vertical and the horizontal ~~s~~ surfaces with a round fillet 10 cm ~~verti~~ both sides. A round glass bottle can be used to compress this fillet to the desired profile, if necessary adding a little mortar to compress into the loose parts. After this you can now apply cement slurry to cover the fillet, meeting the slurry finish of the vertical wall. This whole operation should be done by going around in sequence to allow enough drying to receive the next operation. The slurry finish for the floor has to be taken up only after the roof is finished. Pour water on the floor to keep it ~~weight~~ wet.

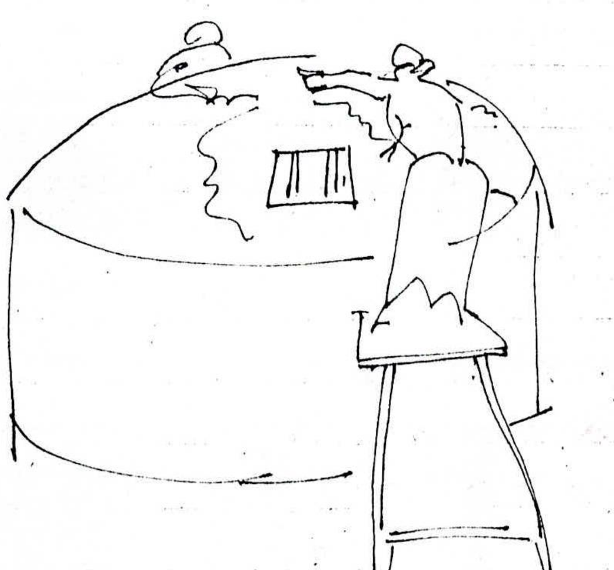
~~Remove ladde~~

~~Preparin~~ Further Work on Roof Reinforcement

Turn the roof cage upside down and start covering it from the inside with cloth.

⊛ Remove ladders and other big things from inside before mounting the cage.

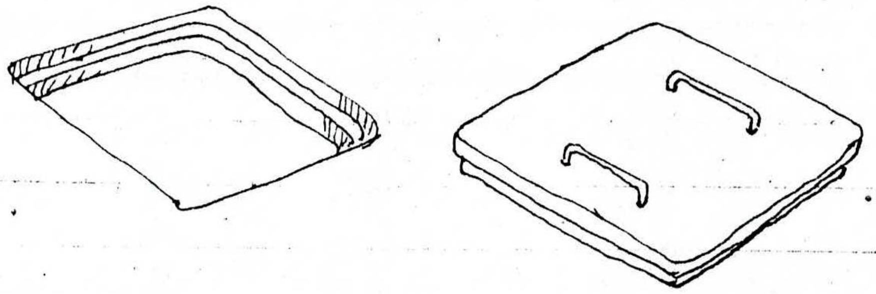
Stitch the cloth tight with each other piece and sew it tight with the cage. Make sure of this tightness by again turning the cage over without the cloth bulging. Remove the bulges if any by futher tightening. ⊛ Mount the cage on the cylindrical wall and secure the two together by binding wire and pliers. Now cut off a manhole cover ~~450~~ 45 cm x 45 cm and surround this cut out with extra ring of reinforcement. Trim of all excess wires and sew back the cloth where sagging. Now fix up inlet pipe plug/s where required, piercing through the cloth. Now support and prop this cage to ~~tot~~ withstand the load of workers.



Prepare 1:3 mortar and apply it on top. If necessary this could be a little more wet than the earlier ones. After this ~~Plastering~~ first coat is over, apply covers to prevent drying. Next day remove the covers to apply the second coat and smooth it with a wooden float.

Prepare manhole cover in a mould

carved in a nearby piece of ground. Make ~~shou~~ sure the thickness does not exceed 3 cm and that the reinforcement stays in the middle of this thickness. Allow the manhole to cure for 3 weeks.



Do not forget to place hooks before casting.

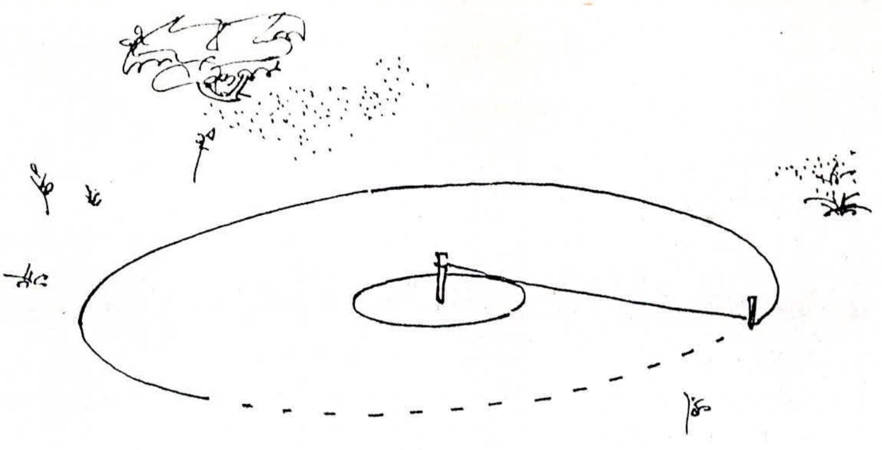
Inside Ceiling Plastering

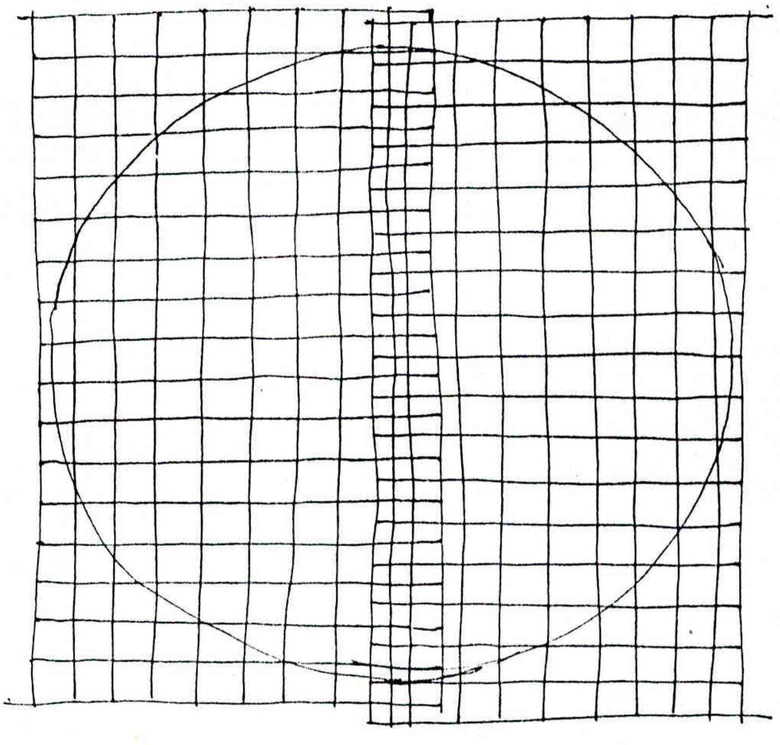
Allow two days after the plastering from top before removing the props below. Now you may plaster it from below with the help of stools placed on planks etc. This plastering must cover all iron from contact with humidity and condensation inside the tank during its life.

