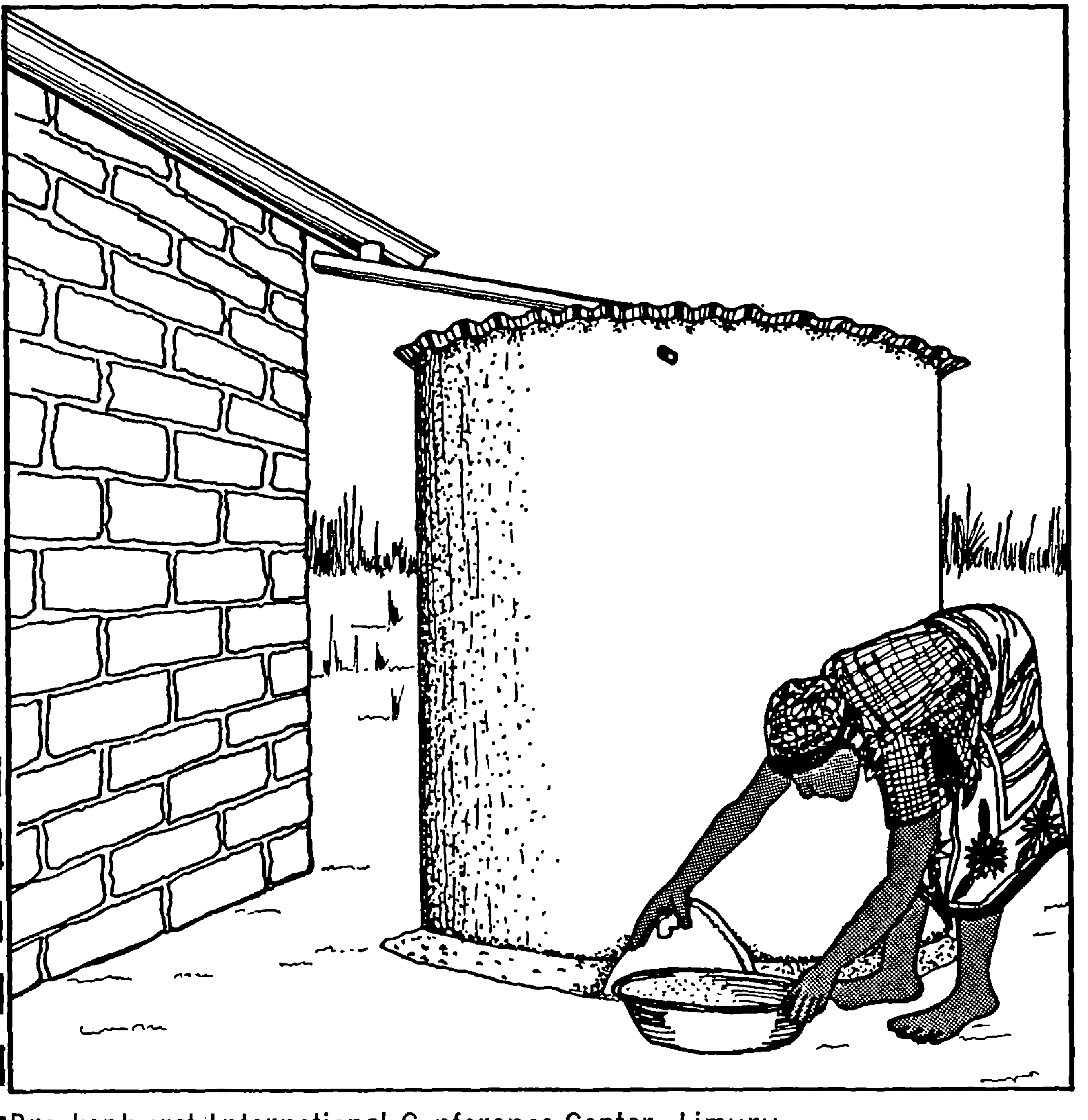
RAIN WATER CATCHMENT FERROCEMENT TANKS
WORKSHOP REPORT



Brackenhurst International Conference Center, Limuru
February 17th-20th, 1987

Organised & Sponsored by: World Neighbors and Oxfam

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CONVERSIONS

$10m^3$ = 10,000 litres = 2,193 gallons

1,000 gallons = 4,560 litres = $4.56m^3$

1 gallon = 4.56 litres

Section I.

Introduction, Workshop Objectives

Ferrocement tanks for the collection of rain water from roofs have been found in many circumstances to be a viable and effective way of collecting and storing water for household use. Throughout Kenya there is an increasing number of tanks being constructed. This spread has led to a diversity of structural design, materials used and construction techniques, and also a variety of approaches to the community organisation and participation for such activities.

World Neighbors and Oxfam felt it would be useful to gather together these techniques and approaches and to share ideas.

The workshop's objectives were to:-

- exchange ideas and experiences in
  - a. the design and construction of tanks for roof catchment
  - b. the community organisation approaches necessary to develop and sustain an on-going program;
- record this exchange of ideas and experiences so that it can be shared more widely;
- create an opportunity for continuing networking and exchange in this and other water catchment techniques.

The participants invited were field practitioners from on-going programs concerned with the construction of ferrocement tanks for rain water roof catchment.

There were 23 participants from 16 programs.

The emphasis of the workshop was to share and exchange. Thus each program invited was encouraged to present their experiences from the field.

The participants also came with their own expectations of the workshop. These were:-

- different designs of tanks (with costs), construction techniques, material required
- how to promote tank construction in the community - NGO/Govt.
- who benefits from the tanks
- problems and successes of programs
- how to harvest rainwater from grass roofs
- selection criteria for where to put up tank
- training fundis (women)
- share experiences between programs
- general water storage e.g. underground tanks
- usage of tanks - after construction what?
- maintenance and repair of tank
- cultural background of community considerations
- water catchment areas considerations
- making projects self-sustaining
- water quality and quantity
- transportation of materials and transporting water to homes
- involving women
- after the workshop, what?
- appropriateness of tanks with respect to other water sources and storage systems

Workshop Structure and Methodology

The workshop was organised to bring together practitioners from the field, in the spirit of sharing experiences rather than teaching any particular methodology. Thus we hoped to discover where we are in terms of design, construction methodology and common problems and issues faced.

This meant most of the work was done through group discussions with reports back to the plenary, and summary of the issues thus raised. Time was also given for individual programmes to present their designs and methodologies to the participants.

To make the process as participatory as possible, and to try to ensure that the workshop addressed the needs and problems of the participants, expectations were solicited right at the beginning, and an evaluation was carried out at the end of each day to discover what participants liked most and least, and what topics they felt should be addressed the following day. Thus the structure of the workshop was continually reorganised according to participants' needs.

Day 1 Contained self-introductions; group discussion sharing experiences in design and dissemination of tanks and presentations of issues from each group; and individual programme presentations.

Day 2 Contained evaluation feedback, group discussions on how to reach the poorest, how to choose an appropriate tank how to organise the programme for continuity; and individual programme presentations.

Day 3 Contained evaluation feedback, group discussion and presentations on thatched roofs, credit/firnancing tank constructions, community organisation; checklist advice for water tanks; resources list; evaluation and discussion.

The Participants and Programs

The 23 participants represented 16 different programmes

Jefferson Kilonga)
Mwakari Mathuva) - Utooni Development Project, Machakos

Been involved in a variety water supply systems since 1977 and particularly in the development of an appropriate cheap tank design and construction method; adapting existing designs. Built over 170. Mainly build 3,000 gallon and 1,600 gallon tanks.

Sebastian Mutua)
Karen Iles) - Kamujine Farmers' Centre, Meru
Patrick Mutia)

Began a tank program with women's groups in May, 1986. The tank constructed is 1,600 gallon capacity a design developed in Utooni.

Patrick Kasyula - Diocese of Machakos. (Rainwater Program)

Program began in 1983 with jars and tanks. Have experimented with a number of designs and constrution techniques and built over 1,200 tnaks. Now concentrat on 2,000 gallon capacity.

Joel Mbiti)
Francis Gray) - Diocese of Kitui
Robert Muumbo)

Build a number of catchment and storage systems. In 1986 have increased the tank construction program with the aim of building 2,000 tanks mostly of 2,000 gallon capacity in the next two years. All the work is done together with self help groups.

Julius Chokera)
Heinrich Gorfer) - Diocese of Meru, small Scale Water Scheme.

Began in 1981 cosntructing boreholes, shallow wells, gravity supply as well as tanks and jars, together with individual communities. Concentrated on 2,000 gallons tank.

Stephen Muroki - CARE, Taita Taveta Water Programme

Covers Taita Taveta and Machakos Districts.

Alfred Oluoch - CARE, Embu Water Programm.

Assist in the construction of a variety of water systems, but aree moving towards more low-cost techniques. Currently concentrate on underground tanks.

James Tumkor - Chepareria Youth Polytechnic, Kapenguria.

Have not begun a tank programme as yet; but are keen to find an appropriate water system for the West Pokot area - interested in 1,000 gallon tanks.

Alphonce Atisa - Mutomo Soil and Water Conservation Project, Kitui.

Construction of a number of water tanks and catchment systems together with self-help groups.

Currently concentrate on 78 m^3 underground tanks.

Melvin Woodhouse - A.M.R.E.F.

Concetrate on ground water supplies and pumps and some water harvesting techniques
Areas of work - Kibwezi, Magadi, S. Sudan and Darada (Tanzania).

Build mainly 2,000 gallon tanks.

Patrick Gacheru - Mukaa Mukuu Farmers' Training and Youth Polytechnic Centre, Thika.

Instructor in the Polytechnic, and just begun the construction of tanks. The constructions so far have been for testing and demonstration and yet to involve communities or groups. Most interested in tanks of 1,000 galls. to 1,600 galls. capacity.

Frans Klausen - U.N.I.C.E.F., Technology Support Unit

The Unit's work focuses on the development of appropriate designs and construction techniques and the spread of the information and skills developed to any interested group.

Having worked on tanks and jars, most current attention is on large capacity underground tanks.

Martin Fisher - Action Aid, Technology Support Unit

Action Aid's main work is in community development spreading out from their support of primary schools. In the school construction appropriate designs of roofing and water catchment are being developed. The constructioon of which can be organised into a local commercial enterprise.

Joshua Mukusya - World Neighbors, Ukambani Water Programme.

Begun in 1985 to spread the experience of Utooni Development Project to other groups in Ukambani, particularly in tanks and sub-surface dams.

To-date with six groups built 170 tanks and 8 dams.

Daniel Mwayaya)
Keith Wright) - World Neighbors

World Neighbors supports work in health, food production and water supply in community development programmes where the emphasis is on the training of local fundis, farmers and community members. Daniel and Keith are workshop facilitators.

Nicky May)
Eliud Ngunjiri) - Oxfam.

Oxfam supports community development programmes which involves water supply.

Nicky and Eliud are workshop facilitators.

Section II

Where We Are At

What is our experience, What can we share and learn?

We divided into groups according to the size of tanks which each project most commonly builds to show experiences to-date.

Each group considered the following questions to guide their discussions and putting together group presentations:

- What designs have you used and are using now? For "design" consider:- materials, preparation, costs, how constructed.
- What lessons have you learnt (positive and negative) from your experience of tank construction?
- What are your experiences in community organisation for tank construction?
- What lessons have you learnt from those experiences?

Group Presentations In Plenary

Tanks Over 3,000 gallons (CARE, Mutomo)

This presentation described Mutomo's work on 78 m^3 underground tanks. (For technical details please see the report on Mutomo's programme presentation section). After discussion they concluded the following:

Advantages of design

- cheap materials:- 1 m^3 costs Ksh.179/=;
- big storage capacity:- useful for longer dry seasons;
- applicable in various areas/sources of water.

Disadvantages of design

- cleaning the tank difficult and needs organisation
- maintenance of hand pump

Construction

- community participation:- cost sharing (community contributes local materials and unskilled labour)

- extensive training of fundis:- informal and formal instruction.

Site Selection

- from the people through local development committees
- from other NGOs - collaboration
- from relevant ministries (G.O.K.)
- community to have committee of the project
- community should be able to share cost of the project

Lessons learnt

Positive:

- community response to construction is good
- maintenance of projects is under the committee members
- training of fundis is successful in the rural areas
- tanks construction in institutions, public places as demonstration
- tanks which are rain-fed only are only suitable in institutions where there can be control of use e.g. schools

Negative:

- community haven't fully taken the idea into their homes

reasons:-

1. still find tanks too expensive.
2. Others haven't realised that demonstrations are for them.
3. Lack of catchments - proper roofs e.g. iron sheet roofs.

Tanks 2,000 - 3,000 gallons capacity (Amref, Utooni, Machakos Diocese, Tigania)

The group summarised their different approaches in the following table:-

Project	Size/ Gallons	Method	Total Cost Shs.	Person Days To Build
Machakos Diocese	3,000	Internal and External Shutter	8,000	21
Utooni/AMREF	2,700	External Shutter	3,200	9
Tigania	2,000	Internal Shutter	4,200	12

Issues raised:-

To avoid cracking of tanks (a social and technical problem):-

- careful mixing of cement is very important
- walls should be as think as possible
- paint the outside of tanks white to reflect sun to keep cement from cracking and drying up
- build in a shady place
- position wash out the pipes such that the tanks cannot be completely emptied
- it was noted that BRC 610 - 45m x 2m - 4" can be used as reinforcing wire instead of weldmesh. Cost is much cheap at shs. 950/= per roll = 11/= per m^2 (as of February 1987)

Community problems:-

- people not paying their contribution, In Utooni if members don't pay contributions towards costs, the tank is removed; In Tigania the tank is not built until a certain amount has been contributed;
- water theft and damage to tanks;

Need for Documentation

Following this discussion, some participants suggested that we need to document information on ferrocement tanks. It was uggested that a working group design a questionnaire to solicit this information.

Above-Ground Tanks : What Do We Need To Know?

- Age of tanks - lifespan
- Condition - cracks, leaking, tap, burst, salt on walls, roof condition, siltation, guttering
- Size - what are biggest tanks? ($50m^3$)
  - dimensions, capacity, materials used
- Shape
- Wall thickness
- Type of reinforcement
- Reasons for (cracks etc.) failures
- Using excessive materials
  (- excessive costs)
- runoff coefficient
- Costing (accurate)
- Strength of construciton
- Quantify - how many made, number of problems

It was suggested that these topics should form the basis of such a questionnaire; but in the event no-one came forward to take the idea any further.

Tanks Less Than 2,000 Gallons (Kamujine, Kapenguria, Mukaa Mukuu, Kitui Diocese)

Design:-

Kapenguria - Sand/cement blocks.
1,000 gallons. Blocks set in spiral.

Mukaa Mukuu - Ferrocement using old G.1 tanks as form + chicken wire + fencing wire.
Less than 2,000 gallons.

Kamujine - Ferrocement + weldmesh and chicken wire. Mabati roof.
1,600 gallons.

Kitui - Water jars - bags filled with sawdust.
750 gallons.
Ferrocement water tanks. Brick tanks (mud + cement)
Plastered with cement.

Discussion

Major problem with building small tanks for individual homes is SOCIAL AND ORGANIZATIONAL rather than technical.

It is essential to identify the needs of the community before introducing water tanks.

Financial aspects are important : tanks must be cheap.
Water jars crack when empty which is more a social than a technical problem.

SUMMARY OF GROUP PRESENTATIONS: Some Issues Arising

a. Cost comparison is not meaningful and is misleading.
   - What items do you consider when costing?
   - It is difficult to cost tanks and therefore difficult to make comparisons on the basis of cost.

b. How do you select group/individual/homes

c. Who benefits? Protecting needs of poorest.

d. Is this what people want or is it just what we are offering people - need to listen to people's needs first.
   Help people understand options, real priorities, advantages of what's on offer e.g. thin tank walls.

e. Follow up on usage - how long does water last and how many people are using it. Give better criteria on design, size applicable.

f. In choosing an appropriate tank one needs to cosnider:-
   - capacity
   - climatic area
   - labour requirement/usage
   - know people's interest first
   - sound technical design
     (lack of documentation)
   - good communications - project and community participate in choosing design).

   - Aim of tank to lighten labour burden e.g. women's peak labour time is during the rainy season
   - Easy repair

g. It is essential to have a proper uniform mix of cement - quality control.

h. Supervision/training of fundis in social and technical skills
   (who do fundis belong to? Life/work for fundis after program)

i. Approach to design:
   - cost (money available)
   - roof size (water available)
   - usage (how much water do people need)
   - capacity

j. Financing tank construction is a central issue - loans/grants, etc.?
   Who contributes and how?

k. Planning ahead for needs of a group of people
   (self-sustaining after programme + business)

Section III.

Group Work On Issues

A number of these difficult issues surfaced during the discussions, and it was decided to analyse in more detail a selected few of the issues. Recorded here are the reports back in plenary together with the following discussions.

Issue A

What problems are there to reach the poorest in the community?

How can these problems be overcome?

The poorest in the community were seen as those with little money; insufficient labour to carry out the daily tasks and thus have no time for extra activities even though such activities may be beneficial to them in the long run; often furthest away from water sources; often in poor health.

The poorest, then, are those who are in most need of water within their compounds.

However, generally they are the most difficult to assist within a programme structure mainly because:-

- the poorest of the poor do not like joining community groups
- they lack the required group contributions
- they lack time to participate in community or group activities
- some rich stand as barriers to development of the poor as this is likely to mean the end of cheap labour, etc.
- the poor lack confidence in themselves, in others and also in their own ways of doing things
- poverty is relative within a community. Nobody wants to accept that she/he is poor or have it recognised officially
- poor communication between the poor and the development agents - here, both parties are to blame
- few want to identify themselves with the poor or to be categoriesed as poor

These barriers could be overcome if the programmes were to focus specifically on the poorest so that time and resources allocated to:-

- program plans be made with the people and to extend those plans building on their "known" (knowledge and experience);

- allow the poorer to make decisions regarding the programme;
- to educate the poor on development planning and decision making of a programme;
- take them to visit similar groups of people already involved in similar activities, to gain an appreciation of what is possible;
- development agencies must plan specifically for any particular community or group to discover what is truly "appropriate".

<u>How do you identify the poor in the community?</u>

- You carry out a survey to determine who is poorest in the community.
- You go into the community, stay and learn for yourself through mixing with the community who is poor.

These suggested approaches were generally regarded by the group as needing further thought and description. <u>There are no easy or straight ansers to this difficult issue.</u>

Issue B

What needs to be done to decide on the most suitable tank?

What are the problems in carrying this out in practice and how can they be overcome?

The following need to be considered before deciding on a tank:-

materials/distance from suppliers
design of tank
other water sources - springs
other possible catchment systems
maintenance of tanks
type of roofs
are pumps necessary/maintenance?
cost of the tanks

are the tanks for community/individual/ groups
demand/need for water
what people can afford
people's needs
how is the group organised
what scheme of finance/credit/payment grants
rules/control of use
carrying out those rules
use - drinking, animals, washing
what collecting surface
need (education/awareness) within the groups/communities.

This could be narrowed to three points:-

- what is the group organisation, awareness and decision making process? (especially regarding who to get the tanks in what order)
- how will the tanks be financed?
- what should be the tank design and size?

Questions to consider:-

Design and size:

- rainfall amount
- length of dry season
- distrance from suppliers
- difficulty of transport
- skilled local labour - need for training
- number of people to use the tank
- what the water is used for - drinking, animals, washing, irrigation

- catchment system - roof, rock, surface
- above ground or underground tanks
- lifespan and maintenance of tanks
- cost:
  - is it what the people can afford
  - is it what the people want
- prevention of contamination
- safety - (it must be roofed)

Finance

- where does the money come from?
- who is accountable for the money?
- who handles the money?
- who makes the decisions?
- how are the decisions made?
- who and how is the maintenance paid for?
- who and how are the fundis paid for?