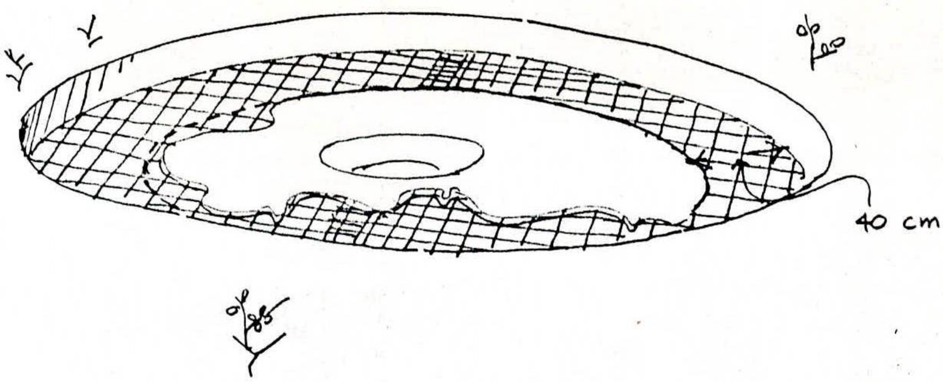
Now remove every thing from the floor. Broom and if necessary mop it clean of all dust and debris. If there are marks or potholes patch them ~~smoth~~ smooth with a stiff 1:3 cement mortar.

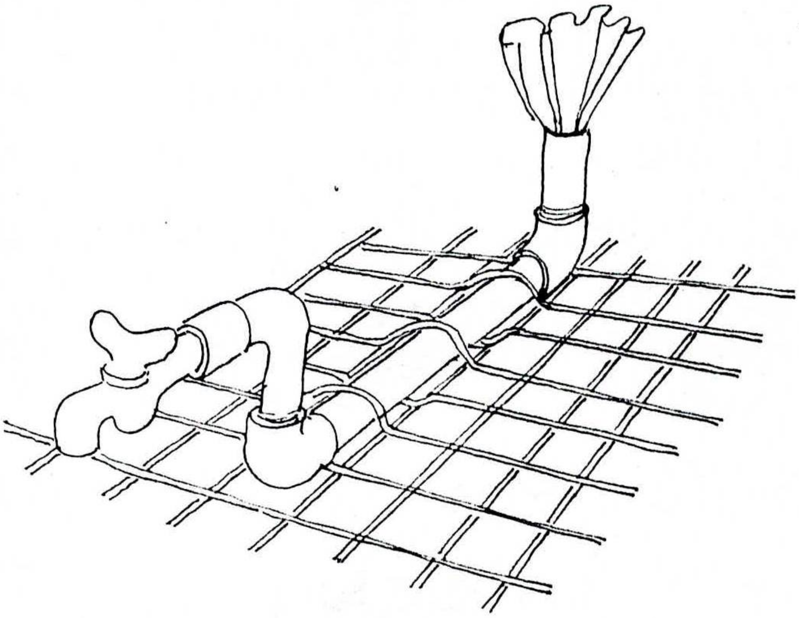
Now prepare a cement slurry with a quantity of fine sand (1 : ½ cement and sand) and add water to produce a mortar stiffer than the slurry used before.

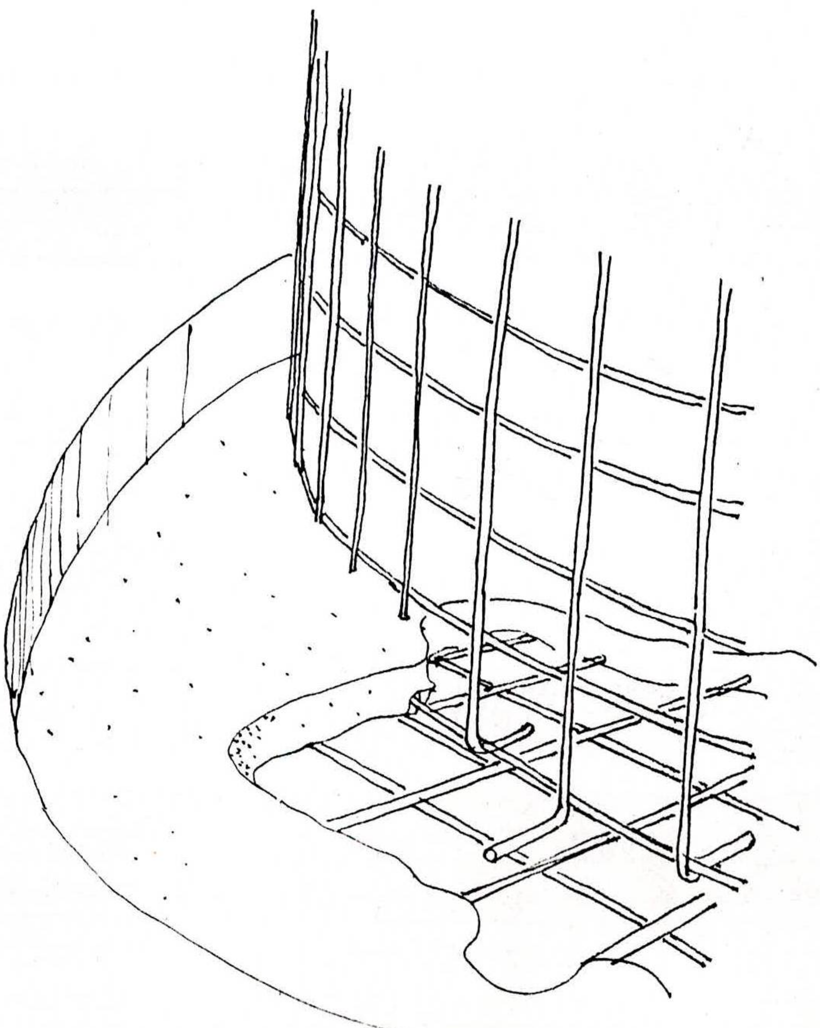
Apply the slurry on the floor, working in such a manner as not to disturb the green cement surface in the process. This can be achieved by first making a 60 cm x 60 cm patch immediately below the manhole and starting off towards the edges finally working from a plank on the first patch. After some initial drying of this slurry finish, put wetted gunny sacks to cover the floor completely. Allow this two days when you should cure properly. Do not pour curing water with buckets or directly from hose. Do this with a plank covered with gunny cloth so as to deaden the speed of water. Fill up the reservoir to a level of 10 cm.

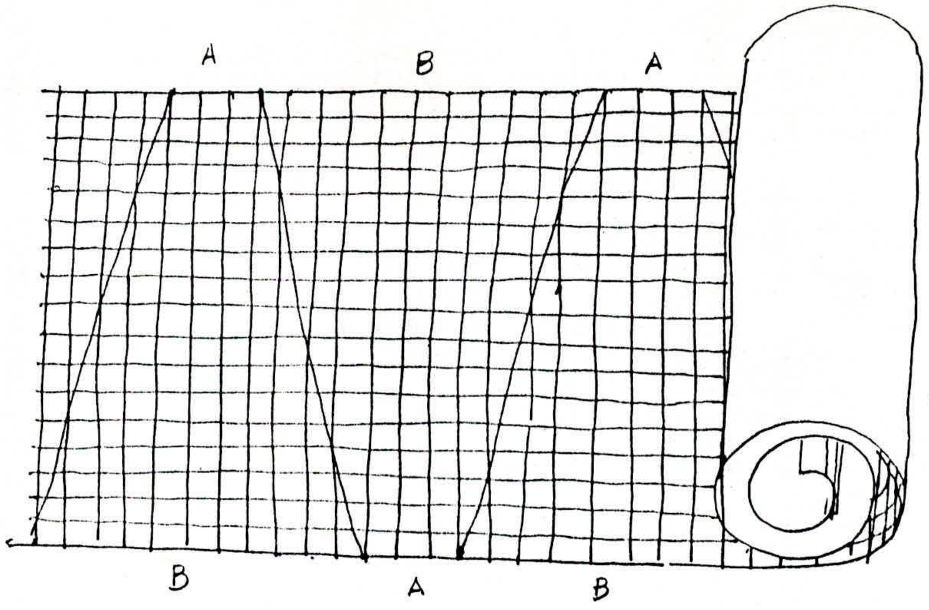





40 cm



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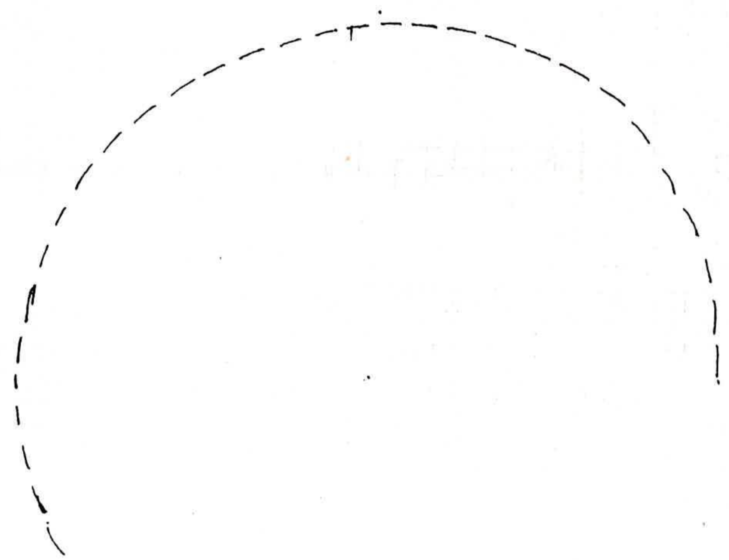
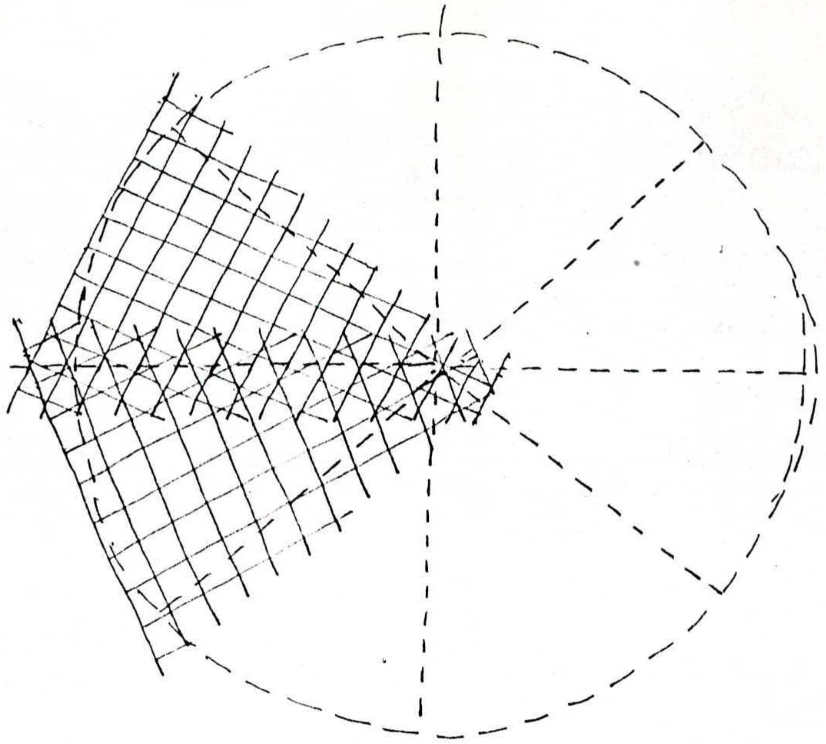
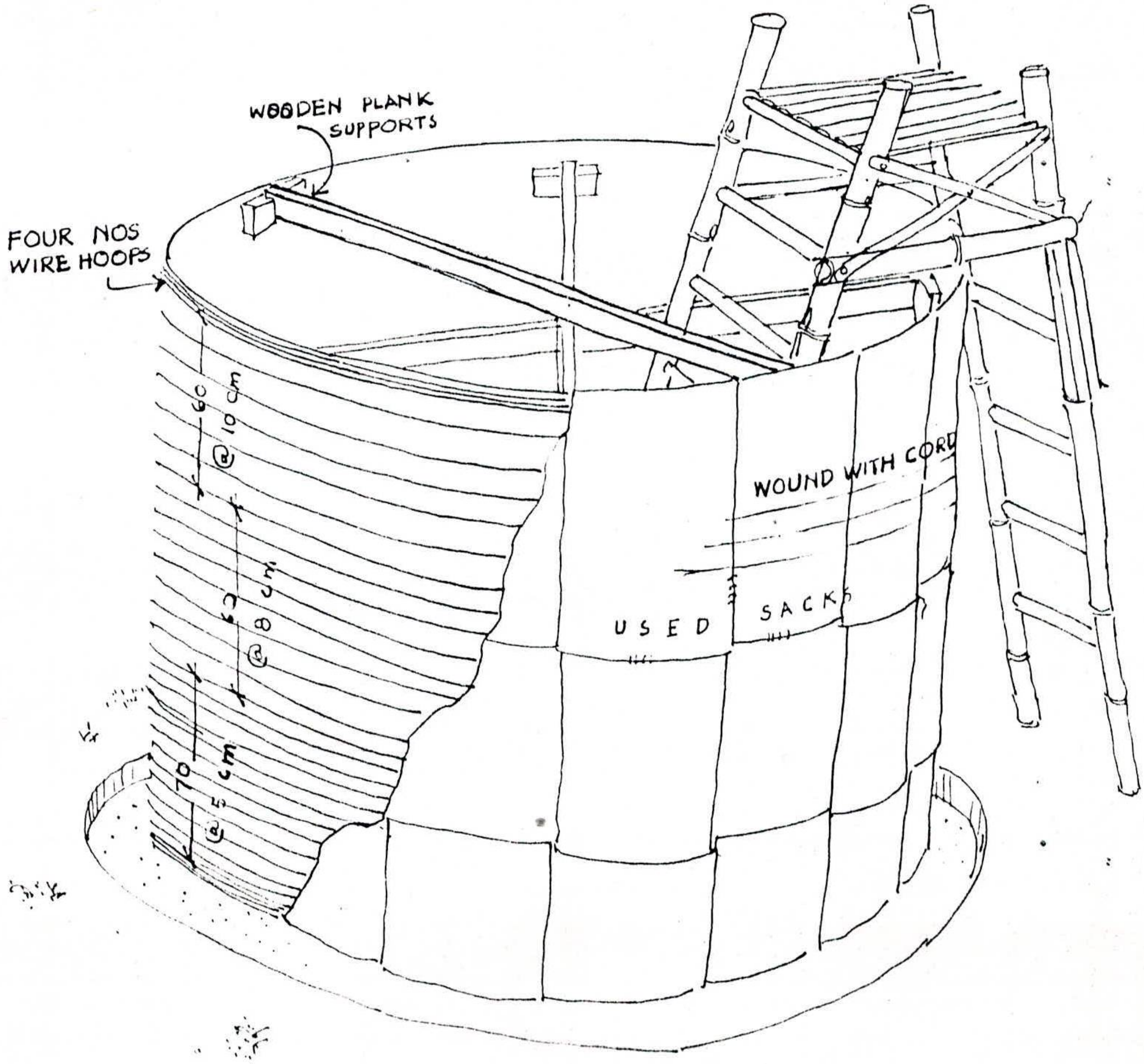
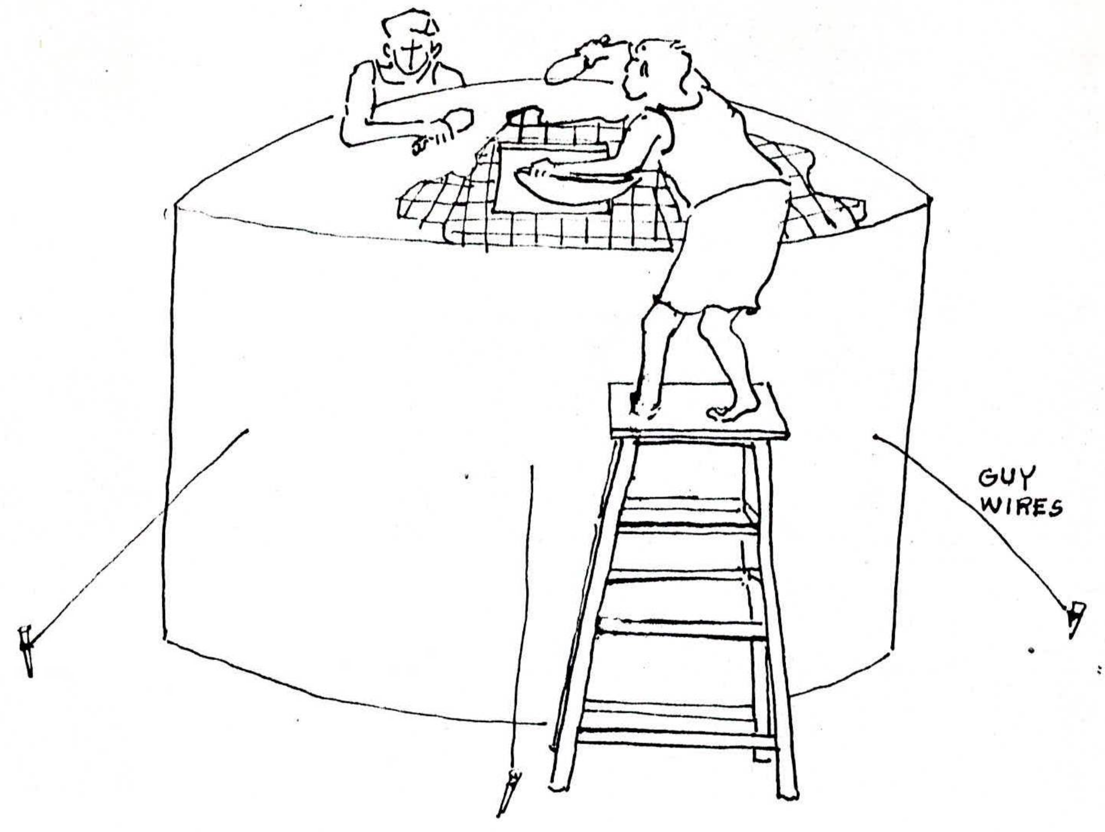
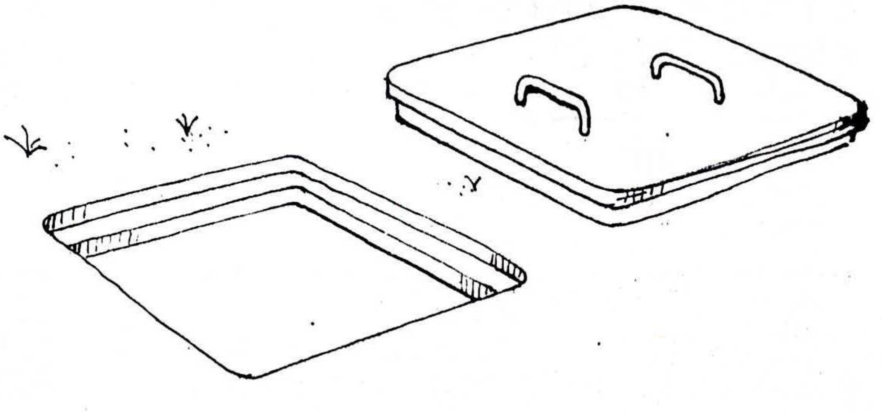