Community Organisation

- how are the people organised?
- who are the leaders and how are they chosen?
- who and how are the decisions made?
- who is to get the first tanks - and why?
- are the people able to express the needs accurately?
- what is the planning process?

It was concluded that no one tank is the most suitable in Kenya. The most appropriate tank design will only emerge when all of the above are considered fully together with the community.

One point that was felt by all:

Communal tanks are unsuitable if only filled by rain water; unless the communal tank is built in an institution such as a school where there is constant control.

How can the programme be organised to be sure that tank construction continues in a community after the programme ends?

What are the main problems and how do you recommend that they be overcome?

After discussion the group presented the following ideas:-

- create awareness in the community of the importances of water and benefits;
- involve the community in decision making from the beginning;
- train the local community in construction of the tanks they prefer/decide on;
- organise the community to focus on long term continuation;
- there should be a system of continuous contribution which is proportional to their income and an established management system to safeguard and foresee that the rules of their organisation are adhered to;
- develop and encourage small cooperative societies which decide on their own needs and priorities;
- let the community be responsible and accountable for their activties;
- involve the Ministry of Culture & Scoial Services field officers and the relevant technical/Ministry in order to familiarize both parties for guidance and advice.

How do you involve the community in decision making?

- A meeting for participatory talk is convened and in this process they come up with a decision.
- After reaching a decision on what to do, the whole group should be involved in the planning of the procedure of the whole project implementation.
- Jog around with their minds to see if they can come up with a possible option to what you have in mind then you make a choice - what is possible for you and what they can afford.
- One uses some type of black mail e.g. denying the community the services they want in order to make them come up with a better option of the type of project they would most benefit from.
- If the agency/donor goes to the community and wants them to decide on what they need the agency to assist, it is a different matter all together; but if the community goes/approaches the agency for assistance, that community already has a pressing problem that has to be solved. Here the question of involving them in decision making does not arise because they already have a project in mind.
- The agency/donor should go to the community and be willing to accept their ideas after learning from them.

Main Themes Drawn Out Of The Discussions Of The 3 Issues (A,B.C)

- identify needs of the community
- create awareness of options
- spend time building up community awareness, confidence, leadership, organisation (especially the poorest within the community, many of whom are women)
- consider time and resources in training:- the community
  the fundis
  the development agencies
- do not assume that you know everything and that you want them to do what you know
- finance - getting resources to the poorest to be able to do this e.g. grants, loan funds, income generating activities

Workshop Participatory Planning

At this stage there were still many topics left to discuss:-

- collecting water from thatched (grass) roofs
- options for reducing costs
- credit schemes for groups + individuals
- water quality versus quantity
- training women fundis
- how can tanks be spread to West Pokot
- women and water
- how can groups get money directly from aid agencies
- how can field people change agency policy
- expectations from Day 1
- which tanks should be promoted most
- practical recommendations for Day 2's group discussions
- how to reach the poorest people
- the simplest way of making tanks
- more on tank construction
- how to reach the community
- where to build tanks
- ground movement affecting tanks

Since time was very limited, we chose the most pressing issues from this list for brainstorming sessions in groups. These were:-

- collecting water from thatched (grass) roofs (of relevance on trying to reach the poorest)
- financing/credit for tanks construction
- community organisation (an amalgamation of reaching the community, women and water, creating confidence)

The participants were randomly divided in four (4) groups and asked to brainstorm and discuss the following issues.

Issue D

What can be used to collect water from thatched (grass) roofs or near to houses with thatched (grass) roofs?

What have you tried - what has worked, what has not worked?

Direct collection off grass roofs:-

Suggestions:

- Direct from grass roof using bamboo guttering into drums/tanks (experimental). Problem was water quality (bad taste) but maybe good for other uses e.g. irrigation? Problems with later filtering water which comes off grass roofs. No one programme had been successful in promoting the use of any water filtering system.
- Water draining from the roof could collect into a trench/open drain around the house and flow into an underground tank; a galla jar or even a plain hole lined with polythene to reduce seapage.

Alternative roofing materials:-

- Polythene sheet on top of grass roof, put on only during rainy season and removed in dry season.
  If covers whole roof, house becomes too stuffy inside.
  Problem with putting on and taking off - inconvenient.
  Would covering half the house only be better?
- Covering the roof with nylon sugar sacks. Need to leave ventilation e.g. between wall plate and roof.
- Cement plastered gunny bags with own gutter as catchment area.
- Covering roof with canvas cloth.
- Temporary matting.
- Plastic woven bags sewn together.
- Old used metal sheets e.g. kimbo tins, debes, flattened and used as tiles.
- Sisal cement tiles and roofing sheets very heavy and support roofing needed makes it an expensive system. (Technical details and costings from Action Aid and Mukaa Mukuu).

Alternative Financing To Obtain Mabati Roofs:

- members of a women's group help each other to buy mabati
- women's "merry-go-round" groups to help members pay for mabatis; supported with other income generating acgivities within the group. This also builds community spirit.

An Alternative To Roof Catchment is Surface Catchment:-

- surface run-off from compound with a slight incline feeding underground tanks;
  Problems: bad water, and danger of children falling into underground tanks;
- use polythene to cover the ground catchment area;
- collect flood water and filter and/or treat with alum/chlorine;
- build a stone wedge with a cement surface near the house and a drainage into an underground container;
- adjacent rocks as catchments to tanks - underground or standing tank
- concrete slab on a raised platform
- gunny bags cemented with nil on a raised platform
- plastic sheets on a free standing platform
- 3 mabati sheets on a platform
  Problem: surface area too small for family needs;
- project the roof of the tank itself as a catchment area with mabati sheets or concrete (if a ground tank);
- collection of water from big trees (where available)

Guttering:-

- bamboo/sisal poles
- kimbo tins
- polythene sheeting

Issue E

What are the different ways tank construction can be paid for (financed)?

How can each different way work in practice?

What have you tried - what has worked, what has not worked?

Nine different financing possibilities were identified.

- merry-round (harambee) within group members and/or community
- harambee from general community for:-
  - individual tanks
  - communal tanks
- joint community and agency (- Y.P.S., school tanks - parents contribute labour, local materials, agency contribute other materials (Action Aid, CARE)
- individual funding - owner pays all (Tigania)
- the individual/group donate their labour + local materials and an outside agency pays for all the materials which the group keeps and continues to revolve
- income generation e.g. (i) independent of water tank (e.g. goat keeping tried by CARE)
  (ii) build tank and/or make building materials for tanks and sell (Action Aid)
  (iii) use the water for income generation
    a. water selling
    b. vegetable growing
    c. poultry, etc.
- grants from any agency (for demonstrations)
- motivation - through advice only. Groups are organised to contribute for tank constructions for individuals
- external grant - whole
  - part costs - 50:50 commonly used

<u>The Schemes Which Are Currently Working Are:-</u>

- direct whole grants particularly for the larger tanks - with unskilled labour and some local materials from the community (Mutomo, CARE, UNICEF)
- downpayment for ½ cost - however, it is only the rich who benefit (individual and program pays ½
- credit scheme using revolving loan fund for ½ + ½ paid by program (Ukambani)
- the group pays ½ cost in advance + sand + hardcore; the other ½ is given as a loan over 10 months. The group administers the loans; repayment direct to project bank account (Kamujine)
- individuals pay all - benefits the richer first, but does allow the building to continue after the programme ends (Tigania)

Each scheme has its problems such as

- full outside grants - does not develop self-sufficiency and the continuation of the project is unlikely
- in a revolving loan fund it is difficult to ensure repayments. Repayments are slow and often bring arguments with and within a group
- full cash payment - does not easily reach the poor
- credit scheme can easily stop when the creditors pull out, but if it lasts long more can be achieved

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No one scheme seemed to be best to use. All those depend for their success on the strength of unity in the group and the integrity, sincerity and ability of the group leaders.

Issue F

How do you in practice enable a community to:

- trust each other
- feel each other's problems
- have strong leadership and control it
- know who will get tanks first
- know their own priorities
- know their own objectives
- to create confidence in women and back up for them to be fundis
- to create confidence and ability in women to run their own programmes

What have you tried? What has worked? What has not worked?

The responses overlapped as all the points are part of one complex process in community/group awareness,organisation and leadership.

- integrate water with other development activities
- try to base all work on the group's knowledge
- start where people's problems are at the time
- help people to understand what is expected of a leader
- project to select candidates, but group decided whether they want these women as tank supervisors; (start as one of water committee and train later)
- have small groups - each to have its own committee or leadership group;
- group should choose its own leaders (not by us, external agencies or outside leaders);
- try to make each member of the group feel their opinion is important;
- groups should work together on common activities;
- the groups to know their own problems and what they want to do about it;
- each group member should know and understand his/her rights;
- group members make decisions together in open dicussion and share responsibilities;
- form groups within a community so that membership is small (less than 50);
- if needs are know, people will prioritise themselves;
- minimum presence and direction from outsiders;
- after group prioritises, outsiders can give input on options and resources available;
- group to have begun to define problems, common goal and to be active in solving them before any programme intervension;
- confidence created through exchange visits between groups with same objectives;
- the group to have a common goal;
- the choice of the order of who is to get the tanks to be made in open discussion (often the chairperson gets first tank)

Involving women more:-

- women build houses - building tanks is very similar
- special efforts to overcome women's lack of confidence and belief in themselves
- women training women fundis and women training men fundis
- Y.Ps. should offer masonry, carpentry, etc. for women and Y.P women instructors
- need more support from authorities for women e.g. chiefs
- encourage women's leadership training, book-keeping
- training women for whole career - or just to bring skills into the group?
- to make women's problems an equally important discussion point
- technical/aid people should listen to women and work with them on solving problems
- not much has been done on creating confidence in women
- Utooni has 3 women fundis - no problems (all are single)
- 80% of supporters and workers in Mutomo project are women; 5-7 projects headed by women, and were successfully completed
- women need support
- at the next workshop 50% of participants should be women

The choice of order of getting the tanks is an extremely important and sensitive issue. Whatever, the method of choice, the group should do the choosing.

Some criteria/method for choice are:

- secret ballot for the order
- age of member - oldest gets the first
- distance from sources of water
- the one who has the biggest problems

The Participants Brainstormed A CHECKLIST of things to consider when preparing a tank construction program.

Social:-

- having the tank is not the immediate solution to water problem?
- is a tank the best solution? Are there other water sources?
- how many people will use the tank?
- water to be used for what?
- how to organise, repair and maintain the tank
- have a plan for finance which includes local people
- start small, sit back listen to what you hear and record and act on what you hear
- ensure proper supervision of fundis
- have people seen a tank of this kind before?
- is the design suitable?
- tanks can help community by reducing daily labour tasks
- create good understanding between project, fundis and group
- discuss openly with groups and formulate plan with them
- will the community be able to carry on making these tanks after the programme ends?
- safety and siting especially children falling in
- what impact will tank have on community (positive or negative)
- how to draw water from the tank
- who will benefit from the project?
- cost - don't believe costings till you've worked them out for yourself
- the bigger the tank (for individuals) the bigger the problem. Ground tanks better for institutions than for individuals

Technical

- survey tank site
- check rainfall pattern, and dry periods - geographical area - heat (cracking) - ground movements
- type of roof - recommend mabati
- is design suitable? There are many different designs. Look at locally available materials

- use good materials - clean sand, clean water
- find out what other projects are doing
- ensure proper curing
- transport of materials and distance
- sanitation ; keep tanks sealed and drawing points well drained (mosquitoes)
- don't try to design own tank, don't experiment using someone else's money
- don't forget the wash-out pipe
- ratio mixing materials and the need to mix properly
- make sure the tank fits under the gutter
- availability of trained fundis/technicians/engineers. Make sure they are well trained
- don't forget about guttering - price and availability

Resources:

Books:

- *The Tribune*, Newsletters No 20 and No 28, 'Women and Water', from International Women's Tribune Centre, 777 U.N. Plaza, New York, N Y 10017, U S.A (Extremely useful steps for people's participation in water projects, addresses of funding and technical agencies for water supply.)
- *Waterlines*, quarterly journal of appropriate water supply and sanitation technologies, from IT Publications, 9 King Street, Covent Garden, London, U K.
- *Appropriate Technology*, quarterly journal, also from IT Publications (address above)
- *OXFAM Field Directors Handbook*, 1985, from OXFAM, 274 Banbury Road, Oxford OX2 7DZ, U K.
- *Manual for Rural Water Supply*, Publication No. 8, St Gall, 1980, SCAT (Swiss Centre for Appropriate Technology).
- *Water Purification, Distribution and Sewage Disposal*, Peace Corps Manual, through Peace Corps Information Collection and Exchange, Office of Programming and Training Co-ordination, 806 Connecticut Avenue, N.W., Washington D C. 20525, U S A.
- *Rain Catchment Tanks (A Guide for the Complete Idiot)*, Marvin Hamilton, from U S Peace Corps Office, P O Box 68079, Mombassa, Kenya
- *The Liklik Buk* (information on hydrams), from Wantok Publications, P O Box 1982, Boroko, Papua New Guinea
- *Appropriate Technology Sourcebook*, Vols I and II, Ken Darrow and Rick Pam, available from IT Publications (address above)
- *Appropriate Village Technology for Basic Services*, from UNICEF, P O Box 44145, Nairobi, Kenya
- *Rain Catchment and Water Supply in Rural Africa A Manual*, Erik Nissen-Petersen, £2.50, from IT Publications (address above)
- *Water Resource Development: The Experience of U S Non-Profit Making Organisation Programs, Issues and Recommendations*, Dulansey, from Technical Assistance Information Clearing House, American Council of Voluntary Agencies for Foreign Service Inc, 200 Park Avenue South, New York, N Y. 10003, U S A
- *The Directory of Organisations Involved in Community Education and Participation in Water and Sanitation*, from the International Reference Centre & the Water and Sanitation for Health Project, P.O Box 5500, 2280 HK, Rijswik, The Netherlands
- *People's Workbook*, Environmental and Development Agency, Box 62054, Marshalltown, 2107 Johannesburg, South Africa
- Technical Advisory Group to U N D P, *Methods for gathering socio-cultural data for water-supply & sanitation projects*, Mayling Simpson-Herbert, and *Technical notes on water supply and sanitation*, free from The World Bank, Rm N-1008, 1818 H Street, N W, Washington D C 20433, U S A.

Advice and Assistance:

- Water Aid (the voluntary effort of the British water industry for the water decade), 1 Queen Anne's Gate, London SW1 9BT, U K
- Intermediate Technology Development Group, 9 King Street, Covent Garden, London, U K
- Water filtration for Third World villages through Rotary International in Great Britain and Ireland Equipment to cap polluted springs, drawing from waterholes and tapping sand rivers, pumping from permanent lakes and rivers Donations considered G S Cansdale, SWS Filtration Ltd, Great Chesterford, Saffron Walden, Essex CB10 1PL, U K
- GATE (German Appropriate Technology Exchange), Traditional Water purification in tropical developing countries and other information, Dag Hammarskjold Weg 1 6236, Postfach 5180, Eschborn, West Germany
- VITA (Volunteers in Technical Assistance), 1815 North Lynn Street, Suite 200, Box 12438, Arlington, Virginia 22209-8438, U S A. Technical information on almost any subject
- UNICEF/NGO Water for Health Project, P.O. Box 6147 Nairobi, Kenya
- Water and Sanitation for Health Project (WASH), 1611 Nor Kent Street, Rm 1002, Arlington, Virginia 22209, U S A Nc government organisations can apply for training courses
- Water and Environmental Sanitation Team, Programme Development and Planning, UNICEF, 866 U N Plaza, Rm A415, New York, N Y 100017, U S A

  Very many of the U N agencies have water and sanitation programmes, including FAO, WHO, World Bank, U N Development Fund for Women, UNESCO, UNEP, UNDP, ILO, INSTRAW, HABITAT, and UNICEF
- International Reference Centre for Community Water Supply and Sanitation, Postbus 5500, 2280 HM Rijswijk, The Netherlands
- TWIN Ltd (address above), documentation and information on different technologies, including irrigation and water.

- Circular storage tanks and silos
  - A. Gmali Spon Ltd. 1979

- Handbook for simple water engineering in Kitui District, Kenya
  - E. J. P. de Nooy
    Available from the Diocese of Kitui

- Ferrocement water tanks
  - S. B. Watt, ITDG - Price £3.95

- Construction manual for 3,500 gallons - ferro-cement water tanks
  - E. H. Robinson - Carribbean Appropriate Technology Centre, P.O. Box 616, Bridgetown, BARBADOS.

- Rainwater harvesting
  - Pacey and Cullis, ITDG, 1986
    Available from I.T. Publications

- No Shortcuts
  - Nicky May and the Networkers

    Price £3.75

    Available from

    CHANGE,
    P.O. Box 824,
    London SE 24
    U.K.

Ideas on book-keeping, leadership training, health, income generation, etc. for women's groups water aid are also represented in Kenya. Contract:

- Action Aid and AMREF have a microfiche library and reader with 850 volumes on Appropriate Technology.

FROM: I.T. Publications

WATER SUPPLY & SANITATION

Appropriate Sanitation Alternatives: A technical & economic appraisal J M. Kalbermatten *et al* (World Bank Studies in Water Supply & Sanitation Vol 1) NEW
Summarizes the findings of the World Bank's research programme on appropriate sanitation alternatives, and discusses how they may be implemented. Intended primarily for planning officials and policy advisers for developing countries. 127pp. Illus. 1982 (Johns Hopkins). £10 35.

Appropriate Sanitation Alternatives: A planning & design manual J M Kalbermatten *et al* (World Bank Studies in Water Supply & Sanitation Vol 2)
Intended for project engineers and for technicians and field workers, this manual describes the details of alternative sanitation technologies and how they can be upgraded Extensively illustrated. 173pp Illus. 1982 (John Hopkins) £11 95.

Community Participation in Water Supply and Sanitation: concepts, strategies and methods Dr Alastair White NEW
A practical monograph presenting options for community participation, the circumstances appropriate to promote them, and possible difficulties to be encountered. 180pp. Illus. 1981 (IRC). £10.75.

† **Wastewater Treatment and Resource Recovery: Report of a workshop on high-rate algae ponds, Singapore, 27-29 February 1980** IDRC, Ottawa, Singapore Ministry of National Development
This report discusses wastewater, water treatment, waste recycling, and renewable resources It examines cultivation techniques, food production, harvesting, and processing in Singapore and Israel. 47pp. 1980 (IDRC). £2.25.

Water-pumping Devices: A handbook for users and choosers Peter Fraenkel NEW
A detailed and practical review of the options available for pumping and lifting water, especially for irrigation, on a small scale It demonstrates the costs and general suitability of the different technical options 196pp. Illus. Forthcoming 1986. ISBN 0 946688 85 0. £10 95.

Water, Sanitation, Health — for all? A. Agarwal *et al*
This book looks into the problems of particular countries and questions whether any significant improvements will occur in the ten years of the International Drinking Water Supply & Sanitation Decade (1981-90) 148pp. 1981 (Earthscan) £3.00.

Water Treatment and Sanitation H T Mann & D Williamson
A handbook of simple methods for rural areas in developing countries. This corrected and revised impression includes a new Appendix on planning in developing towns 96pp Illus. 3rd edition 1982. ISBN 0 903031 23 X. £4 95.

The Buba-Tombali Water Project, Guinea-Bissau, 1978-81 Prepared by IRC under assignment of the Directorate General for Development Corporation of the Netherlands NEW
A case study of a grass-root project in which water was not only treated as a technical and scarcity problem, but also a hygiene and health issue. 118pp. Illus 1982 (IRC). £7.25.