WOODEN PLANK SUPPORTS
FOUR NOS WIRE HOOPS
60 @ 10 cm
@ 8 cm
70 @ 5 cm
WOUND WITH CORD
USED SACKS

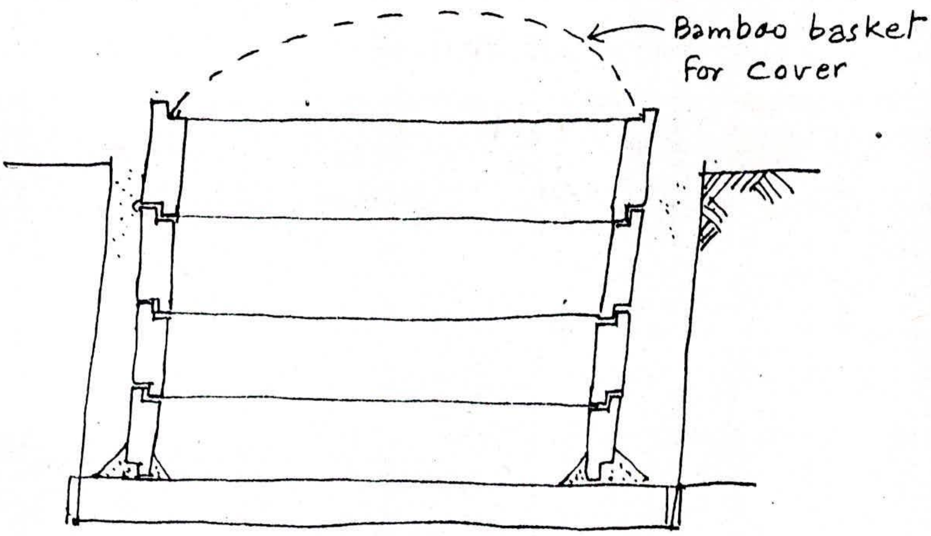

GUY
WIRES



Immediately after Clay Segment Tanks

Precast Concrete Ring Tanks

Reinforced Concrete rings are cast in annular steel/wooden shuttering which is dismantled after the ring casting is completed. The rings are then allowed to aquire strength under wet gunny sacks and then if possible, placed under water.



The lowest ring should be placed on a base prepared as in the case of clay segment tanks. The bottom of this should be collared with 1:3 cement mortar on both inside and outside. The rings should fit into each other as shown in the sketch to prevent displacement and consequent leakage.

The roof of this could be also in precast roof panels, ~~but a right sized bamboo basket, covered with plastic could do the job almost equally well.~~ or cast in situ / precast ferro-cement.

~~On~~

Throughout the construction take special care to

i proportion the materials accurately

ii mix dry thoroughly before wetting

iii add the right quanlity of water. More of water improves workability but also reduces strength and imperviousness.

iv provide overlaps in weld mesh as for reinforcement

v tamp the dryish mixes working into the close meshes

vi ~~Do not~~ provide spill proof back up when plastering from the other side

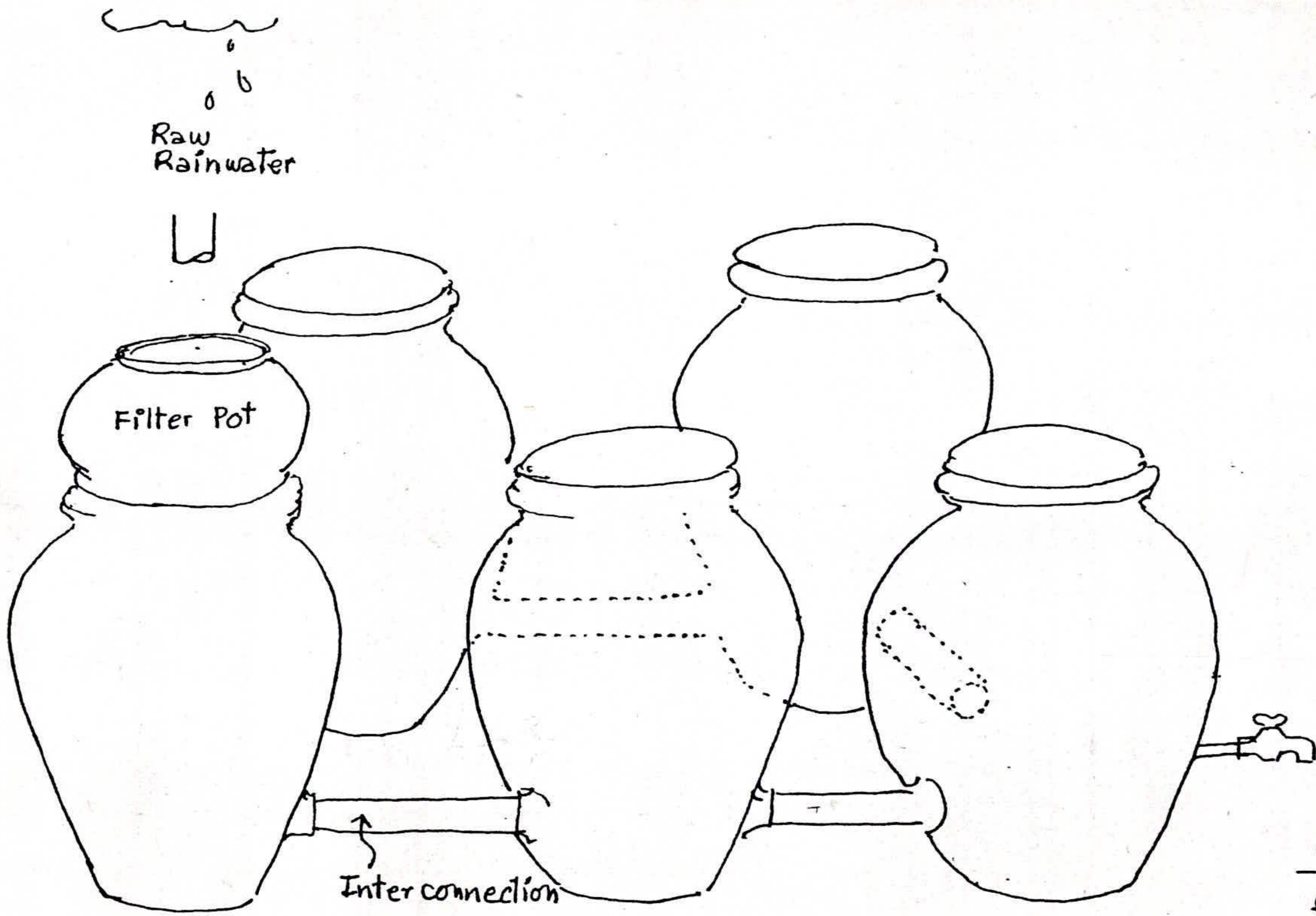
vii cover the plastered surfaces by polythene sacking or such material immediately after the work is over to protect the thin sections from over drying

viii always plaster in two coats, particularly on the surfaces in contact with water

RANJANS (Clay Pots)

A ranjan is a large sized clay pot. The sizes available differ from place to place depending on the soil characteristics as well as artisan practices. However, they have to be used in a battery ~~f~~ to keep a meaningful water storage.

← figure



RANJAN BATTERY

for RWH storage

However experience at Centre of Science for Villages (CSV) Wardha has been that seepage losses could not be arrested and anybody interested in this technique needs to make sure of this factor.

To make the battery work, the ranjans should be made to order. They should have socketing arrangement (within the fired body) at bottom, built in the green stage. This will make inter connection much more trouble free. One of the ranjans should have a water tap for withdrawal of water and a water level indicator to reduce the possibilities of contaminants entering the storage. Terra cotta filter pot with perforations at bottom and a body to fit snug on the mouth of the ranjan should also be ordered along with the ranjans. Terra cotta lids to cover the ranjans would also be very necessary to maintain freedom from infection. This will set up the project on right lines

Sodium Silicate is a well known water proofing treatment and needs to be applied to ranjan. Care should be taken to use the sodium silicate paste immediately after removal of cork as it dries very fast. This should be smeared on a the whole surface in contact with water

Clay segment tanks have also been built at CSV but they too suffer from seepage losses. Perhaps rainwater is highly mobile across porous walls and the waterproofing treatment needs to be perfected before taking these terra cotta methods on a large scale.

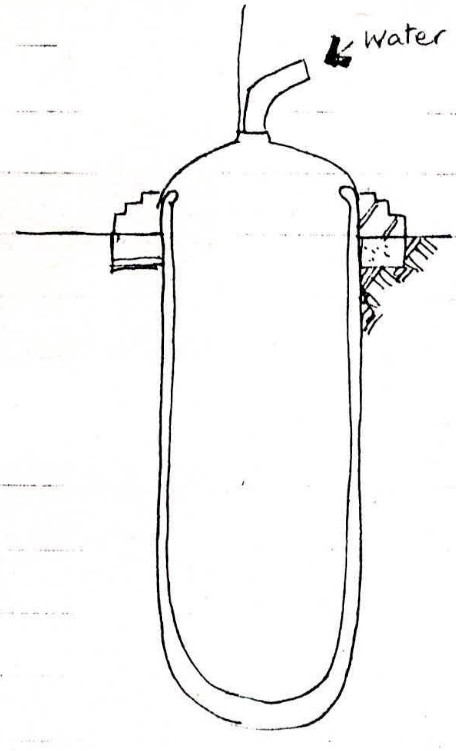
SOME IMPORTANT POINTS FOR CEMENT & CEMENT-BIOMASS TANKS

i. Proportioning, dry mixing and curing are critical to all cement structures. Most failures occur on this account and can be avoided by a little care at the right time, and no cost.

ii Any concrete tank should not be used for storage of potable water for 50 days after the last piece of cement work is over, as the curing process within this period releases substances harmful for internal consumption

iii Any bio-mass material embedded in wet concrete undergoes swelling as is natural to it. On drying of the structure it shrinks back while concrete shrinks

POLY-MAT RWH Container



This method is suitable to locations with hard strata very near the surface.

i. Mark out a ring ~~shaped~~ on the ground with 62 cm and 83 cm inner and outer concentric radii. ~~diameters~~. Dig out a trench 20 cm deep between the perimeters. Firm up the sides of the trench. Sprinkle water and ram firmly.