Community water development Edited and selected by Charles Kerr NEW
This collection of articles from *Waterlines* and *Appropriate Technology* covers the areas Sources of Water; Abstraction, Pumping and Distribution, and Training and Maintenance. The Editor has organized and introduced articles which have proved of particular interest, in such a way as to be of the greatest use for reference and for training. 192pp. approx. Forthcoming 1986. ISBN 0 946688 23 0. £6 95.

Environmental Health Engineering in the Tropics: An introductory text S Cairncross & R. Feachem
Describes the many major infectious diseases in tropical developing countries that are amenable to control by health engineering, and discusses such engineering with an emphasis on domestic water supplies and improved excreta disposal. 296pp. Illus 1983 (John Wiley). £7.95.

Environmentally Sound Small-Scale Water Projects: Guidelines for planning G Tillman
Written for community development workers in developing countries, to serve as a general guide when planning projects which protect and conserve natural resources. 148pp. Illus. 1981 (CODEL/VITA). £5.95.

Evaluation for Village Water Supply Planning A M. Cairncross *et al*
A guide to the evaluation of village water supply projects for engineers, rural health workers, development field workers, planners and policy makers 180pp. 1980 (John Wiley). £13.20 (Hardback).

Ferrocement Water Tanks and their Construction S B Watt
This book describes how cylindrical water storage tanks of up to 150 cubic metres capacity can be built using wire-reinforced cement-mortar. It covers design and planning, with an indication of costs; standard and recommended methods; alternative designs and construction methods; calculations of the expected loads the reinforced mortar must carry, roof catchment water supplies; and sources of further information. 118pp. Illus. 1978. ISBN 0 903031 51 5. £4.95.

Water, Wastes and Health in Hot Climates Ed. R Feachem, M McGarry & D Mara
A multi-disciplinary approach to the problems associated with water and wastes in hot climates, particularly those of the tropical developing countries Provides a basis for the interdisciplinary activities required to make best use of available resources. 399pp Illus. 1977 (John Wiley). £5 00.

Guidelines for Drinking-water Quality: Drinking-water quality control in small-community supplies Vol 3 NEW
For use by countries as a basis for the development of standards which, if properly implemented, will ensure the safety of drinking-water supply Vol 3 deals with small-community supplies, particularly in rural areas. 130pp. 1985 (WHO). £7.00.

Guidelines on Health Aspects of Plumbing Floyd B. Taylor & William E Wood NEW
Contains practical and technical details of plumbing systems as well as suggestions to drawing up and administering a comprehensive code and the likely problems. For health and sewerage authorities. 160pp. Illus. 1982 (IRC). £7.25.

A Handbook of Gravity-flow Water Systems New edition Thomas D. Jordan Jnr
The book was originally written for the construction of gravity-flow drinking water systems for rural communities in Nepal, but most of the principles presented here are applicable in locations around the world. The material is organized for quick reference, and allows overseers of both engineering and non-engineering backgrounds to understand quickly and easily. 250pp. Illus. 1984. ISBN 0 946688 50 8. £5.95.

Hand Dug Wells and their Construction S B Watt & W E Wood
This definitive work provides practical step-by-step guidance in the techniques of digging and constructing a well. It includes the principles of groundwater storage, the actual construction, the materials required and details of additional sources of information. 234pp. Illus. 1977. ISBN 0 903031 27 2. £5.95.

Hand Drilled Wells: A Manual on siting, design construction and maintenance Bob Blankwaardt
A practical and well tested manual for all those seeking to provide clean drinking water and hygienic sanitation by low-cost hand drilled wells in a rural environment. 140pp 1984 (Rwegarulila Water Resources Institute, Dar es Salaam). £8 00.

Handpumps for Use in Drinking Water Supplies in Developing Countries E F. McJunkin NEW
A state-of-the-art report, prepared under the sponsorship of UNEP and WHO Includes the use, operation, nomenclature, energy analysis, component designs and manufactures of various types. 230pp. Illus 1977 (IRC). £7.25.

Wood and Bamboo for Rural Water Supply: A Tanzanian initiative for self-reliance K van der Heuvel
Describes a 9-month project using wood and bamboo water pipes for water supply. Well illustrated with detailed technical information. 76pp. Illus. 1981 (Delft University Press). £4 00.

9 King Street, London WC2E 8HW, UK

Hand Pump Maintenance in the Context of Community Well Projects
compiled by
A. Pacey
A guide to the technical and social problems involved in community well projects, with an extension and evaluation of the different types of hand pump available 44pp Illus Revised edition 1980 (Oxfam/IT Pubs) ISBN 0 903031 70 1 £2 95

Human and Animal-powered Water-lifting Devices: A state-of-the-art survey
Bill Kennedy & Traudi Rogers
A report which covers the technical, socio-economic, and training aspects of this important subject. 160pp. Illus. 1985. ISBN 0 946688 75 3. £7.50.

Laboratory and Field Testing of Handpumps
Goh Sing Tau NEW
A technical study containing detailed descriptions of field testing protocols of an easily maintained handpump incorporating low cost plastics in the manufacture of the below ground components carried out in Malaysia 138pp 1985 (IDRC) £5 00

Making the Links: Guidelines for hygiene education in community water supply and sanitation Maricke T Boot NEW
A simple description, for community hygiene promoters and their trainers, as well as planners, technicians and survey staff It discusses the main water and sanitation related diseases and how they can be prevented or reduced as well as community hygiene education. 82pp Illus 1984 (IRC). £3.75.

A Manual on the Automatic Hydraulic Ram for Pumping Water S B Watt
Contains details of how to make and maintain a small hydraulic ram on a suitable site The second part takes a more technical look at ram performances and design considerations and contains a useful annotated bibliography. 38pp 1975 ISBN 0 903031 15 9 £3 95

Manual for Rural Water Supply
Highly detailed construction and maintenance manual, with many scale drawings for the planning and execution of drinking water projects 5pp. Illus. 1980 (SKAT). £15 95.

A Model for the Development of a Self-help Water Supply Program C Glennie
Presents one version of a practical model for developing, with high community participation, water supply programmes in developing countries 56pp. 1982 (World Bank). £5 00

† **Village Handpump Technology: Research and evaluation in Asia** Ed D. Sharp, Graham
This monograph presents summaries of the results of IDRC's Asian network of water-supply projects It identifies future research priorities, specifically the need to investigate large-scale manufacturing of the polyvinyl chloride (PVC) pump and the social and public-health factors that are an essential part of the programme 72pp. 1982 (IDRC). £2 00.

Village Water Supply in the Decade: Lessons from field experience C Glennie
Gives a first-hand detailed account of a successful rural water supply programme in East Africa, describing how it originated and developed over a period of 10 years 162pp Illus 1983 (John Wiley). £ 95 (Hardback).

Participation of Women in Water Supply and Sanitation: Roles and realities
Christine van Wijk-Sijbesma NEW
A state-of-the-art survey produced jointly with UNDP, based on practical experience drawn from 800 sources. It also describes the benefits and ways of involving women in the planning, implementation, maintenance, evaluation, health education and agency support. 200pp Illus. 1985 (IRC) £10 75

Planning & Evaluation for Community Water Supply and Sanitation
Wouter T Lincklaen Arnens NEW
An annotated bibliography Includes information on institutional arrangements, legislation, financing, manpower, technology and community participation. 153pp Illus. 1982 (IRC) £3 75.

Public Standpost Water Supplies
Ed A Pacey NEW
The findings of a study for the World Bank. It provides insights into economic and financial aspects of planning as well as the social, organizational and managerial aspects 104pp Illus 1985 (IRC) £7.25

Public Standpost Water Supplies: A Design and Construction Manual NEW
A step by-step method for engineers and technicians. Drawings and bills of quantities that can easily be adapted to local conditions. 92pp. Illus. 1985 (IRC). £7.25

Rainwater Harvesting
The collection of rainfall and runoff in rural areas Arnold Pacey with Adnan Cullis NEW
This book emphasizes the importance of social, economic and environmental considerations when planning and implementing projects For *rural development workers, it aims to fill the gap in existing literature on the gathering and storage of water running off surfaces on which rain has* directly fallen 224pp Illus 1986 ISBN 0 946688 22 2. £7.95.

Rain Catchment and Water Supply in Rural Africa: A manual E Nissen-Petersen
A simply written guide to obtaining a regular water supply using only locally available skills 96pp Illus. 1982 (Hodder & Stoughton) £2.50.

Rural Sanitation: Planning and appraisal
A. Pacey
This document is written for hospital staff and community development workers in Third World countries who are planning to start sanitation or hygiene improvement programmes 68pp Illus. 1980 (IT Pubs./Oxfam) ISBN 0 903031 72 8 £3 95.

Small Water Supplies R. Feachem & A M Cairncross
A guide to small-scale water supply, with sections on water sources, pumping, treatment, storage and purification 78pp Illus. 1978 (Ross Institute). £3 50.

Solar Water Pumping: A Handbook
Jeff Kenna and Bill Gillett
A 'state-of-the-art' survey — together with guides to costs and criteria for choice of pumping methods 132pp Illus 1985 ISBN 0 946688 90 7. £12 50.

Using Water Resources
The water section from the VITA handbook on village technology, with information on sources, lifting, storage and purification 144pp Illus. 1977 (VITA). £5 95.

† **Rural Water Supply in Developing Countries: Proceedings of a workshop on training held in Zomba, Malawi, 5-12 August 1980**
This proceedings discusses low-cost renewable energy technologies now available or being field tested It presents guidelines for new directions in rural water supply training 144pp 1981 (IDRC) £4 50

† **Rural Water Supply in China**
A translation from five Chinese manuals on water supply techniques, this report discusses potable water, source improvement, water treatment, supply configurations, and well drilling and repairs. 92pp 1981 (IDRC) £3 50.

SSF Caretakers Manual J T. Visscher & S Veenstra Revised edition NEW
A practical manual covering step by-step technical aspects of the slow sand filtration process, community involvement, operation and maintenance, cleaning and resanding 80pp. Illus. 1986 (IRC) £3 75.

Small Excreta Disposal Systems
R Feachem & A M Cairncross
An extremely useful introduction to a range of sanitation techniques, with abundant detail on smaller systems, from pit privies to sewerage systems 54pp Illus 1978 (Ross Institute) £3 00.

Small-scale Irrigation Peter Stern
This excellent and clearly illustrated book has been written primarily for those working with farmers on development and extension in rural areas who do not have ready access to much of the technical know-how needed for developing irrigated agriculture on a small scale. 176pp Illus. 1979 (IIIC/IT Pubs.). £5.95.

Sanitation in Developing Countries
Ed A Pacey
The result of a 1977 conference at Pembroke College on non-sewered waste disposal, with an emphasis on the relationship between sanitation and health. 238pp. Illus. 1978 (John Wiley). £3 95.

† **Sanitation in Developing Countries: Proceedings of a workshop on training held in Lobatse, Botswana, 14-20 August 1980**
These proceedings discuss sanitation and waste-disposal techniques in Ethiopia, Kenya, Tanzania, Malawi, Botswana, Zambia, Mozambique, and Lesotho It examines development and training programmes for professional, technical, and village-level personnel. Recommendations for specific follow-up activities are included. 172pp. 1981 (IDRC) £4 50.

Sanitation without Water — New edition
U Winblad & W Kilama NEW
Deals with dry systems for on-site composting or disposal of excreta and organic residues. 133pp. Illus. 1984 (SIDA). £2.50.

Septic Tanks and Aqua-privies from Ferrocement S B Watt
The book is for public health engineers, planners and field workers engaged in improving sanitation. It describes the potential of ferrocement as a construction material; the problems of design of septic tank and aqua privy systems and the various technical options in low-cost sanitation; gives details of how septic tank and aqua privy waste treatment and soil disposal units are designed and constructed, and gives step by step construction details of a ferrocement septic tank built for the commercial market. 108pp Illus. 1984. ISBN 0 903031 95 7. £4 95.

WOMEN

Appropriate Technology Journal: Women's issue

The December 1982 issue (Vol 9 No 3). 36pp £2.25. (see page 37)

Blacksmith, Baker, Roofing-sheet Maker — Employment for rural women in developing countries Marilyn Carr

A source of ideas for all those who are helping develop cash-producing work for Third World women. It uses over 50 case studies to show how less conventional projects have developed the earning power of women in more competitive fields of activity, the evidence is taken from 22 countries and covers 38 trades. 158pp Illus. 1984. ISBN 0 946688 15 X. £5 95.

The Domestication of Women: Discrimination in developing societies B Rogers

Examines how development planners deal with issues relating to women, including discrimination against women in development agencies, distortions in research, and data use for development planning and myths about women's 'natural' place in society. 200pp. 1980 (Tavistock Publications) £5 50.

The Impact of Technology Choice on Rural Women in Bangladesh: Problems and Opportunities Gloria Scot and Marilyn Carr

Mechanization of the major agroindustries in Bangladesh has resulted in the loss of thousands of jobs for rural poor women. This paper analyses the cause and effect of the adoption of new technologies, particularly in the rice milling industry, and attempts to show how alternative technology improvements make greater economic sense as well as produce more positive effects for women. 108pp. 1985 (World Bank). £10 00.

Improved Village Technology for Women's Activities: A manual for West Africa

Contains practical possibilities for the utilization of agricultural wastes and the by-products of women's processing activities. It focuses on four main processing activities — cassava, vegetable oil, coconut and fish. 292pp. 1984 (ILO). £10 00.

The Tech and Tools Book: A guide to the technologies used by women around the world Ed J Sandler & R Sandhu (NEW)

A research manual of appropriate technologies used throughout the world in women's projects. Includes sections on support systems, a credit training and technology transfer 200pp. Illus. 1986. ISBN 0 946688 17 6 (IWTC/IT Pubs). £7 95.

Women in Development

A resource guide for organization and actions intended for all concerned with the integration of women in development projects. 228pp. Illus. 1983 (ISIS) £3 95

Women and Small Business (NEW)

A collection of articles on the women's perspective on topics relating to earning income, including credit, marketing, production and management. Originally published in the IWTC Newsletters from 1981 to 1985. 120pp. Illus. 1985 (IWTC). £6 95.

Women and the Transport of Water Val Curtis (NEW)

The haulage of water is one of the most arduous and time-consuming tasks for rural women. This paper looks at the scale of the problem in general and in particular in Kenya, and suggests ways in which improved methods of transport could help. 64pp. Illus. 1986. ISBN 0 946688 42 7. £5.95.

† **Women's Issues in Water and Sanitation: New responses to an age-old challenge** K P. Pilipino (NEW)

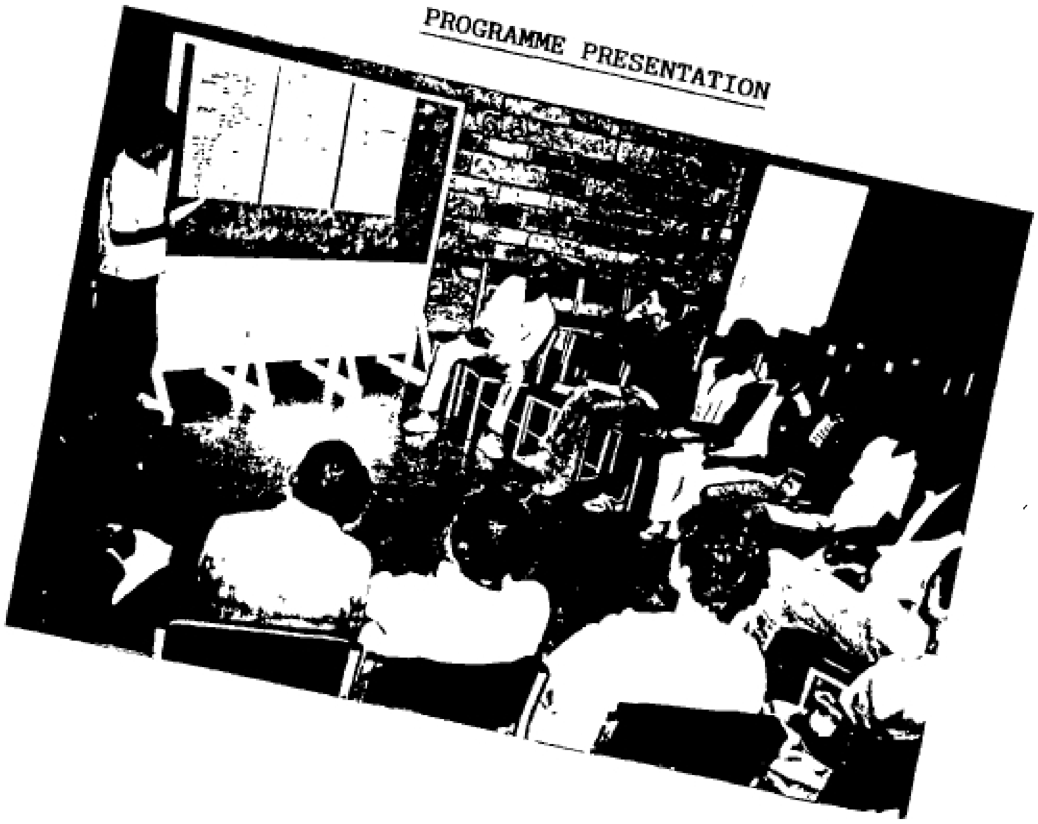
This publication documents the results of a seminar held in the Philippines in 1984, by reviewing women's past efforts in water supply and sanitation activities and presenting abstracts about ongoing research. 200pp. 1986 (IDRC). £6 00.

Ferrocement Tanks

A filmstrip which describes in detail the step-by-step construction of a ferrocement tank.

Available from World Neighbors, Nairobi.

PROGRAMME PRESENTATION



PRESENTATION FROM CARE INTERNATIONAL IN KENYA

RURAL WATER DEVELOPMENT

CARE's present approach is moving away from pumping water projects to low cost water proejcts with minimal maintenance cost. Such as spring protection, lining and equiping of shallow wells, excavation of dams, (pans) gravity flow pipe systems, solar pumps and roof catchments.

CARE gets to the community through direct contact or through Ministry of Water Development, Ministry of Culture and Social Services and other NGO's to support the community efforts in completing their ongoing projects. It is at this stage that CARE, in collaboration with the above parties including that community, assesses the needs for water supply.

Although the community has various needs for water e.g. Domestic use, Livestock, Irrigation etc. by and large the provision of water is determined by the availability of water sources depending on geographical conditions of the area. The priority for water needs goes to Domestic use. In order to meet this need we consider the most economical system that can provide potable water to the community, over the years we have found out that roof catchments meet these requirements.

ROOF CATCHMENTS

CARE has focussed its assistance in roof catchments in primary schools, secondary schools, and health centres with the hope that the idea of roof catchment and storage water tanks can be duplicated in the homes of the community members. We plan to build some demonstration tanks at individual homes to enhance this idea of roof catchment.

ROOF CATCHMENT TANKS

~~CARE has developed~~ three types of roof catchment water tanks in various parts of the country depending on availability of local materials and fundis, in order to minimize the cost of building the tanks. These type of tanks are:-

1. Ferrocement tanks
2. Rubble stone tanks/undressed stones
3. Baked bricks

During these tanks construction CARE emphasises on cost sharing where the community provides local available materials such as sand, stones (hard core) unskilled labour. CARE provides the remaining materials and skilled labour including supervision.

CARE trains the fundis from local Youth Polytechnics Instructors, ex-graduates of those Youth Polytechnics and local artisans. After their training CARE contracts them to build the water roof catchment tanks in various sites and they are paid by CARE. The fundis are motivated by giving them more contracts and paying them down payment at agreeable percentage while the rest is paid after the completion of work. We have no credit scheme on this issue at the moment.

Presently the tanks that have been constructed have shown no problems at all. The community however, are aware of carrying out any necessary repairs and maintaining the gutters and the tanks. The quality of water in few tanks which were not covered is bad and arrangements are underway to cover them otherwise quality of water in those tanks which are covered is good. All the roof catchment tanks built by CARE assistance are ground level tanks.