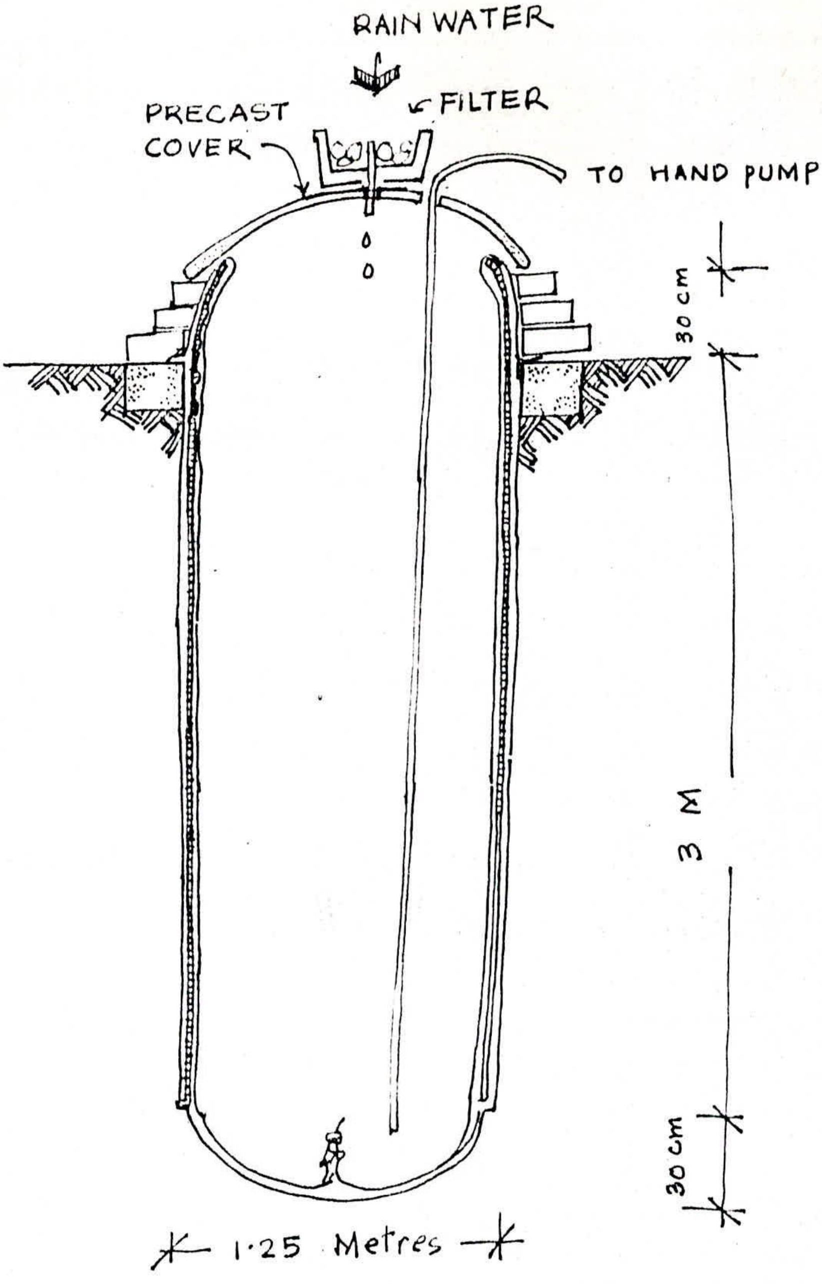
ii Prepare 1:2:4 cement conc. and lay it in the trench to form a ring beam. Allow two days for the beam to harden.

iii Dig out the ground within the ring to a depth of 3 metres in a well form. Dress the sides to the right cylindrical shape. Fill up cavities with soil + cowdung mixture. If necessary plaster this well with cow-dung (Gobar) plaster to a smooth shape.

iv Carve out the bottom of the well to the shape of a saucer with a ht. of 30 cm.

v Insert a bamboo mat 3·7 m wide ~~cylinder~~ (dia 118 cm) x 3·3 metres tall, into the well. Take care to see that the mat gets taut against the sides of the well.

VI Drape a thick gauge polythene pipe (with the lower end tied) over the inside of the



POLY-MAT RWH CONTAINER.

bamboo cylinder with about 30 cm polythene length turned over the outer side of the cylinder. Pour some water at bottom.

VII Raise a brick wall over the ring beam sandwiching the polythene cloth between the bamboo and brick rings, as shown in the sketch.

VIII ~~Place a~~ Prepare a bamboo basket 1.2 metres dia. Drape it with plastic. Cover the container with this cap. If desired, openings for inlet pipe and drawal pump can be made in the basket to keep the water safe from contamination.

Materials Reqd.

- One bag cement
- Bamboo mat 3.75 m X 3.8 m
- Polythene pipe 20 swg 6 mtrs long
- bricks

Brick Tanks

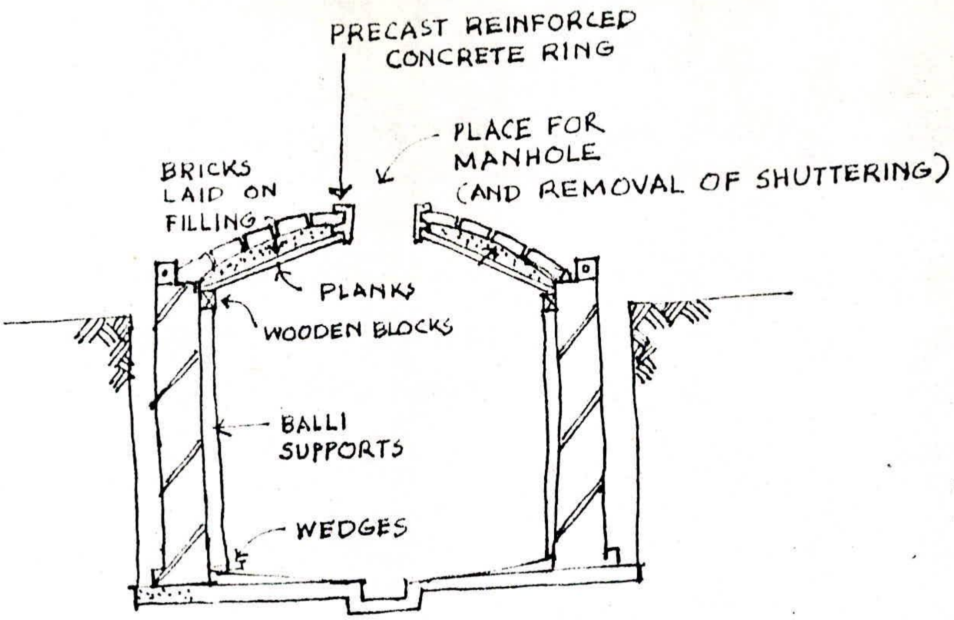
Bricks are the most commonly used materials for construction. However it may not be out of place to ~~provide~~ bring out a few points which are likely to escape attention

i. The bricks must be good strength non porous bricks. For this a few thumb rules may be followed. Reject bricks which get broken into two, freely dropped from a height of 2 M on ordinary hard ground. On performance of this, immerse ~~the brick~~ a weighed dry brick in water for 24 hours. The weight gain of the so immersed brick should not exceed 18 %.