DESIGN OF TANKS

MINISTRY OF WATER DEVELOPMENT STANDARD MASONARY WATER TANKS

Formerly CARE used to build tanks as per MOWD standards which were found to be expensive and required extensive skilled labour which in most cases is restricted to MOWD fundis only. It is due to this high cost expenses that CARE decided to explore on low cost technologies. Through other NGOs e.g. 20M3 tank costs about Shs.40,000/= (2,000/= per 1m3).

FERROCEMENT TANKS:

The Danida started building this type of tanks at Mutomo Kitui District and their capacities vary from 10M3 to 50M3. CARE promotes the 20M3 tanks (See the attached sketches). From experience we have modified the plaster by making the outside plaster a continuous run from roof to wall, this has also reduced the cracks between the roof and the floor. We have also introduced the use of water proof cement which was not there before. This strengthens the walls and prevents the leakages. In some areas the roof has been changed to G.C.I. roof slanting inside thus providing more catchment areas.

The advantages of these type of tanks are (1) cheap and local materials hence low cost, few people are required for labour. Time taken to build the tank is about 9 days. Sizes of tanks can allow for wide choice.

The disadvantages of ferrocement tanks is that it requires a minimum of about 6" of water in the tank at all times. We started working with ferrocement tanks in 1985 and we have not known of its life span. The cost of 20M3 ferrocement tank costs about K.Shs.12,000/= including labour (Shs.600 per 1M3).

RUBBLE TANKS

The idea of rubble tanks came to CARE through a Peace Corps Volunteer in Kisii in 1985. These type of tanks vary from 5M3 to 100M3. Rubble tanks construction involves the use of hadcore as the main ingredient of the tank walls with minimal mortal built by use of a mould.

The roof is covered with G.C.I. sheets or plain sheets. The construction of 10M3 tank takes about 18 days to complete. No mofification has been made. Currently we have built tanks ranging from 10M3 tO 20M3.

The advantages of this tank is intensive use of local materials e.g. stones, cheap, takes few days to construct, very minimal leaks.

The disadvantages of rubble tanks is that they cannot be built anywhere one wants because it requires a lot of stones for the walls. The mould requires a pick up and at least it might be easy to make one at site which will require the service of a carpenter.

The cost of 20M3 rubble tanks is K.Shs.21,200/= including labour (K.Shs.1060 per 1M3)

BAKED BRICKS

Brick tanks have been in use for many years in areas where bricks are locally available (made). Bricks are generally made of sandy soil mixed with water, moulded and sun dried. The dried bricks are baked for construction.

Currently we have built tanks ranging from 10M3 to 20M3. These sizes the bricks are laid horizontally like blocks to give a wall thickness of 6" (150m). Barbed wire and/or hooping are used for reinforcements. They are covered with G.C.I. sheets.

Their advantages are that more local available materials used are contributed by the beneficiaries.

The disadvantages of this type of tanks is that they can only be constructed where soils are suitable for brick making.

The cost of about 14M3 is about Shs.7,240/= approximately 520/= per 1M3.

PROPOSED CREDIT SCHEME

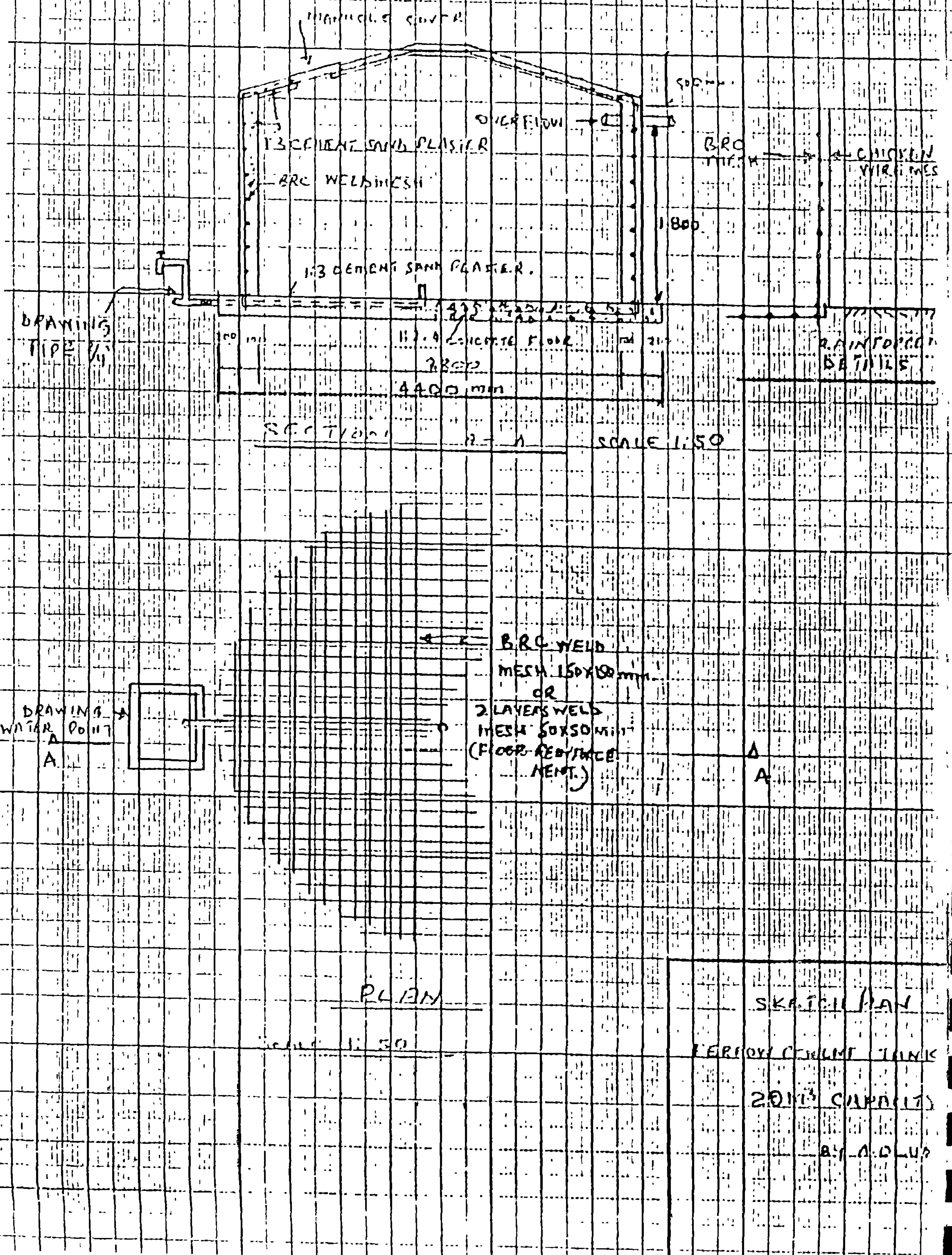
Although the type of tanks mentioned are cheaper than MOWD tanks the community (who are considered poor) cannot be able to construct them in their homes as they will still appear expensive to them.

It is proposed that the idea of a credit scheme might help if NGOs together with Government of Kenya could come up with idea. The NGOs/GOK can make funds available for individuals and arrangements be made for the recovery through a financial institution similar to other credit facilities offered by other organizations such as A.F.C. If this idea is encouraged this might assist in providing potable water closer to the comminty by the year 2000 as per Government of Kenya target.

SUMMARY

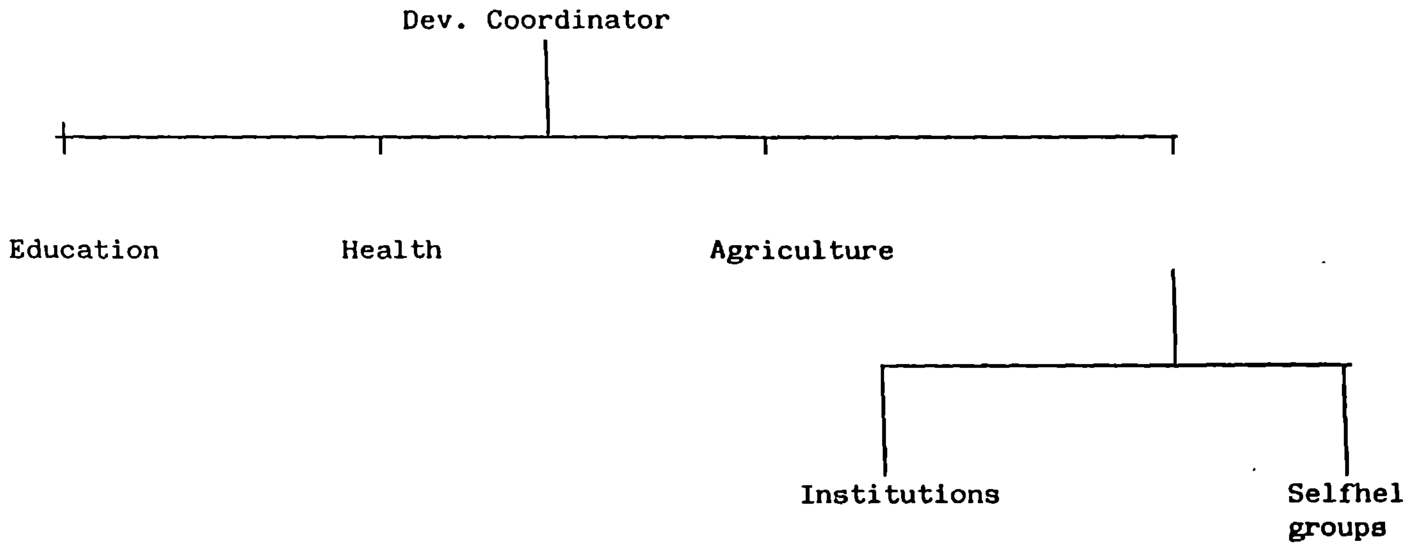
The decision of the type of a tank to be constructed rests on the community, therefore the technical advise should be considered appropriate at that level. (Community level). Through experience we have found that the types of tanks we have mentioned above are applicable in different parts of the country with the necessary modifications, depending on the geographical location.

Contribution from: Boinett, Oluoch & Muroki


MANHOLE COVER
500mm
OVERFLOW
1:3 CEMENT SAND PLASTER
BRC WELD MESH
BRC MESH
CHICKEN WIRE MESH
1800
1:3 CEMENT SAND PLASTER.
DRAWING PIPE
3800
4400 mm
REINFORCEMENT DETAILS
SECTION A - A
SCALE 1:50
B.R.C WELD MESH 150x100mm
OR
2 LAYERS WELD MESH 50x50mm
(FLOOR REINFORCEMENT.)
DRAWING WATER POINT
A
A
PLAN
SKETCH PLAN
FERROCEMENT TANK
20m³ CAPACITY

Catholic Diocese of Kitui Water Program Frank Gray

The Diocesan Development office has this structure with all the work carried out through self-help groups and institutions.



Water Development Department

Thirty seven (37) people are employed by the Diocese on two (2) year contracts. Outside contractors are used when needed particularly for the roof catchment tanks.

Water Staff

Water Engineer and co-partner
Technicians (2 Nos.)
Building Inspector (1 No.)
Area Coordinators (6 Nos.) + outside sub-contractors
Fundis (16 Nos.)
Roof catchments (6 Nos.)
Storeman/clerk/typist

The area coordinators' role is to organise groups, - objectives and priorities, and to enable the groups to provide the local materials and the food and accommodation for the fundi.

It was found that the best systems for the poorer people are wells, springs, and rock catchments. Whereas the roof catchment tanks are more appropriate for the more affluent families.

In the program the local/individual contribution is less for wells, springs and rock catchments than for tanks.

The program had built more than 1,000 750 gallons water jars but although they had received few complaints they felt unhappy with the construction (transport of the filling very difficult, cracking, leaking limited capacity).

In 1986 the Diocese received increased funding for tank construction and so the program began to review their thinking - rainfall, storage possibilities, and program guidelines.

Mean annual rainfalls approximates to
Central:- 750 to 1,000 mm.
Southern/Western/Northern:- 500 to 750 mm.
Eastern:- 500 mm.

Storage:

Ex. on 5m x 3m house (average house size)
Vol. available/year = 5 x 3 x 750 x 80 = 9,000 litres
Ex. on 50 litres/house/day
Vol. required (to cover dry season of 4 months) = 4 x 30 x 50 = 6,000 litres
Max. cap. decided as 10,000 litres (2,000 galls.)
10 cu. m.

Most homes have restricted headroom which limits tank size.

The larger storage the less appropriate for poorer families.

However, roof catchment is the ultimate water supply system for Kitui in an affordable price range.

Main Program Guidelines

1. Tanks designed to suit individual households
2. Tanks to be within affordable price range???
3. Maximisation of group participation
4. Improve efficiency for construction and transportation
5. To reduce dependence on imported materials.

The self-help groups must demonstrate that they have a committee able to run other projects and be able to operate as a group and make group decisions. The group decides on who gets the tanks and in what order.

New Program

Began in December 1986 and January 1987 in training fundis to build a variety of different tanks. This workshop including the area coordinators whose job it is to organise the groups for the water system the group itself has chosen.

The costs, designs and construction techniques were all compared (a mabati tank was not built but costed for comparson).

Tank Comparisons:

1. G.C.I. circ. tank
2. Ferrocement water jar
3. Machakos type tank
4. Ferrocement tank (Watt)
5. Ferrocement tank (Unicef)
6. Traditional burnt brick tank.

Comparison Costs Include:-

1. All materials (local and non-local)
2. 10% contingency
3. Labour costs (local and non-local) (40/= per day for fundi, labour 25/= per day)
4. Food and accommodation costs
5. Transport costs (3/= per km. for vehicle use).
6. Overheads

The findings were:-

Type	Overall Cost Ksh. (1987)	Capacity Gallons	Cost/ Gallon	Diocese	Group
GCI Tank	7,480	2,000	3.74	6,350	1,130
Water Jar	3,008	750	4.01	1,540	1,469
Machakos type	4,949	1,200	4.12	2,759	2,190
Watt type	5,734	2,000	2.87	2,570	3,164
Unicef type	7,231	2,000	3.62	4,371	2,860
Brick type	6,174	2,000	3.09	3,204	2,970

The program decided to build the tank as described in Ferrocement Water Tanks and Their Construction by S. B. Watt (ref: Resource Section for more details)

Frank did not want to give more conclusions as he stressed that each programme area will have different needs and costings.

e.g. A 1,200 gallon tank cost 1,900/= in Machakos and 4,049/= in Kitui. This is due to cost of materials, construction techniques and what is calculated in the costings.

Comparing directly costings from program to program is inaccurate - the only way is to build the tanks and compare for oneself.

The present programme is planned to construct 2,000 tanks in the next two years.

Tanks

Mabati form was prepared, fundis trained + the first 5 build in public places for demonstration. The capacity of these tanks is of 2,000 gallons. Total built = 150.

Mould

Made of 4 sections of C61 sheets 6' high int. = 8' - 6"

wall thickness	=	2"
floor "	=	3" - 4"
floor reinforc.	=	6mm bars of 12" c/c
Wall reinforc.	=	chicken wire + plain galvanised wire 12g.

Corrugation

¾" outlet + 1½" w/o

Cover : plain sheets or 26ft.)

Timber frams 3" x 2"

Cost:

cement, sand, ballast	Ksh.1,650/=
other materials	Ksh.1,450/=
labour transport + contingencies	Ksh.1,100/=
Total	Ksh.4,200/=

Advantages/Disadvantages

a. Makes it easy for fundis to construct, uses little time to build (to apply plaster)

b. Sometimes car is needed to transport the mould (if distances are excessively long)

People's Participation

People pay the overall costs	)	No credit
All the tanks so far built, were	)	scheme no
for individuals	)	subsidies

First design had no roof (to keep costs low) but it was added later.

Present Set-Up:

2 crews of fundis using 2 moulds under the supervision of a head fundi who is also i/c of purchase and organisation of materials. People requesting tanks pay first to avoid problems later. Fundis are liable for major repairs if crack occur due to poor construction (not because of faulty curing)

5,000 gallon tank

Mainly built for storage tanks in rural water supplies. Some design used, with more reinforcements. Cost = Ksh.12,000/=. Started only recently.

Discussion

Q. What coordination and exchange of ideas is there within the District?

A. Only through the DDC

There is plenty of scope for such activity and great need for tanks, to that people and programmes could easily work together.

(However, there is often more confusion and difference over payments and contributions rather than confusion in designs, between programmes).

Q. Why did you stop the jars construction?

A. Mainly because of the difficulty of transporting 36 bags of wood chippings which is used as the filler. We tried more locally available materials such as sand or manure, but they did not work so well as wood chipping.

Q. How was the jars programme organised?

A. Responded to requests from established groups. The jars were built by sub-contractors. The revolving loan fund was difficult to administer and slow to revolve. The organisation is now carried out by the area coordinators.

Q. Are the area coordinators given guidelines to help group in the process of selecting the order of who gets the tanks first?

A. Not yet, but it must be done soon, and will be decided by workshop group decision within the programme.

DIOCESE OF KITUI

20TH NOVEMBER 1984

WATER JAR CONSTRUCTION --
GUIDELINES FOR FUNDIS

The following is a brief set of guidelines for fundis constructing water jars under the wing of the Kitui Diocese. Any fundi constructing such water jars will require several weeks of practical training before attaining a reasonable level of competency. Below are guidelines for fundis who have reached this level.

Notes:

1. All mix ratios are as follows:

   cement:sand:kokoto

   e.g. a 1" : 3 : 2" mix is one portion of cement, three portions of sand and two portions of kokoto.

2. The sand used should be clean, coarse river bed sand, sifted, if necessary, to remove any stones.
3. All plaster must be mixed thoroughly and hence be of a uniform colour.
4. An enormous amount of local participation is always essential in any Diocesan water project.

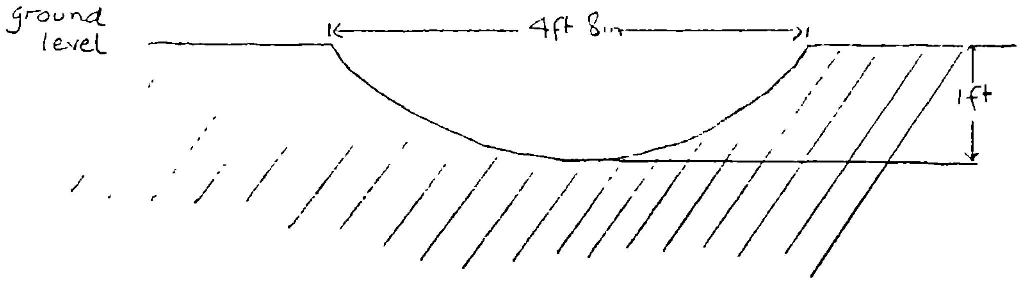
-----DAY 1-----

A. LOCATION OF WATER JAR: A suitable site should be found for the jar bearing in mind the following-

   1. the proximity of the catchment building, e.g. house,
   2. the roof guttering,
   3. the wishes of the people concerned.

B. FOUNDATION:

   1. Dig a hole which taks the shape of a segment of a sphere. The diameter of this hole should be 4 feet 8 inches. The depth should be 1 foot as in Fig. 1.



F-g. 1.

2. Fill this hole with 1 inch kokoto and compact them well.
3. Form a ring of bricks, at least 9 inches high, around the edge of this hole and secure them with some binding wire. Fig. 2.

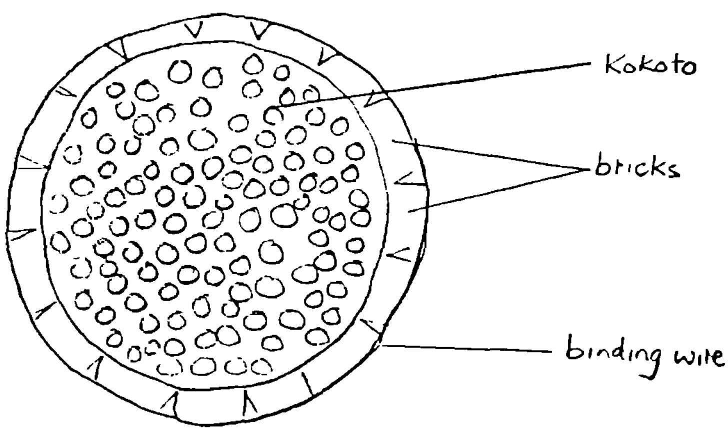


Fig. 2.

4. Onto the kokoto, pour 3 inches of a 1:3:2 concrete mix and beat it well.
5. Cut 12 lengths of wire each being 20 feet long. Lay these wires evenly across the top of this concrete with their centres meeting at the centre of the foundation. These will be used for the vertical reinforcement wires. To the centre, attach one length of wire at least 360 feet long. This will form the horizontal reinforcement wires.
6. Suitably position the pipe on top of this concrete.
7. Pour in a further 3 inches of 1:3:2 concrete. Beat it well. Smooth and level the surface with a steel trowel. Cut a hole through this concrete to the outlet pipe. Apply a generous coat of Nil (cement and water paste) to the surface. The thickness of the foundation concrete is now 9 inches.

C. THE COVER:

1. Dig a hole again in the shape of a segment of a sphere - 2 feet 4 inches in diameter and 4 inches deep.
2. Place a Blue-band tin in the centre of the hole to allow for the inlet gutter pipe.
3. The reinforcement is formed as in Fig. 3. out of double inter-twined strands of binding wire.

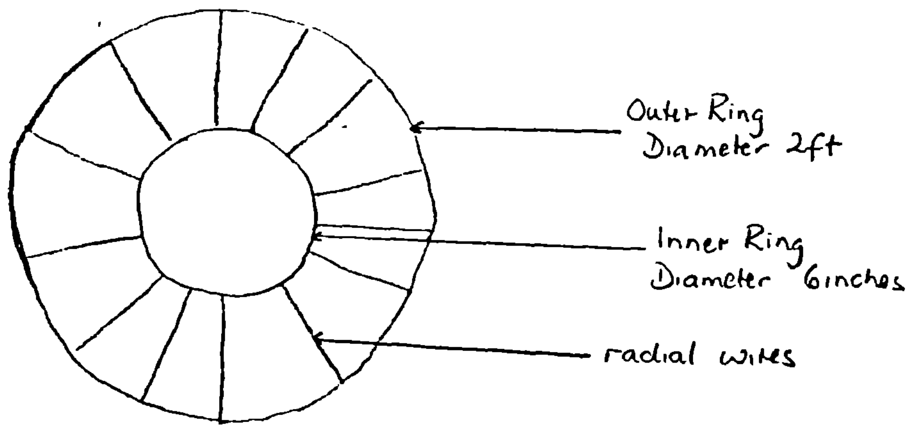


Fig. 3.

Note:
All wires are doubled and intertwined.

4. Pour two inches of 1:3 mix into the hole and beat it. Position the reinforcement centrally. Apply a further 2 inches of 1:3 mix and beat well.

-----DAY 2-----

D. CONSTRUCTING THE BODY OF THE JAR:

1. Remove the bricks from around the foundation.
2. Position the mould bag centrally on the foundation. Stuff the bag with wood chippings, compacting them well as the work proceeds.
3. As the water jar will take the shape of the stuffed mould bag, it is very important to ensure that the bag, when staffed, is level and symmetrical all around.
4. Apply a generous coat of Nil all over the bag.
5. Apply one coat of plaster ½ inch thick all around. The mix is 1:2.

The Main Body Reinforcement: (Fig. 4.)

6. Make a dobule stranded ring of wire 8 feet 2 inches long and place it over the top of the jar.

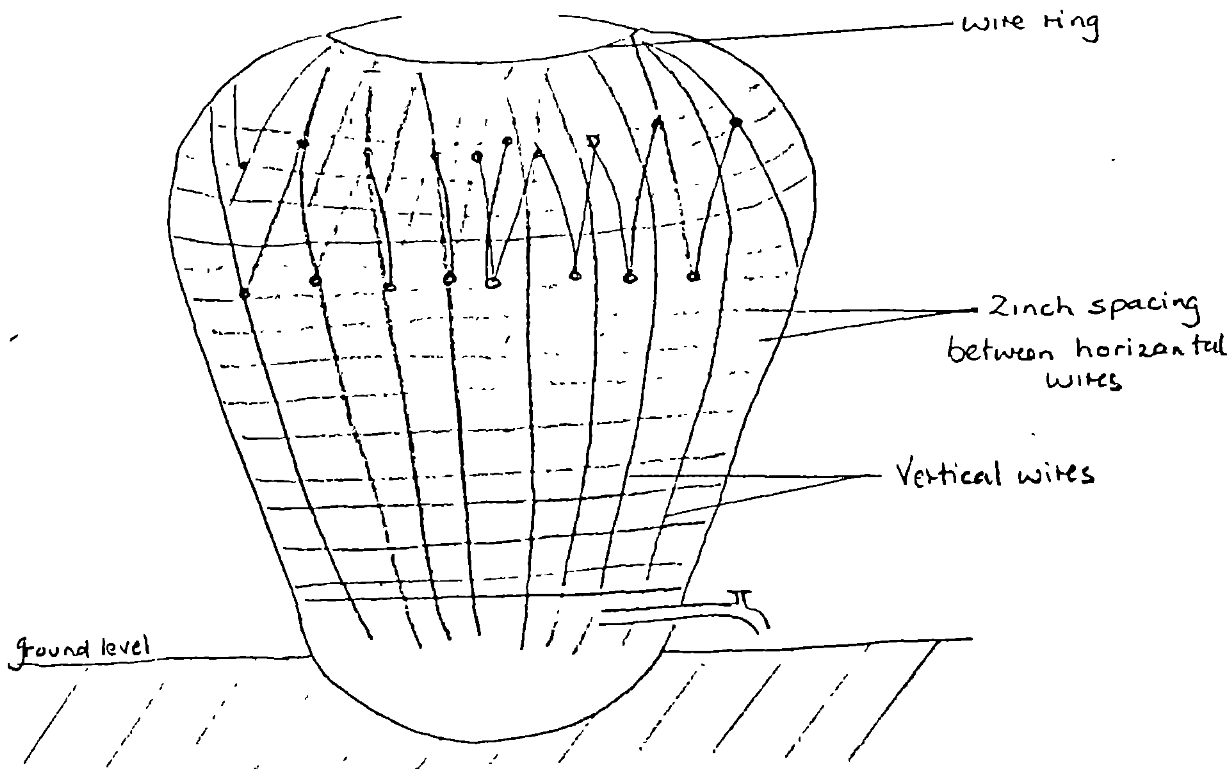


Fig. 4.

7. Bring up the vertical wires and loop them under this ring to overlap themselves by about 12 inches.
8. Wrap the long wire (in foundation) around the jar in a spiral fashion, maintaining spacing of 2 inches between each horizontal wire, continuing up until it meets the looped over section of the vertical wires. See Fig. 4.
9. From a point 2 feet below this attach a long piece of wire and connect it from the end of each vertical wire to the horizontal wire in a diagonal manner as shown.
10. Apply a second coat of plaster (1:2) leaving a rough finish for binding to the final coat.

----DAY 3----

11. Apply the final coat of 1:2 plaster with a smooth finish.

----DAY 4----

E. FINISHING OFF

1. Remove all the wood chippings from the jar and replace them in the sacks.

2. Remove the mould carefully.
3. Thoroughly wash the mould.
4. From within the jar, apply a 1 inch thick coat of plaster (1:2) along the joint between the wall and the floor of the jar - coming 3 inches up and 3 inches in from the corner. Apply a generous coat of Nil over this plaster.
5. Also, from within the jar, check for any flaws in the wall of the jar and cover them with a generous coat of Nil.

F. CURING

Fill the water jar with water. It should remain full for at least 20 days.

A P P E N D I X

MATERRIALS REQUIRED:

Sand............................	10 wheelbarrows
Cement..........................	5 bags
Kokoto..........................	4 wheelbarrows
Wire............................	5 kg.
Tap.............................	1
Pipe............................	1
Socket..........................	1
Water...........................	3 drums

Machakos Diocese   Presentation by Patrick Kasyula

1. The development office started construction of water tanks in 1986 with only two people involved.
2. Before starting the construction they had visited many women's groups and seen water problem as top priority as these women used to buy corrugated iron sheets tanks which did not last long (1 - 2 years) then they start leaking because of rust.
3. The cost of these tanks was very high - (3 - 4 thousand shillings).
4. The couple started with the building of water jars which after a short period became unpopular partly because they were small and partly because they were not durable.
6. They moved to concrete tanks which are very popular in the whole district and outside as well e.g. Kitui, Taita, Meru, etc. They are popular because of the strength.
7. There are over 3,000 tanks of this type in the whole of Machakos District.
8. At the moment more than 100 development groups are involved in the construction of these tanks.
9. The procedure is that the client individual/group fills a form in the development office and pays a fee of Shs.100/= for the construction of the tank.
10. There are three sizes of tanks:

900 gallons	-	Shs.1,600/=
1,200 gallons	-	Shs.1,900/=
3,000 gallons	-	Shs.5,300/=

People choose what they want and what they can afford.
11. If one starts with a smaller tank and later requires a bigger one the group he belongs to does the construction without involving the Diocese.
12. The development office serves even those who do not belong to groups but individual tanks are more expensive in that bulk buying and transportation is not involved. For groups they build more tanks, therefore more materials are bought and transportation becomes cheaper. So individual tanks in this case will cost more.
13. Since the services are requested by many people in far places of the district the client is usually requested to send a fundi to Machakos for training in concrete tank construction then goes back to carry out the construction for the client. It is cheaper in that only training fee would be involved.

Materials used:

Gauge 24 corrugated iron sheets (taken to a factory for rolling)

Barbed wire 12½ gauge

Cement

Sand

Balast

Cement, balast and sand are mixed to the ratio of 1:4:3.

Problems:

Only one tank in the programme leaked and this was attributed to poor mixing of cement, sand and balast.

Qeuestions

Q Does the Diocese organise the groups?

A - No, they do not because they can only work with already organised groups

- The groups (development) are formed for that particular purpose and when the work is over, they disband.
- The Diocese improvises in the construction of tanks but there is no outside assistance.
- The Diocese had donors especially for the training of fundis and since the withdrawal of the donations, the Diocese has to charge more for the building.
- The fundis are paid Shs.200/= per tank.
- 900 gallon tank takes:

  11 bags of cement

  1 wire mesh

  1 kg. of water proof
- There is no set rule on the types of gutters for the roofs. The commur or individual can have them made from used tin cans of kimbo, blue band etc.

The programme was started by the Diocese with a grant of Shs.20,000/= with two people and then the communities were involved later.

- The tanks of not go beyond 8 ft. high otherwise they will collapse.
- Other problems are: The projects are too many

  the groups also are too many

MACHAKOS DIOCESE

P.O. Box 640
Telephone 21442
M A C H A K O S

R A I N W A T E R   T A N K

The Machakos Catholic Diocese is selling 3 kinds of Rainwater Tanks. A 900 gallon, a 1,200 gallon and a 3,000 gallon. (Resp. 4,000 litres, 5,400 litres and 13,500 litres).

The tanks are made out of concrete rings, using corrugated iron sheets, half circular ben as a mould. The concrete is reinforced with barbed wire.
The approximate sizes and prices are:-

	900 galls.	1,200 galls.	3,000 galls.
Diameter	1.75 m.	1.75 m.	2.6 m.
Height	1.65 m.	2.40 m.	2.50 m.
Price	1,600/=	1,900/=	5,300/=

This price includes construction materials, skilled labour (1 fundi) and transport. However, it excludes aggregates, sand and hardcore (which have to be collected by the owner). One should also provide accommodation and food for the fundi, 2 casual labours and water for the construction. It will take approximately 6 working days to complete the tank. After completion, the owner should pour water on the tank (inside and outside) 3 times a day for 2 weeks for proper curing. Gutters are also exlcuded from the price.
If you are interested start the following procedure.

1. Fill application form, enlcose registration fee of Ksh.100/= and pay for the tanks at the Development Office.
2. Prepare the site with the required aggregates, sand and hardcore.
3. Make arrangements with the water tank coordinator, Mr. Patrick Kasyula for the exact place of the tank and for the day of starting the construction.

Required materials for the tank.

	900 gals.	1,200 galls.	3,000 galls
Cement	9 bags	11	28
Weldmesh 8' x 4')	2	2	5
Barbed wire	½ role	½ role	1 role
Water proof cement	1 kg.	1 kg.	3 kg.
Outlet pipe + tap	1 (½")	,1 (½")	1 (¾")
Timber (6" x 1")	70 ft.	70 ft.	120 ft.
Timber (3" x 2")	100 ft.	100 ft.	60 ft.
Poles	-	-	8
Nails	3 kg.	3 kg.	3 kg.
Local materials (to be provided by owner)			
Aggregate (½")	20 wheelbarrows	30 W/Barros	5 tons
Sand	20 "	30 "	5 tons
Hardcore	10 "	10 "	3 tons

Leo de Vrees
WATER ENGINEER
MACHAKOS CATHOLIC DIOCESE

17/2/87

APPLICATION FORM

WATER TANK PROGRAM

MACHAKOS CATHOLIC DIOCESE

P.O. Box 640 MACHAKOS Tel 21442

1. This application should be filled in duplicated one copy for the applicant and sent to the Water Department Diocese of Machakos P.O. Box 640 Machakos
2. The application forms must be accompanied by a registrat ion fee of 100/- to be paid to the accounts clerk of the Development Office.

Name of Project ____

Division _____________________ Location _____________________

Sub Location __________________ Village _______________________

The Project is located ____________ Km/miles from ________ (Township)

Name of person responsible for the project _________________

____

Has the project support from the local authorities (Sub- chief)

____

Amount of funds raised _____________________________________

People's contribution at present ___________________________

Address to which all letters should be sent _______________

____

DESCRIPTION OF THE PROJECT - Indicate clearly what you prpose to do, how many families will be served, which water source, etc ____

____

____

____

____

Place _______________ Date ___________ Signed ________________

Designation ______________________

building and construction

A ROOF CATCHMENT WATER TANK PROGRAM IN MACHAKOS DISTRICT, KENYA

This article describes a practical experience on a rainwater tank project currently under implementation by the water department of the development Office of the Machakos Catholic Diocese. It is both the technical design as well as the method of implementation which made the project to become a success.

In a preiod of two years some 1200 tanks were constructed serving 8000 people with water for domestic use. The project is still expanding with a growing construction rate, presently of 70 tanks per month.

The design:

The design is made for a cilindrical water tank of barbed wire reinforced concrete. Its volume ranges from 4000 litres to 5400 litres depending on the heighth. (See also drawing).

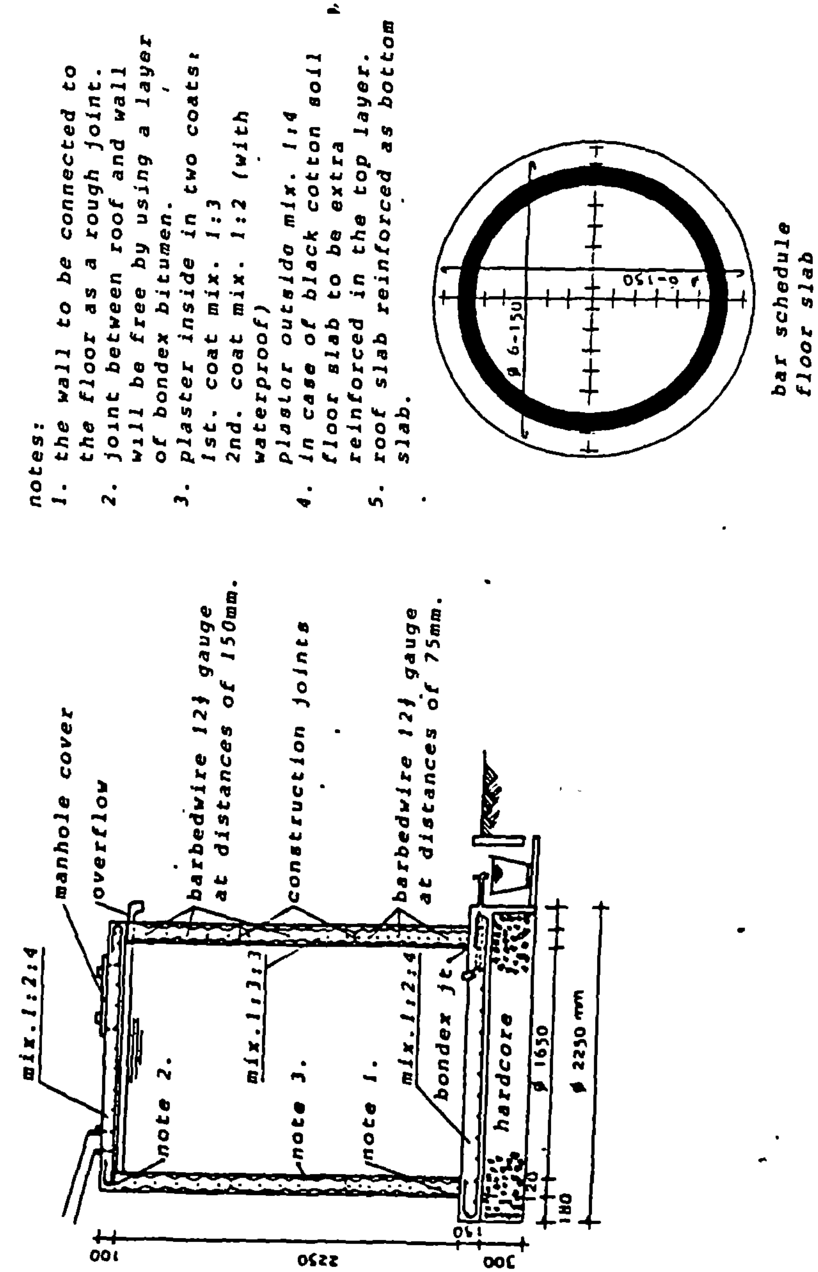


figure 1. concrete watertank made with corrugated iron mould; volume 5400 liters (design: A.C. Thiadens)

These volumes are recommended for small family homes with a minimum roof catchment of 20m², normally built of corrugated iron sheets.

In most parts of the District annual rainfall measures 500mm and above, divided over two rain seasons in the periods March - Mary and October - December. This means that in a dry period of 100 days, the water consumption should be rationed to resp. 40 or 54 litres per day per tank before the next rains refill the tank.

The mould (shuttering) is made out of corrugated iron sheets (24 Gauge), half circular bended. These half circle sheets are joined together with bolts and nuts to form two rings (inner and outer). Bending of corrugated sheets is quite common in the Kenya Metal industry. In almost every district's Capital a bending machine is available. The reason to use corrugated sheets, instead of flat sheets, is because of the form stiffness it creates in the radical direction due to its corrugation. A fairly thin metal sheet can be used and it does not require any extra reinforcement such as stell strips. Thus the mould becomes light, cheap and easy to transport, compared to the type of mould made from flat sheets or timbers. At present in Kenya the corrugated mould costs Ksh. 1200 (or US$75) and can be used for at least 50 tanks.

Note:
Naturally the same technology can be applied for tanks with bigger diameters. So far the Project constructed some 70 tanks of 3000 Gallons (13.500 litres) for institutions like schools despensaries etc.

Building proces step by step

Day 1: Construction of foundation with the floorslab and the first wall ring. Labour: 20 workman hours.

Day 2: Mould to be lifted to construct second wallring (Fig. 2) Labour: 6 workman hours.

figure 2. the second wallring being constructed.