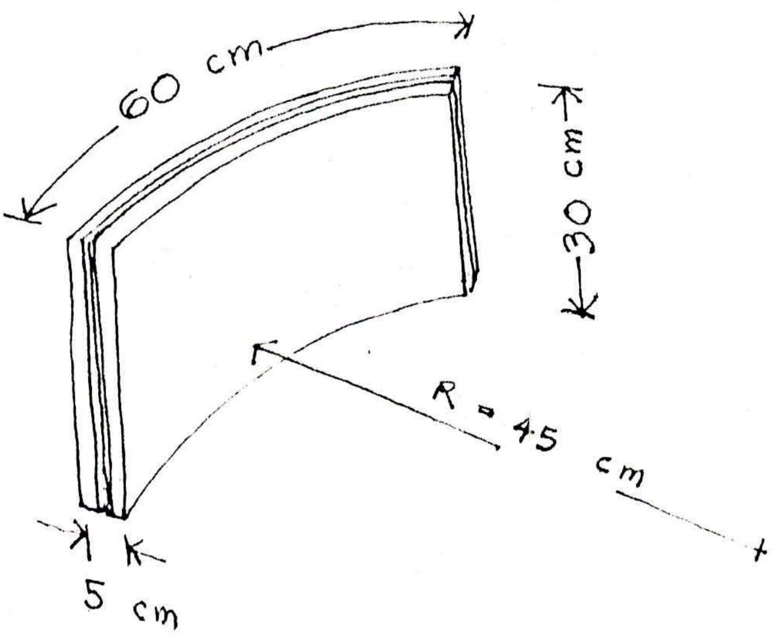
[illegible] Bricks should not contain lime Kankars (nodules) which can burst on contact with water and seriously weaken the bricks.

ii Large sized (community scale) containers may need a specialist look into the design of the tank, by way of panel stiffeners or reinforcement

iii As a thumb rule, round tanks are stronger. They also need



A METHOD OF CONSTRUCTING BRICK DOME



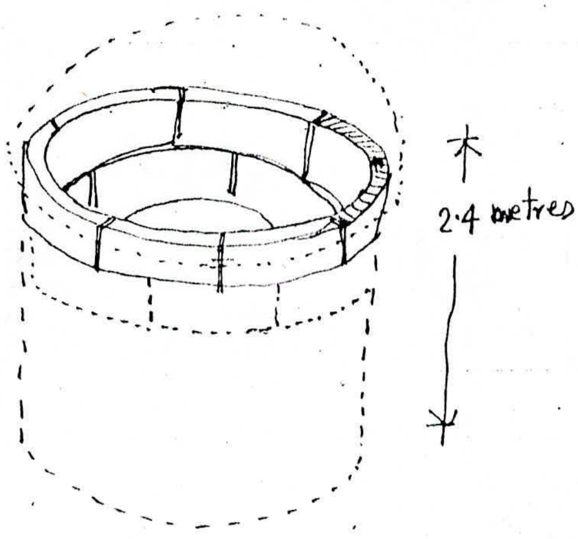
DETAILS OF CLAY SEGMENT

a smaller number of bricks to produce ~~a of~~ the same final volume in container.

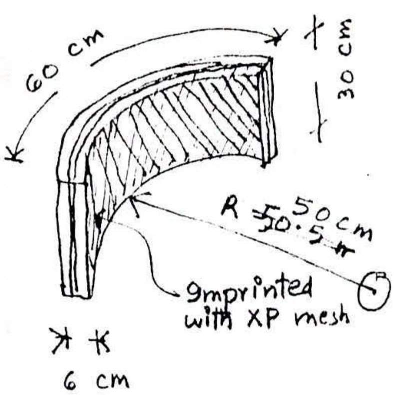
Round brick tanks can be covered by brick / concrete dome, R.C. slab, precast R.C. slab etc. depending on the size of the tank

Clay Segment Tanks

Tank walls, can also be built with large sized burnt clay panels. These panels are called clay segments.



2 M^3 Tank

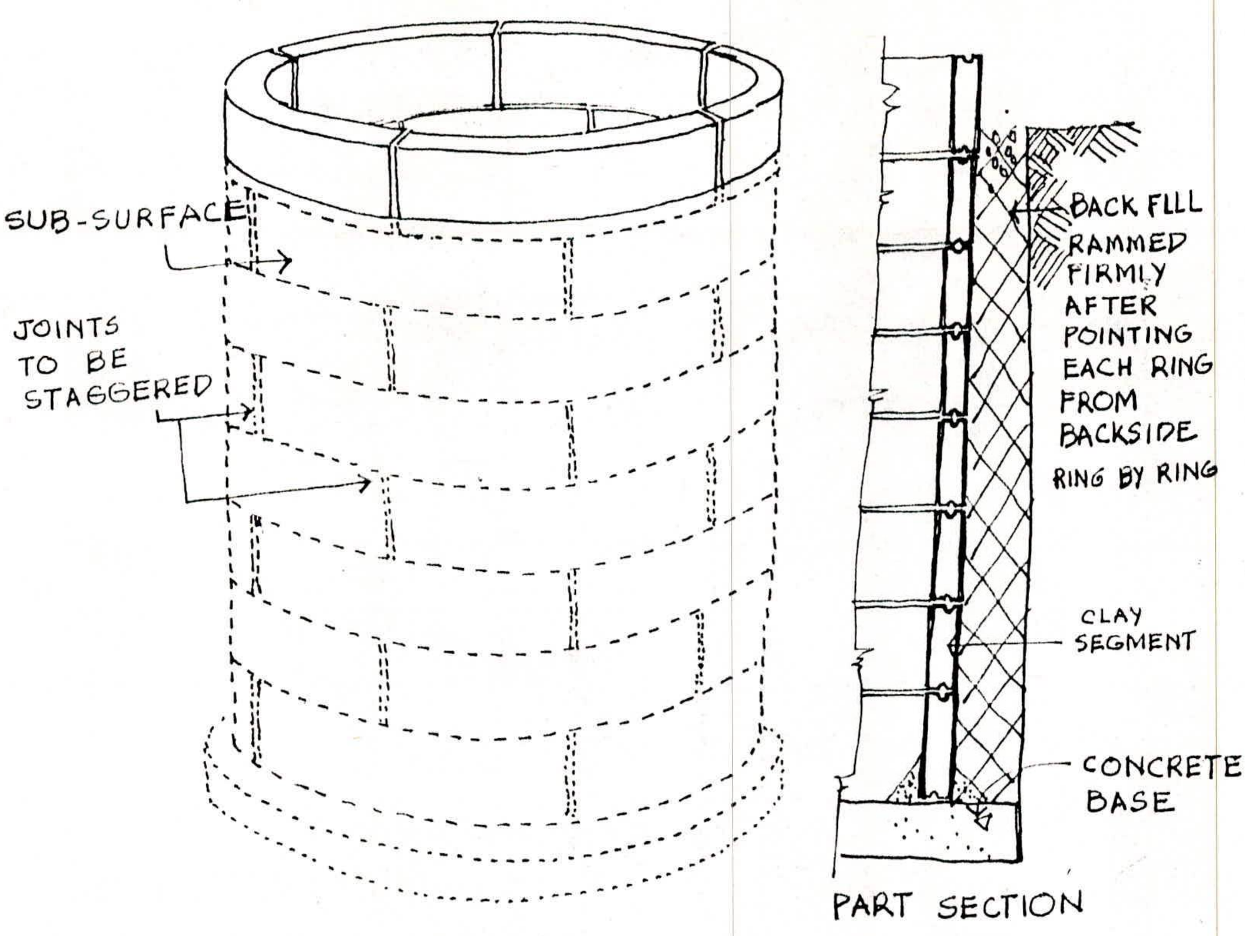


i Get clay segments made to the curvature (of 50 cm outer radius) on peripheral length of 60 cm x 30 cm tall, to a thickness of 6 cm. Five such ~~samples~~ segments will make a ring and eight rings in vertical wall will contain about 2 M^3 of water.