Day 3: Third wallring. Labour: 6 workman hours.

Day 4: Remove mould so as to start the plastering at the inside. First coat mix 1 : 3, second coat mix 1 : 2. (Mixed with water proof compound) Final coat with pure cement. Labour: 20 workman hours.

Day 5: Fixing shuttering and reinforcement, after which the roofslap will be concreted. Labour: 20 workman hours.

Day 6: Outside wall to be plastered and the water point to be constructed. Labour: 10 workman hours.

Day 7: Until day 14: For proper curing the tank should be kept wet by pouring water at least 3 times per day: 7 workman -hours.

Day 14: The roof shuttering can be removed and after clearing inside the tank is ready for use: 6 workman hours (Fig. 3)

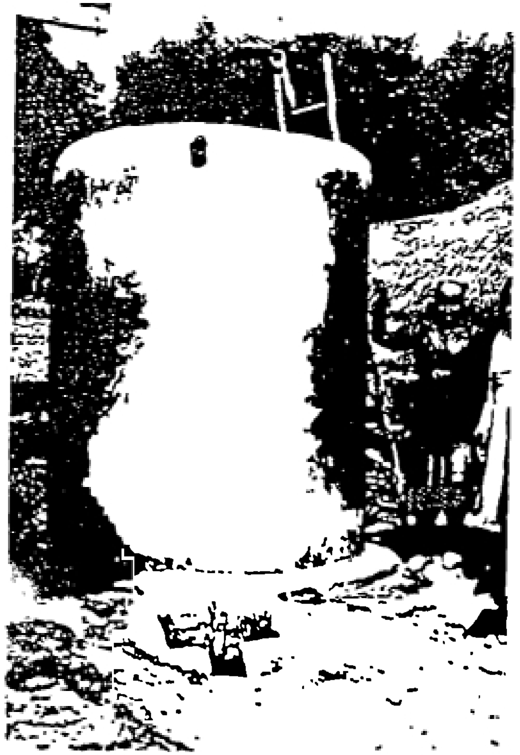


figure 3. the water tank is ready.

If everything is well planned, one mason can build two or even three tanks in the same time.

Implementation method:

The project's objective is to work with groups.
Once a group is prepared and has paid for at least 3 water tanks to the water Office, the implementation process starts: The water office provides transport for local materials such as sand while stones and unskilled labour are provided by the group members themselves. During the construction of the first three tanks the instructor trains a local mason. Usually after a short period more people get interested seeing these tanks and start to make efforts to join the group, and pay for a tank. It is this effect of spreading which has made the project to grow extensively.

Other advantages to work with groups are:

1. It is economical to construct more tanks in the same time in a certain area.
2. It becomes worthy to train a local Mason chosen by the group.
3. Group members will help each other in collecting sand and stones.
4. In some groups the members help financing each others tank by contributing a monthly fee. For example, a group of 50 members contributing 50/= each per month, raises a total of 2500/= enabling them to built 2 tanks. Thus in a period of 25 months all members are passed.

Project costs: (based at 1985 prices)
In below diagram a break down of the average cost on the various tanks is listed:

Cost Subject	Tank volumes (prices in Ksh.)		
	4000 litres	5400 litres	13.500 litres
Local materials(sand,stones)	100/=	125/=	300/=
Materials from hardware supplier (cement etc)	1080/=	1280/=	4360/=
Moulds	20/=	20/=	40/=
Transport	100/=	125/=	400/=
Skilled labour	200/=	250/=	400/=
Unskilled	200/=	250/=	400/=
Administration & Management	200/=	200/=	200/=
Total costs (Ksh.)	1900/= (US$115)	2200/= (US$135)	6100/= (US$370)

Note: exchange rate: 1 US$ = Ksh. 16/50 (October 1985)

Comments & Questions

- It takes about 15 days working time to complete the construction of such a tank.
- It costs not more than 15,000/- together with local contribution.
- Hand pumps cost 925/= which is contained in the cost of the tank construction.
- Maintenance of the tank and pump is done by the groups and the trained fundis. The expenses are met by the groups through their committees.

Q How well are the committees working?

A Projects are selected by the sub-DDC and committee members are selected by the groups themselves together with the Assistant Chiefs so they must be accepted by the groups.

Q How many tanks have been built?

A So far 42 have been built and this year it is planned to have 47 built.

Q Have you had any problems with the tanks?

A Reinforcement has been a problem but it is being phased out.

- The water is used for domestic requirements at the moment.
- The other problem with these tanks is cracking in the base but now proper mixing is ensured for the whole construction.
- The only way to clean the tank is by someone climbing into the tank and cleaning it thoroughly before the next rains. All clients and consumers are advised on the cleaning methods accordingly.
- A follow-up on the capacity and how long the water would last is not very good but it can be used for abour 4 - 5 months.
- These tanks are mostly constructed in schools and other institutions.
- After excavation, the plastering is done directly onto the soil in the bottom.
- The community supplies the water for the construction of the tank so it really does not have to be near a water point.
- Thickness of the wall is 4"
- Water-proof materials are not used because of the damage they would cause. Mutomo Mark 4 Pump is used for pumping the water out. (This pump has been development by the project).

1.) A hemispherical ground tank of ferro-cement at a primary school. The tank's volume is 78,000 litres and its cost, including guttering, is Ksh. 15,000.

2.) Excavation of the hemispherical shape is guided by a radius wire 312 cm long which is tied to a peg on a soil centre post.

3.) Upon completion of the excavation and removal of the centre post, the wall of the excavation is plastered with a mortar mixture 1:3.

4.) After the excavation has been plastered with a 2.5 cm coat of mortar, it is ready for reinforcement.

5.) The reinforcement consists of 2 rolls of barbed wire 16 g. and 3 rolls of chicken wire 1" mesh.

6.) The chicken wire is nailed onto the plastered wall with 2½" nails. Overlapping of the wire should not be less than 15 cm. Thereafter barbed wire is nailed on top of the chicken wire.

7.) The barbed wire is nailed in a spiral that is spaced about 25 cm apart and begins at the lowest point of the excavation. The wire is also nailed in vertical lines that are spaced at 25 cm at the top of the excavation.

8.) After completion of reinforcement, two of 2.5cm coats of mortar are plastered onto the reinforcement and smoothened to finish. This work must be completed within one day and cured with polythene sheeting.

9.) The plastered groundtank is heightened 60 cm by a brick or stone wall and reinforced with 8 rounds of barbed wire. Roofing sheets are then nailed onto 4" x 2" timber supported by a centre post of 1½" G.I. pipe.

10.) Square of triangular gutters with skirting 30 m long are fixed onto the roof of the school. Skirting prevents spill-over of run-off during storms.

11.) Sisal poles and creeper vegetation are a cheapor solution for roofing than iron sheets.

12.) Groundtanks are also built for collecting run-off from rocks.

13.) A hemispherical groundtank built of murram, lime and cement holds 22,000 litres and costs Ksh. 1,300.

14.) Excavation is guided by a radius wire of 210 cm fixed onto a centre post, which will be removed later.

15.) 1 portion of cement, 4 of lime and 32 of murram are mixed with water.

16.) The moist mixture is plastered onto the walls of the excavation in a 5 cm coat and smoothened.

17.) On the same day as plastering, a watertight coat of 1 part cement to 4 parts lime is mixed with water and applied with a trowel onto the still moist plaster.

18.) The intake channel must also be completed with plaster and a watertight coat within that same day.

19.) Thereafter the walls of the intake channel and the tank are levelled by an extension of stones set in the same mixture as the plaster.

20.) This type of low-cost tank can be used for storing rainwater run-off from roofs, rocks and ground surfaces.

21.) This cylindrical tank of ferro-cement holds 20,000 litres and costs Ksh. 13,000 including gutters.

22.) A circular excavation 10 cm deep is filled up halfway with concrete, 1:2:4, 5 cm thick.

23.) B.R.C. wire mesh is placed on top of the concrete together with a draw-off pipe unit. Thereafter the excavation is filled up with another 5 cm of concrete and compacted.

24.) A cylinder of B.R.C. wire mesh, radius 191 cm, is placed in the wet concrete.

25.) The lower end of the cylinder is tied firmly to the B.R.C. mesh placed in the foundation.

26.) Chicken wire is thereafter rolled tight around the cylinder of B.R.C. wire mesh.

27.) Binding wire, spaced 10 cm apart, is then rolled tightly around the chicken wire.

28.) Sewn-together sacks are rolled around the cylinder and tightened against the wiring with rounds of string.

29.) From the inside of the cyliner a 1 cm coat of mortar 1:3 is smeared against the wiring and sacking.

30.) The following day, the sacking is removed and two a 1 cm coat of mortar 1:3 is plastered onto the wall from the outside and then cured with polythene sheeting.

31.) After completing the outer plaster of two coats an inner coat of mortar 1:3 of 2cm thickness is applied and the following day together with a coat of cement slurry for water proofing.

33.) This ball-shaped tank of ferro-cement holds 7,000 litres and costs Ksh. 2,100.

34.) Rings of iron rods, 8 mm, are formed around circles of pegs.

35.) A total of 17 rings of various sizes are made.

36.) The rings are tied together to form a ball with a diameter of 240 cm.

37.) Chicken wire, 1" mesh, is tied tightly around the ball leaving only the man-hole open.

38.) Excavation for the tank is done with a radius wire, 125 cm long, fixed to the end of a stick 65 cm above groundlevel.

39.) Mortar, 1:3, is plastered in a 3 cm coat onto the sides of the excavation.

40.) The ball of reinforcement is set into the still moist mortar.

41.) Strands of sewn-together sacking material are tied tightly around the ball. Rounds of string keep the sacking in place.

42.) A coat of 3 cm mortar, 1:3, is plastered onto the reinforcement and sacking material from the inside. The surface is smoothened and made watertight with a coat of Cement slurry.

43.) The following day the sacking is removed and a thin layer of plaster, 1:3 cm, is applied to the outside of the tank. The tank is then cured with polythene sheeting for 2 weeks.

44.) Triangular gutters, hanging in a skirting, are fixed to the roof for harvesting rainwater.

MUTOMO SOIL AND WATER CONSERVATION PROJECT

Mutomo Office,
P.O. Box 125,
MUTOMO.

WC/11/9/20

16th February 1987

1. Materials for 78,000 lts. G/T. Ksh. 15,000.

3 Chicken wire Rolls. 16G.

2 Berbed wire Rolls 1m. x 2.5 cm.

47 Bags of cement.

20kg Nails 2½"

15 Tons of Sand.

6 tons Hard Core. (Big Size)

30m Polythene Sheet.

30 Drums of 200lts of water.

Roofing of 78 m^3.

230 ft. 100mm x 50mm.

4kg 4" Nails.

15 Iron sheets 3m. 32g.

7m. Chicken wire. (1m x 2.5cm)

3.25m. 1½" Piller Pipe.

4kg Roofing Nails.

Construction time 15days for 2 skilled fundis

Proportion 1:3.

2. Hemspherical Cement/lime/Marrum G/T. 22,000lts cost Ksh 1,300/=
(Without Roofing.)

20 Bags Lime

3 Bags Cement

4 Tons of Good Murram.

3 tons of Hard Cores.

20m Polythene sheet.

20 Drums of water

Construction time 5 days 2fundis.

Proportion 1cement 4lime. 32murram.

3. Ferrocement stading W/T. 20^{3}m.

B.R.C. 1 Roll. No. 65 or 66.

Cement. 25 Bags.

Chicken Wire 2 Rolls 1m x 15 mm

Sand 3 tons.

Ballast 2 tons.

25 Drums of water.

Binding Wire 10 kg.

Draw Pipe + Tap

Sugar Bags 20

Sisal Twin 1 Roll.

Labour and working days, for 2skilled fudis. 8 days.

Proportion Concrete 1:2:4

Mortar 1:3

4. Cylinderical Ball Tank. 7.000lts cost Ksh. 2100/=

8mm Remforcement bars. 80m.

Cement 10 Bags.

Chicken Wire 40m. of 1m. x 2.5cm.

Binding Wire 3kg.

3m. x 15mm Horse Pipe

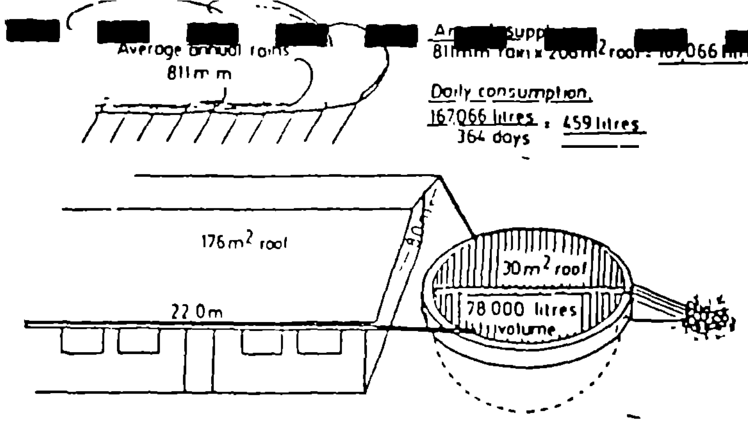
15cm x 15mm Piece of Pipe

working Days 2 skilled fundis 5 days.

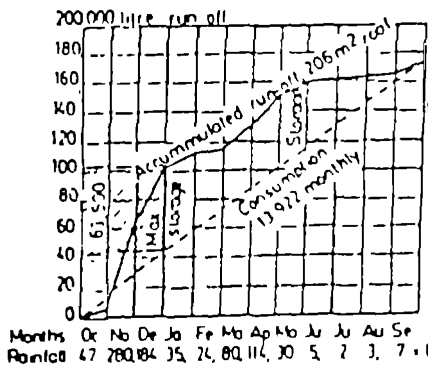
Proportion 1:3

Alphonce Atisa.
Senior Construction Foreman.

AA/nks.



1. Principles

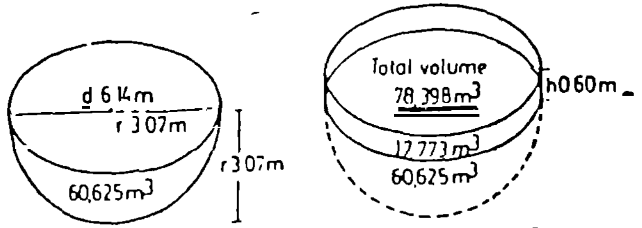


167066 litres of run-off

DETERMINATION OF REQUIRED STORAGE
(Supply minus consumption in the 3 peak months)
47+280+184mm × 206m² = 105 266 litres supply
-13 922 litres × 3 months = -41 766 "consumption
Minimum storage requir. 63,500 litres

2 Storage Requirements — ENP

LOWER PART — UPPER PART



Volume of sphere $\frac{\pi d^3}{6}$

Volume of hemi-sphere

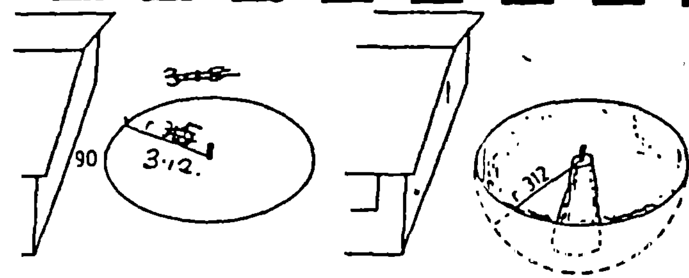
$\frac{22 \times 6.14 \times 6.14 \times 6.14}{7 \times 6 \times 2} = 60,625$ litres

Volume of cylinder $\pi r^2 h$

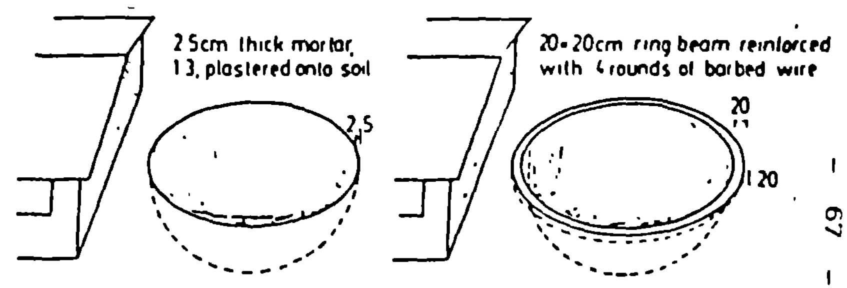
$\frac{22 \times 3.07 \times 3.07 \times 0.60}{7} = 17,773$ litres.

60 625 + 17,773 = 78 398 litre volume

3 Calculation of Storage Volume.

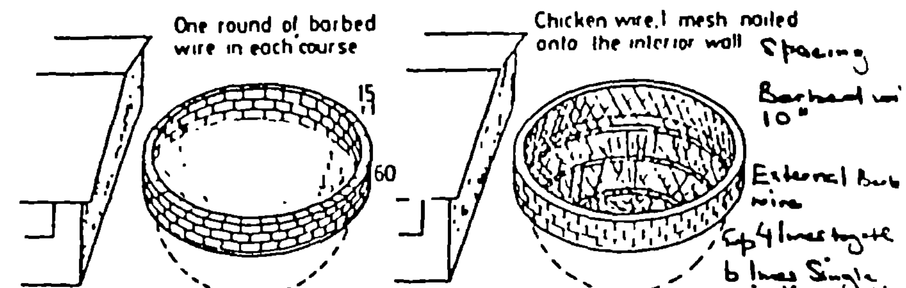


4. Excavation.

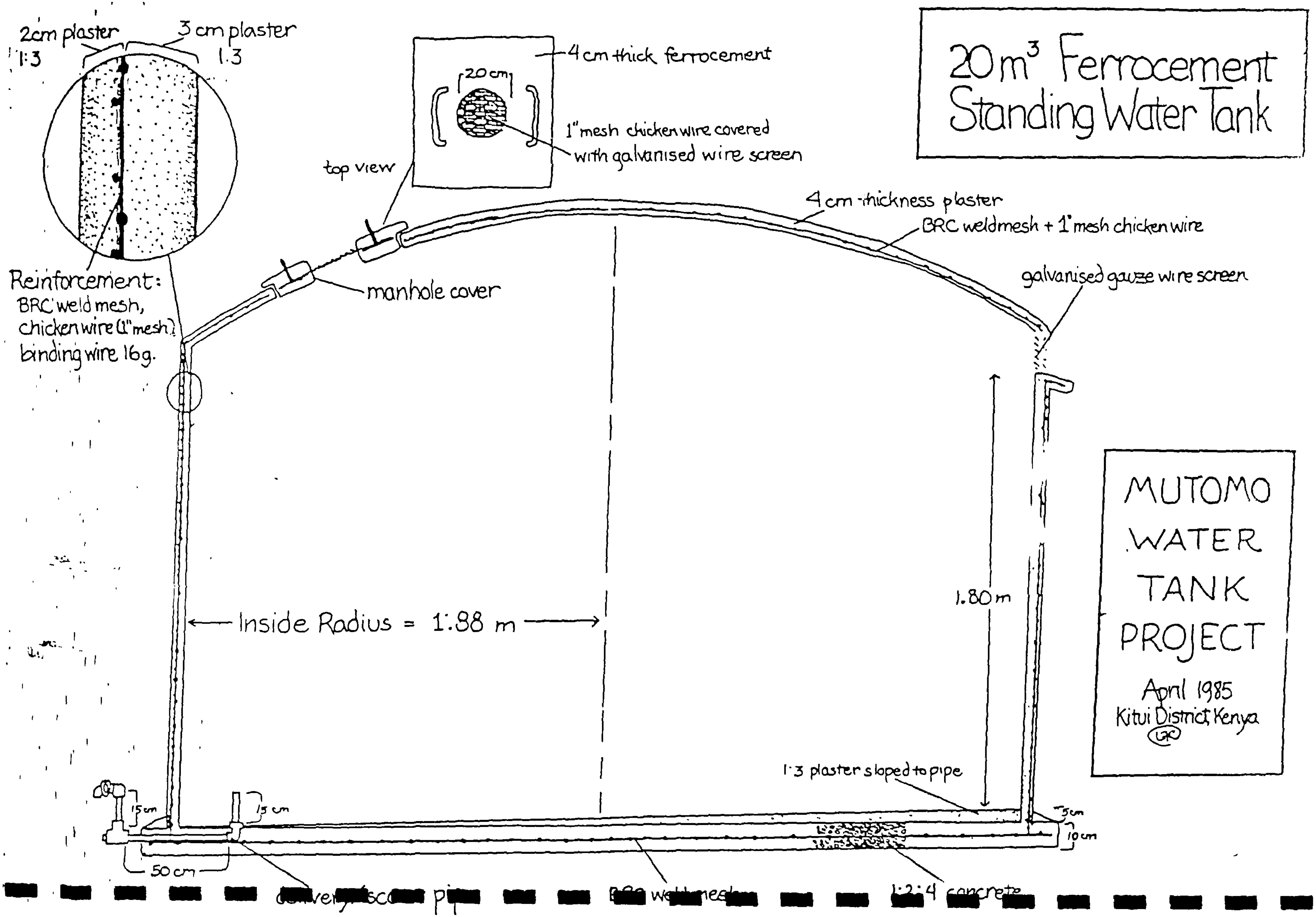


5. 1st Coat of Mortar. 6. Ring-beam

67



7. Extension of wall. 8. Reinforcement


20 m³ Ferrocement Standing Water Tank
2cm plaster 1:3
3 cm plaster 1.3
Reinforcement: BRC weld mesh, chicken wire (1" mesh) binding wire 16g.
top view
4 cm thick ferrocement
20 cm
1" mesh chicken wire covered with galvanised wire screen
manhole cover
4 cm thickness plaster
BRC weldmesh + 1" mesh chicken wire
galvanised gauze wire screen
Inside Radius = 1.88 m
1.80 m
1:3 plaster sloped to pipe
15 cm
15 cm
5 cm
10 cm
50 cm
[redacted]
MUTOMO WATER TANK PROJECT
April 1985
Kitui District, Kenya

67A

Tigania Small Scale Water Schemes presented by Hienricho Gofer

1. History - Started in 1982 as a result of Rural Health Program communities requests:

   provision of a safe water supply

   1st feasebility studies - carried out

2. Problems - No surface waters apart from seasonal streams. The three possible alternative water developments:

   - piped gravity supplies from springs
   - underground tanks
   - rainwater harvest

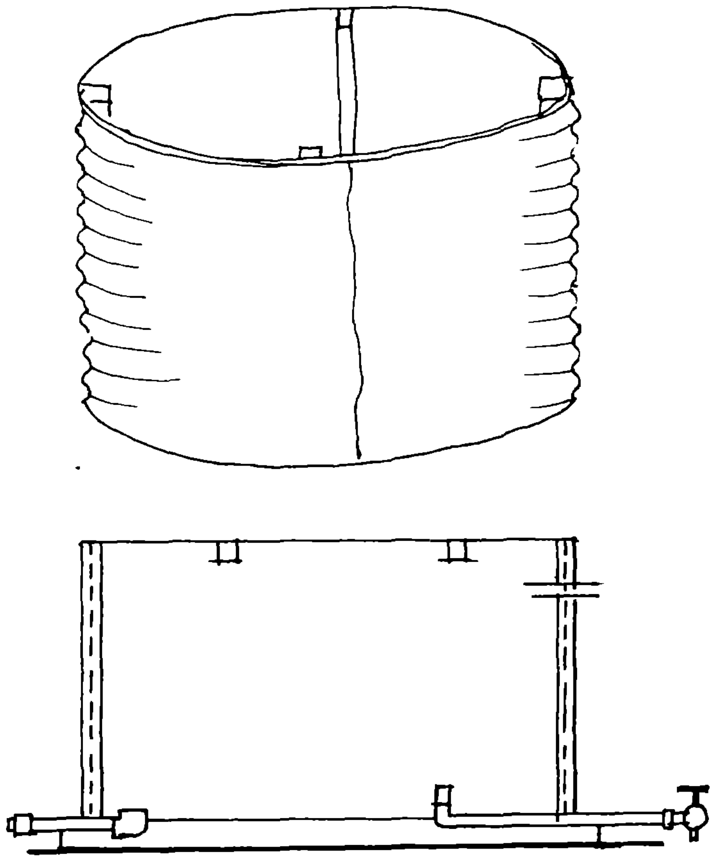
3. Water Jars - Commenced late 1982 after fundis were trained in Machakos (Utooni). Water jars capacity = 500 gallons. Ten of these jars were built in centre of subsidised prices; construction method: bag + saw-dust filling.

4. Organisation/participation

   - People paid 60% , project 40% in cash people collected sawdust, transported it + provided kokoto + water for construction. Total cost + Ksh.1,000/=. Some people requested 2 - 3 jars/household - bigger capacity storage.

5. Tanks - Mabati form was prepared, fundis trained + the first five (5) built in public places, (often schools) for demonstration.

   Tank capacity = 5,000 galls.
   Total built todate = 150



Mould made of 4 sections of CGI sheets 6 ft. high with interior diameter 8 ft. 6 ins.

Wall thickness	=	2 ins.	
Floor thickness	=	3 - 4 ins.	
Floor reinforcement	=	6 mm diameter bars at 12 ins. separation	
Wall "	=	chiken wire plus plan galvanised wire 12 gauge in each corrugation.	
Outlet	=	¾ ins. plus 1½ ins. w/o	
Cover	=	plain sheets (26 gauge) on timber frames 3 x 2 ins.	
Cost	=	cement, sand, ballast	1650.00
		other materials	1450.00
		labour, transport + contingencies	1100.00
		Total	Sh.4200.00

The first design had no roof (to keep costs down) but was added later.

6. People's Participation

People pay the whole cost - no credit schemes
- no subsidies

All the tanks so far built were for individuals.

7. Advantages/Disadvantages

(a) Using a mould makes it easy for fundis to construct, uses little time to build (especially to apply plaster)

(b) For long distances a vehicle is need to transport the mould.

8. Present set up

- 2 crews of fundis using 2 moulds under the supervision of a head fundi who is also in-charge of purchase and organisation of materials.
- People requesting tanks pay first to avoid problems later.
- Fundis are liable for major repair if cracks occur due to poor construction (but not liable if due to faulty caring - that is the fault of the owner).

9. 9,000 gallon tanks

- started only recently.
- used primarily for storage
- same design as for 5,000 galls. with extra reinforcement
- cost = 12,000/=

Observations/Comments

- the water committee chooses who was to receive the first tanks, doubt if the poorest people were chosen first;
- after the first 10 jars were built at subsidised cost (program paid 60%) interest fell;
- subsidies have stopped continuity of the program. Now it has been better since the people pay all the cost right from the beginning of the program;
- jars too little capacity to be useful therefore turned to tanks;
- think it is better to have 2 x 2,000 gallon tanks than 1 x 5,000 gall. tank;
- the system of individuals paying the total cost doesn't make tanks accessible to the poorest;
- mould costs 4,000/= (in 1983);
- the mould sheets could be put vertically, bent by hand and flatten out after use - this could reduce costs.

<u>Questions</u>

Q. - What problems did you have?

A - At first built 5 tanks of 2,000 galls. in each centre as a demonstration but the people showed no interest in them.

Q - If the fundi is to be liable for repairs how do you ensure he returns?

A - We keep close contact with all the fundis.

Q - How can you be sure of proper caring?

A - You can't. You can explain to the owners but it is difficult to get across the importance.
In Utooni it is the fundis who are also responsible for supervising the caring.

Q - If a tank develops a problem is it difficult to know whose fault it was?

A - No.

Q - Do many people want to train as fundis?

A - No.

Q - Are your designs free to use elsewhere?

A - Very, very!!

Q - How are the fundis supervised?

A - By trust.

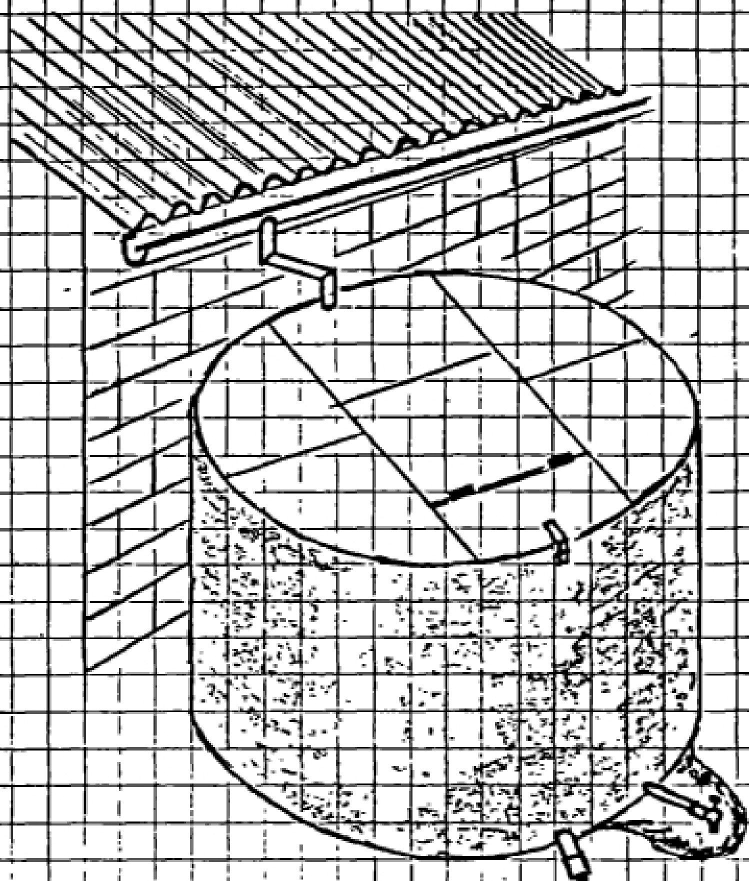
Q - Are the fundis paid as full-time employment, or by the job?

A - On casual basis.

Q - Does the floor need the reinforcement or it is just for security?

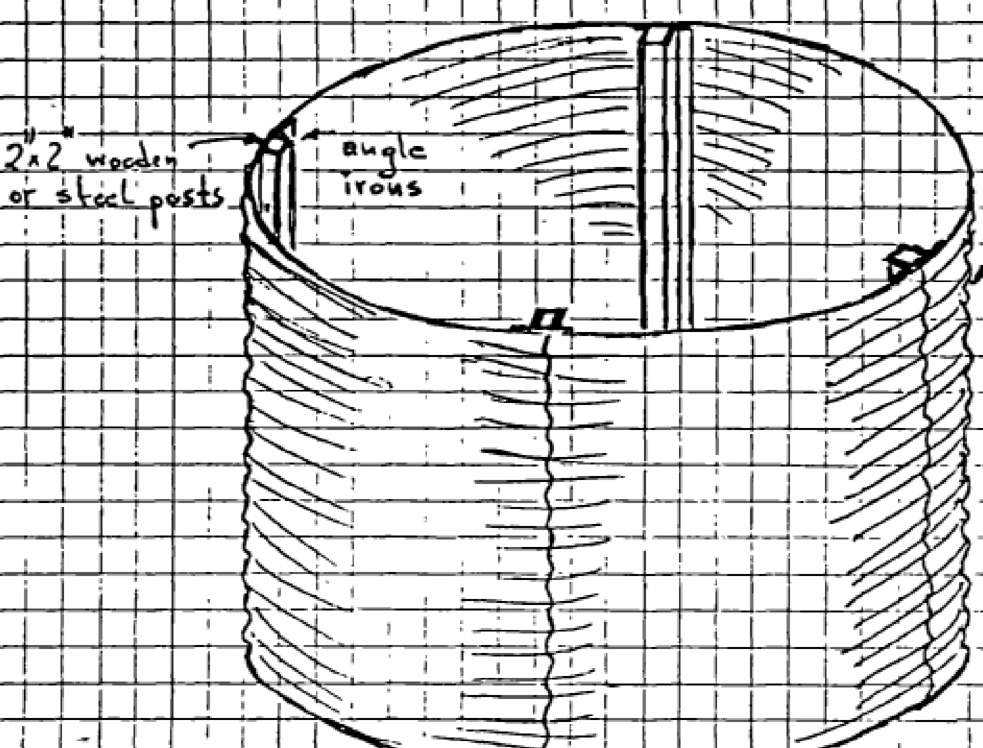
A - Not tested to be sure.
- In Kitui Diocese there is no floor reinforcement and has not created any problems.

FERROCEMENT TANK
10,000 Lit. capacity



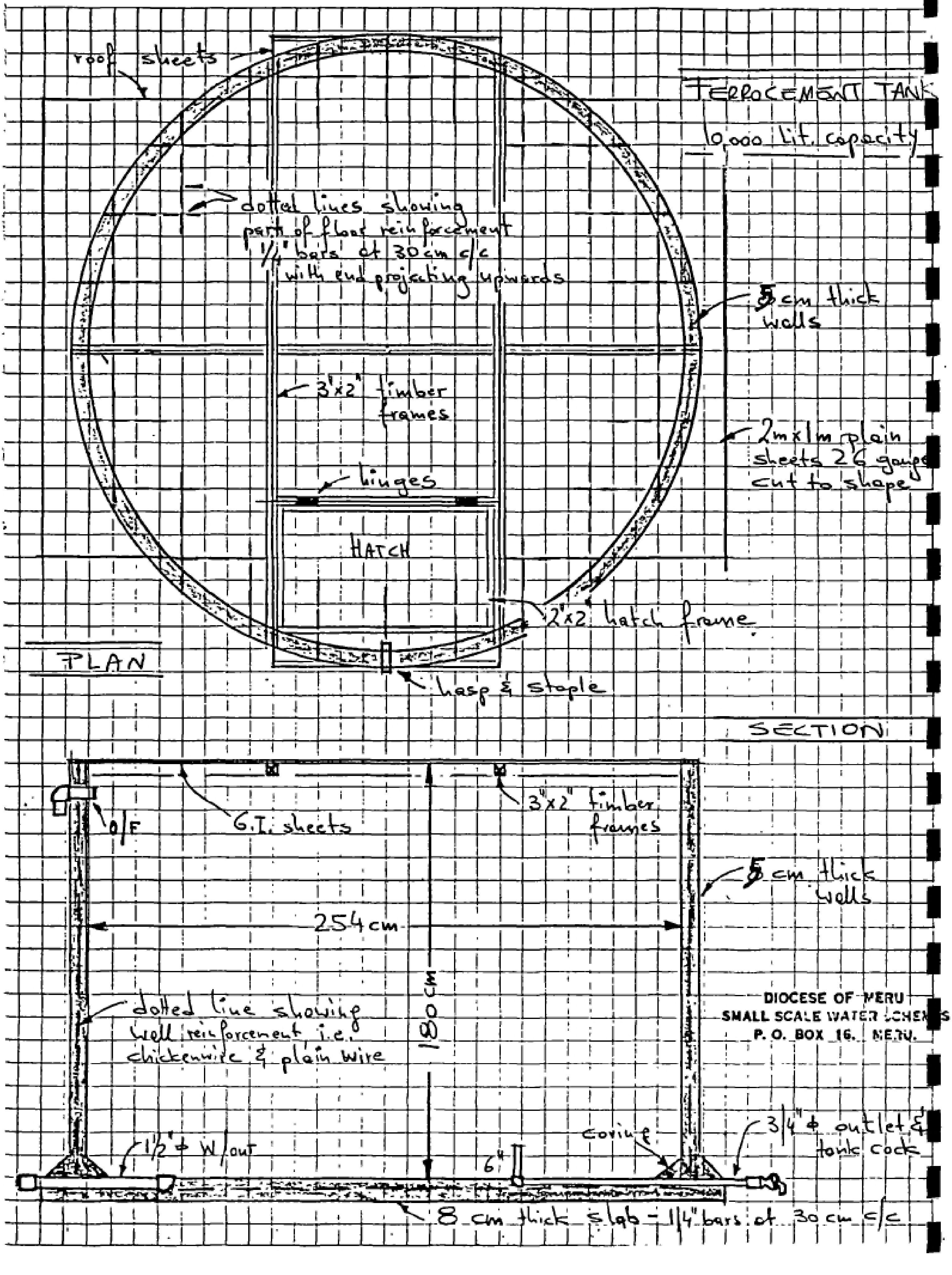
Technical datas :
internal dia = 254 cm
height = 180 cm
wall thickness = 8 cm
cover - plain GI sheets