ii Mark out a circle with 60 cm radius on the selected piece of ground. Dig a well to this radius to a depth of 2.15 Metres

iii Pour water at the bottom and ram the surface. If this strata still happens to be soft or black cotton soil the location may be abandoned.

iv Prepare 1:2:4 cement concrete with water just enough to make it workable



CLAY SEGMENT TANK

Lay this concrete and ram it to a thickness of 15 cm. Allow this to dry for a while and cover it with wet sacks thereafter. Leave it for Two days to aquire strength.

V. Lay segments to a radius of 50 cm (outer) with cement mortar 1:3 in bed and on sides. Allow each ring to aquire strength before raising the next. Complete the well with eight rings. Fill up the joints on the outside of each ring with 1:3 cement mortar, before packing the gap with sand.

VI Apply stiff cement slurry with a small quantity of fine sand (1 cement, ½ fine sand and 1 part water) to the inside of the well and smoothen it with wooden float. Wet the segments thoroughly before plastering.

VII Prepare 1:3 stiff cement mortar and make the fillet at the bottom of the wall. Cover this fillet also with stiff slurry. Continue the slurry also on the floor, to a smooth finish.

(There are reports that mortars made with 1 cement, ½ cow dung and ½ water have proved beneficial in some cases)

VIII Paint the whole inside with cement slurry.

The well is now ready. This could be covered with a bamboo basket (inverted saucer) with provision of inlet and outlet as in the case of polythene tube container.

COMPARATIVE COSTS OF CONTAINERS

PARTICULARS	RATE PER LITRE in Rs
Ranjan (Terra Cotta. Pots)	2·00
Brick Tanks	1·00
Ferro Cement Tanks	2·00
Clay Segment Tanks	0·60

(SOURCE C S V WARDHA)

much less. The result is loss of bond between the two materias and strain cracks. Any water passing through the hair cracks, which also allow oxygen sets the bio mass on degradation route and the combination material fails.

Composites of bio-mass and cement could possibly work if the bio-mass is fully sealed before start (without the sealant interfering with the bond) and this is quite expensive besides being inappropriate in most cases, as of today.

on separate page or box

SOME DO'S & DON'TS

i. Train away the overflow and spilt water to a secondary reservoir - away from the house.

ii. Keep a piece of copper in the storage. Copper is a wel known germicide.

iii. Provide a locking arrangement on the extraction end as well as man-hole covers.

iv. Instruct the user not to plant trees near the RWH roof as the falling leaves may become a menace.

v. Instruct the user to broom and sweep the roof before every monsoon and reject the first few flushes till the water is crystal clear.

KEY ELEMENTS OF PROJECT SUCCESS STORIES

i. 'Felt' need of the beneficiary community or household

ii. At least a part of the ideas, funds and physical labour comes from the beneficiary/ies.

iii. Involvement of beneficiaries in planning, implementation and maintenance

iv Started small

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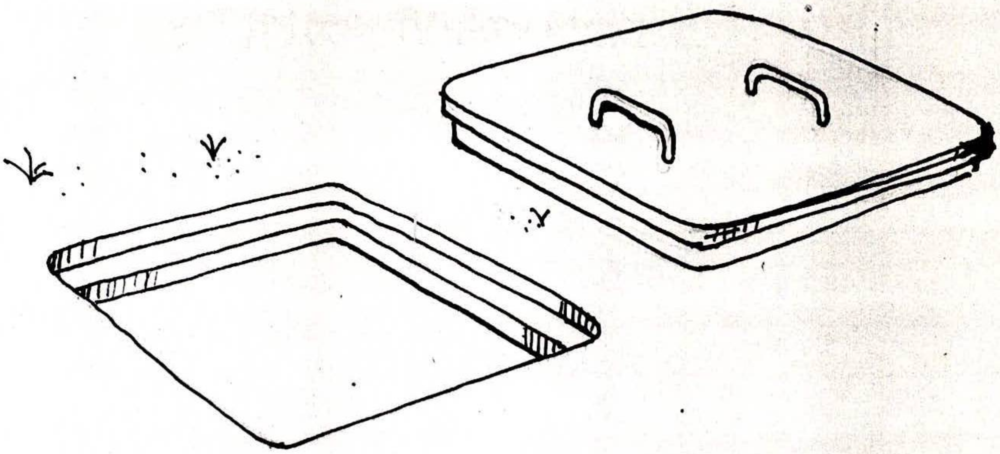


Fig 35. CASTING MANHOLE COVER

WITHDRAWAL

Withdrawal is a very important aspect of the RWH system and it would be the duty of the builder agency to impress this importance on the users' minds.

- In the case of tanks above ground the problem can be easily tackled by providing a tap at the bottom. ~~This~~ The withdrawal plane of this tap should be at least 5 cm above the floor level to keep clear of the sedimented silt.

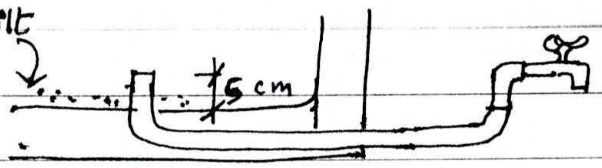
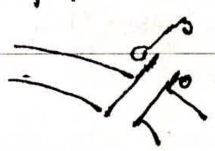


FIG 40

- The sub surface tanks, however, ~~are~~ is the more popular ~~one~~ because of its inevitability in the case of ground catchments. ~~and~~ Further the sub surface tanks are much cheaper.

  Preferably the water should be drawn by a pump. The pump should be either free standing or installed independently of the tank structure and water sucked through a flexible hose. The tank cover should be provided with a 5 cm dia ~~lockable~~ hole for insertion of this pipe. If possible this hole should be normally kept closed



by a flap which should have facility for being locked.

~~If this is not possible~~

Where a rope and bucket system cannot be done away with, this bucket and rope should be exclusively for this use alone, and the manhole cover under lock and key. ~~Wherever~~ The user should keep this bucket and rope in a protected place after use, to avoid contamination.

FIG 41

SOME DO'S & DO NOT'S

i Direct the overflow and spilt water to a secondary reservoir - away from the house.

ii Keep some piece of copper in the tank. The metal is known to be germicidal.

iii Provide a locking arrangement on the extraction end as well as manhole covers.

iv Instruct the user not to plant trees near the RWH roof and tanks. Falling leaves and roots in search of moisture create trouble.

V Instruct the user to broom and sweep the roof / and ground catchment just before the onset of monsoon and also reject the muddy flushes before admitting only clear water.

VI Provide a sump in the floor of the tank to facilitate removal of sediments.

KEY FACTORS OF RWH SUCCESS STORIES

i 'Felt' need of beneficiary.

ii At least part of ideas, funds, physical labour comes from beneficiary.

iii Involvement of beneficiary in planning, implementation and maintenance.

iv Started small, preferred household scale.

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