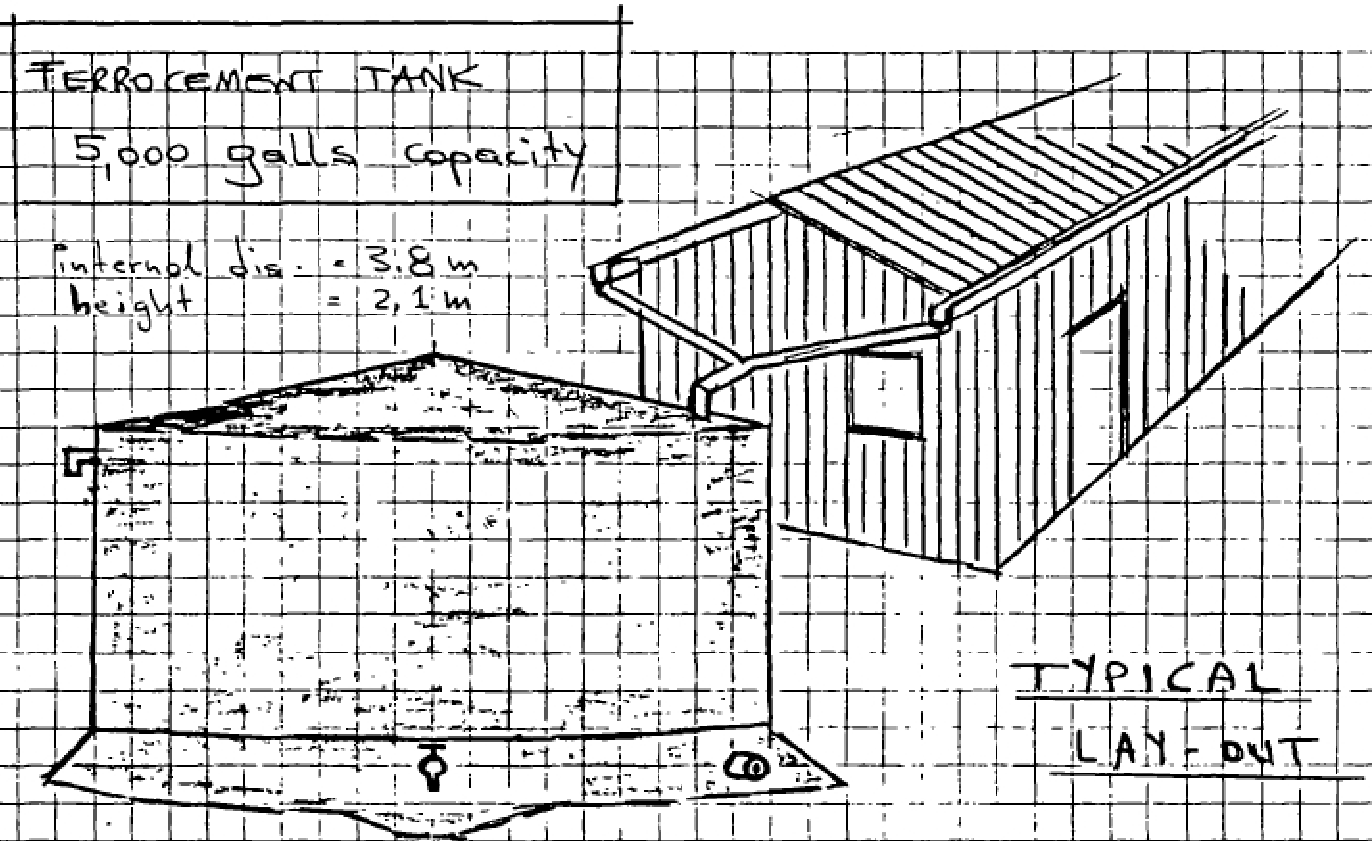
THE FORMWORK

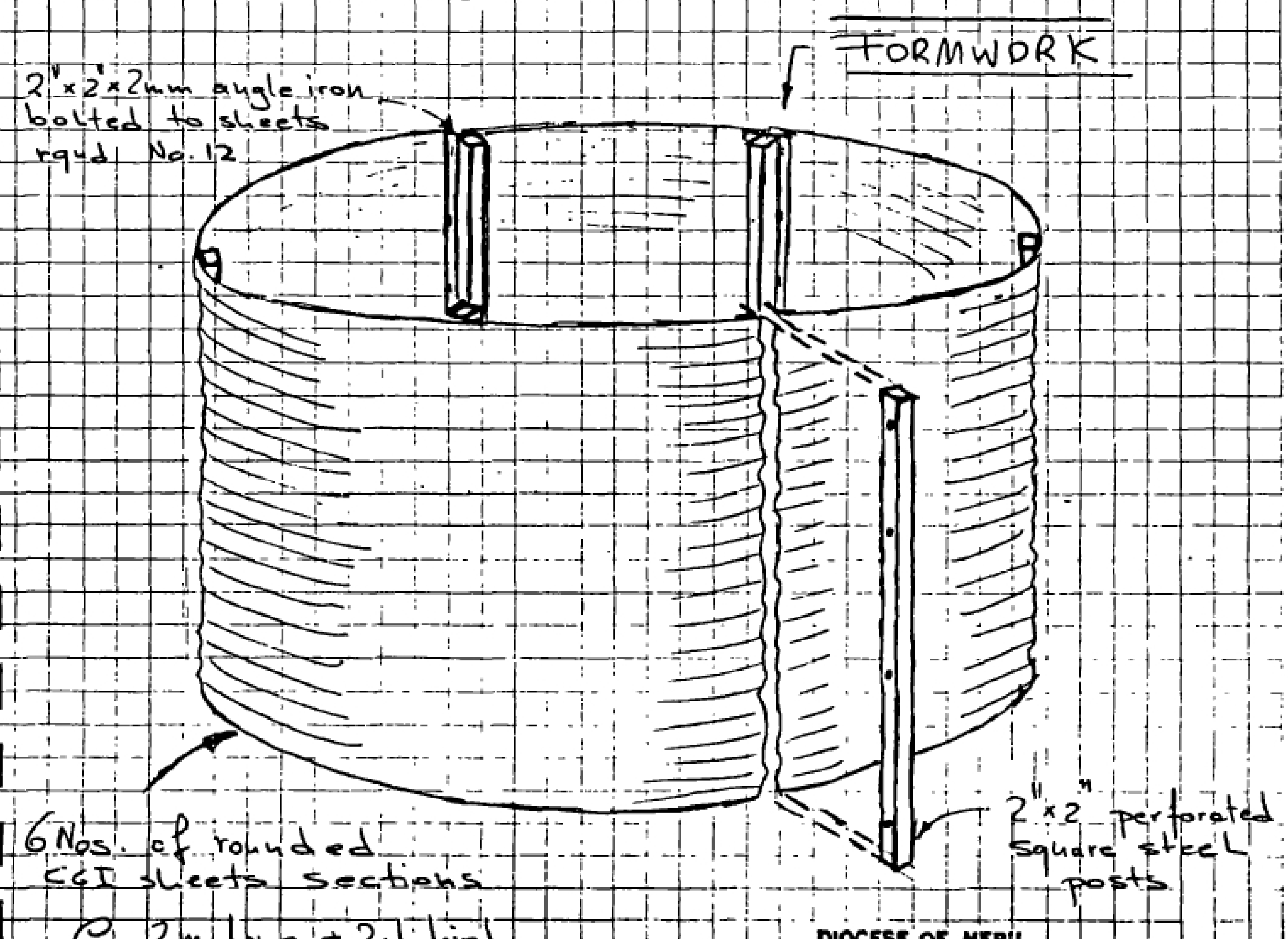


4 Nos. sections
made of CGI
sections @ 2m
long - 24 gauge

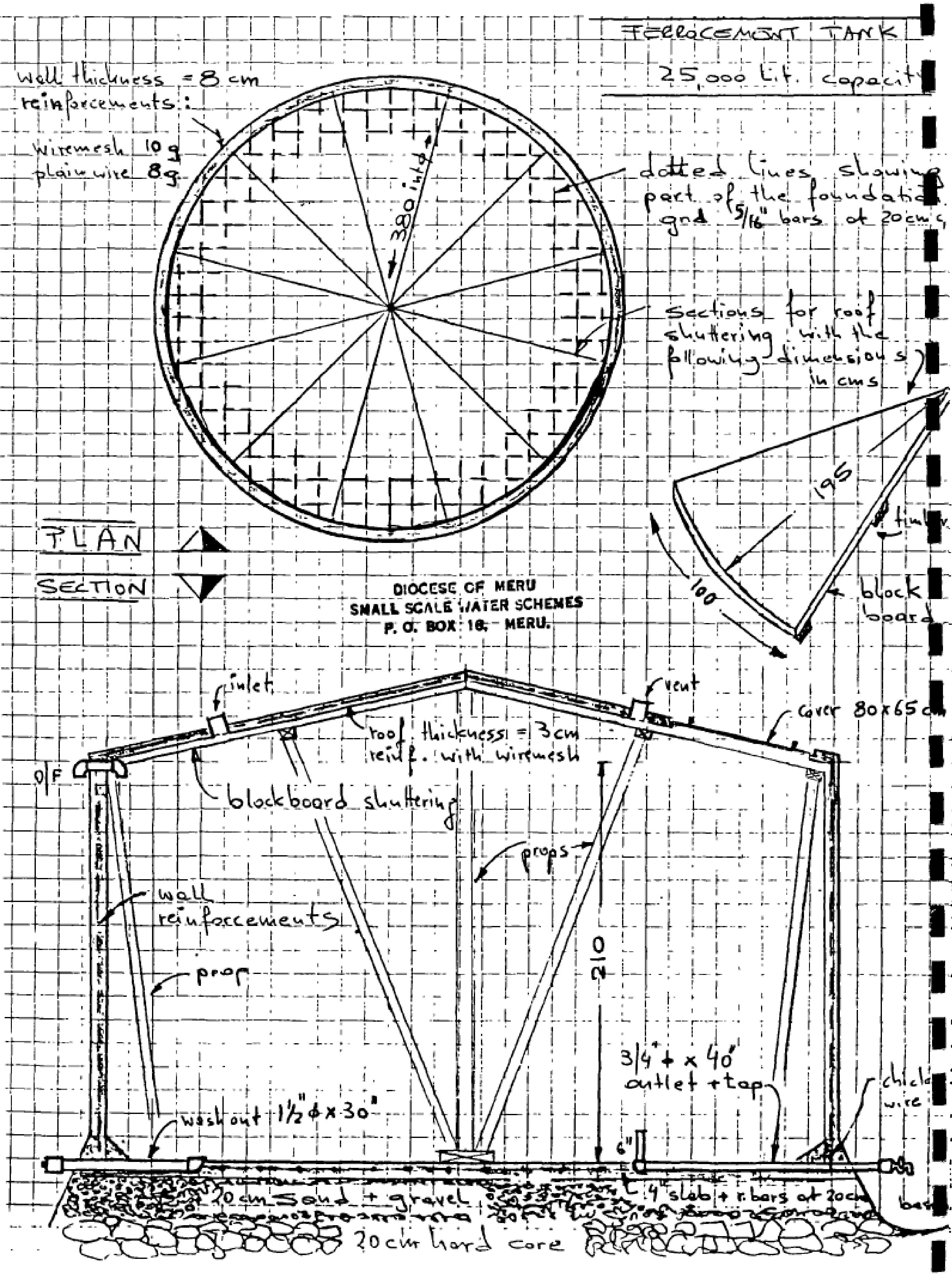
DIOCESE OF MERU
SMALL SCALE WATER SCHEMES
P. O. BOX 16, MERU.


FERROCEMENT TANK
10,000 lit. capacity
roof sheets
dotted lines showing part of floor reinforcement 1/4" bars at 30 cm c/c with end projecting upwards
5 cm thick walls
3"x2" timber frames
2m x 1m plain sheets 26 gauge cut to shape
hinges
HATCH
2"x2" hatch frame
PLAN
hasp & staple
SECTION
O/F
G.I. sheets
3"x2" timber frames
5 cm thick walls
254 cm
180 cm
DIOCESE OF MERU
SMALL SCALE WATER SCHEMES
P. O. BOX 16. MERU.
dotted line showing wall reinforcement i.e. chickenwire & plain wire
coving
3/4" ϕ outlet & tank cock
1/2" ϕ W/out
6"
8 cm thick slab - 1/4" bars at 30 cm c/c

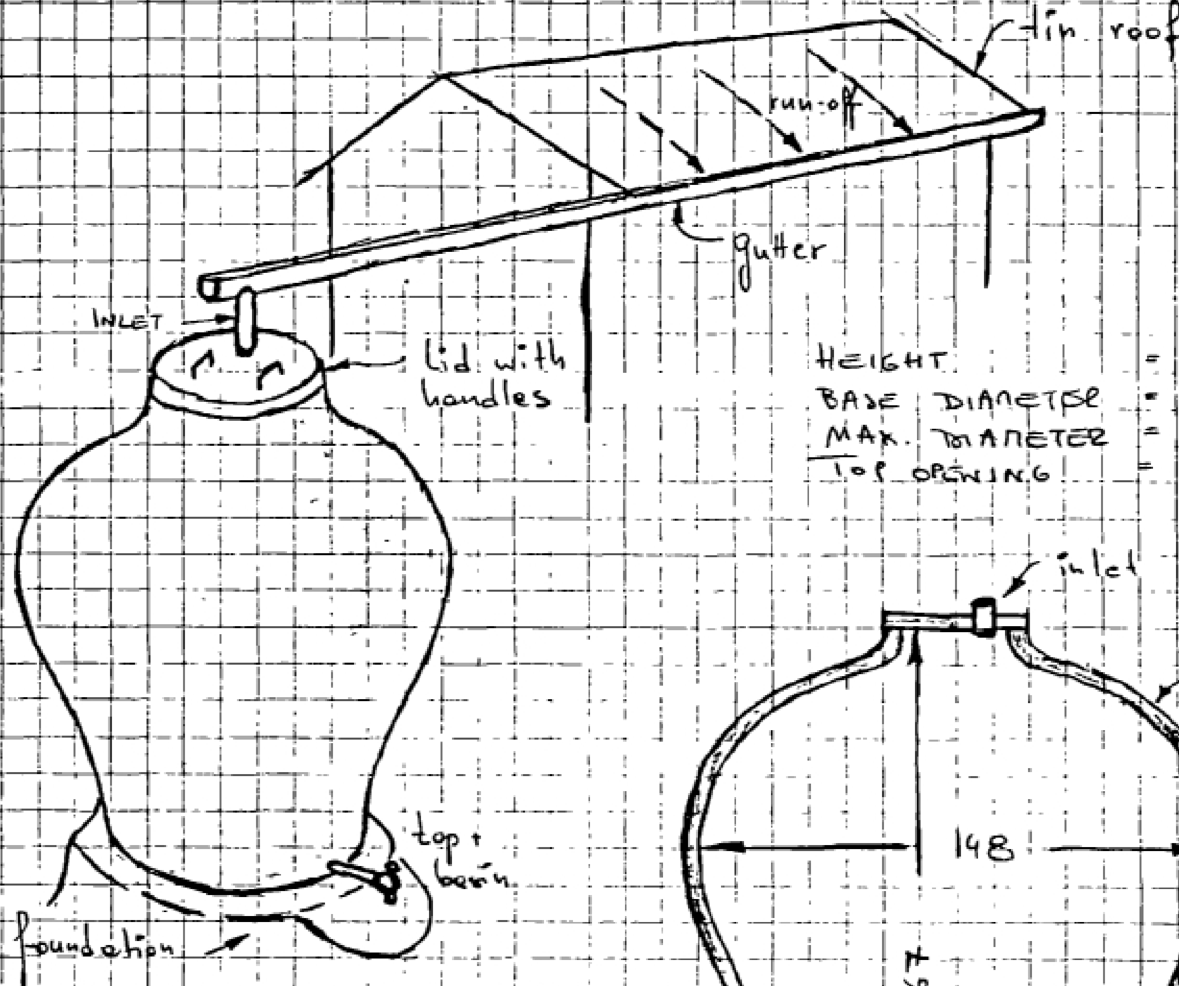




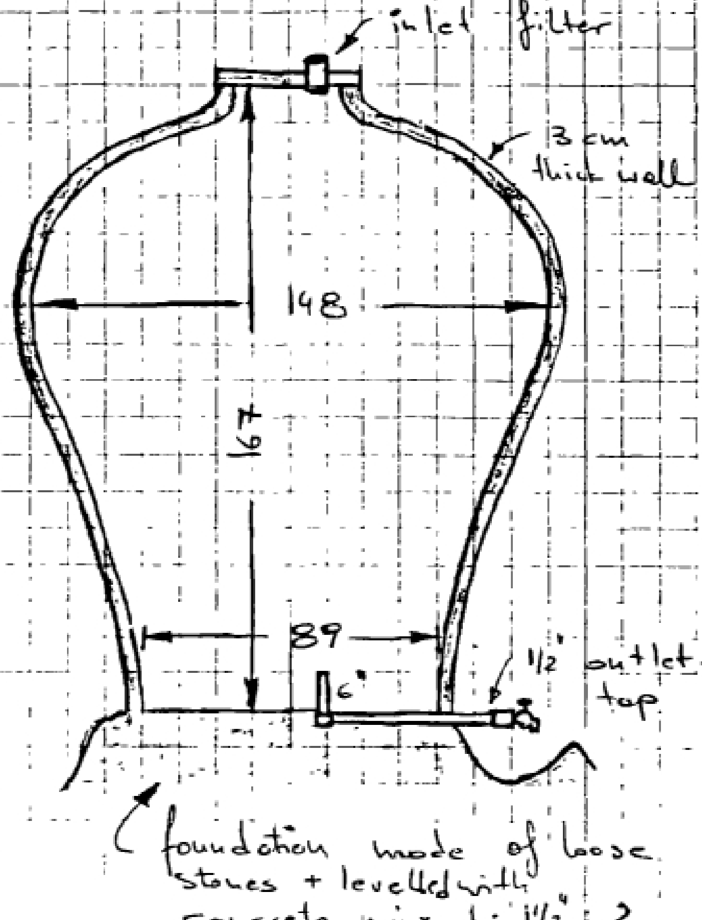
DIOCESE OF MERU
SMALL SCALE WATER SCHEMES
P. O. BOX 16, MERU.

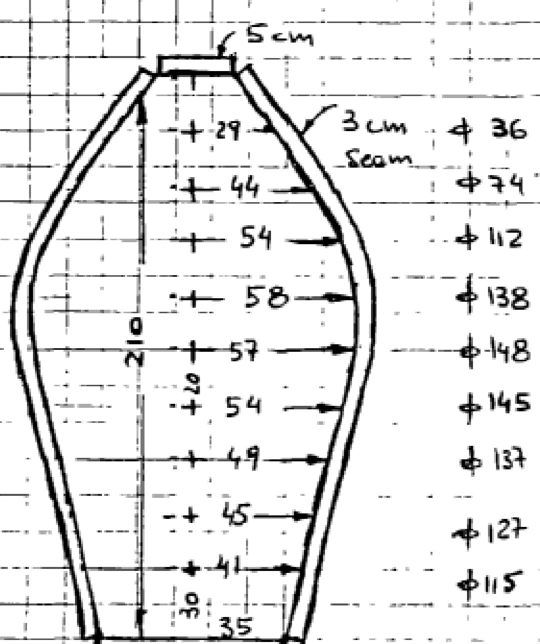

FERROCEMENT TANK
25,000 LIT. capacity
wall thickness = 8 cm
reinforcements:
wiremesh 10 g
plain wire 8 g
380 int d
dotted lines showing part of the foundation grid 5/16" bars at 20 cm c
sections for roof shuttering with the following dimensions in cms
195
100
timber
block board
PLAN
SECTION
DIOCESE OF MERU
SMALL SCALE WATER SCHEMES
P. O. BOX 18, MERU.
inlet
vent
cover 80 x 65 cm
roof thickness = 3 cm
reinf. with wiremesh
O/F
blockboard shuttering
props
wall reinforcements
prop
210
3/4" ϕ x 40"
outlet + tap
chicken wire
washout 1½" ϕ x 30"
6"
20 cm sand + gravel
4" slab + r. bars at 20 cm
20 cm hard core

CEMENT WATER JARS - CAPACITY 500 galls
UNICEF TYPE - USING CLOTH FORM



HEIGHT	=	167 cm
BASE DIAMETER	=	89 cm
MAX. DIAMETER	=	148 cm
TOP OPENING	=	35 cm





DIOCESE OF MERU
SMALL SCALE WATER SCHEMES
P. O. BOX 16, MERU.

CLOTH FORM: 4 Nos. needed per bag

Kamujine Presented by Patrick Mutia and Karen Iles

Kamujine Farmers' Centre caters for farmers groups, women's groups, 4K clubs and Youth groups.
Eight months ago, after women's groups had outlined their main problem as being water supply, KFC began its water project. Their first idea was a gravity pipe, but after visiting Utooni in February, 1986, a team of fundis from Utooni then returned the visit to KFC and trained fundis in the Kamujine area to build ferrocement tanks. 3 teams of 3 fundis were trained in Kamujine, and later 2 more teams of 3 were set up. 24 tanks have already been built; it would have been more but they have run into a problem of lack of materials.

The groups organise themselves and aim at independence in the future.

- The members contribute money to a group account so the group is in charge.
- The group pay half the cost of the tank and the project lends them the other half, which they re-pay over 10 months.
- The group then reimburses money loaned by the KFC project by bank transfer.
- Group members provide sand and hardcore; the project delivers the rest
- Tanks are being built in the coffee zone therefore there is cash available to pay for tanks construction.

They want a simple technology that the groups can handle and build and are using the same construction techniques as Utooni.

They have also planned a water seminar to train women to make their own tanks, meaning greater self-reliance.

The main source of water is rivers, and the main problems are the distance for women to carry water; back, head and neck aches. Alternative ideas considered:

- wheelbarrows (which some men use)
- gather water off roofs into pots and drums
- hydrams cost 3,000/= at Murang'a Institute of Technology

For the poorer and drier areas where there is less income from cash crops, there is the question of how to collect water from grass roofs becomes very important.

Utooni Development Project presented by Joshua Mukusya

The project began in 1978 and the first three years were spent organising the community and seeing what would work[3]

The aims of the project as identified by the community are:

- providing water
- improving the food situation
- improving health facilities
- storing seed
- income generating activities
- livestock production
- dealing with social problems
- training and educating the community
- revolving loan
- planting trees

Nine committees were set up with one central committee made up of representatives from the nine committees. Their first step was to seek help from the Ministry of Agriculture on soil conservation for a sub-surface dam. Though not entirely convinced about the technology, the Ministry of Agriculture donated cement and the dam succeeded. Thereafter more were built with support from World Neighbors and Oxfam. Success in building dams gave the community confidence to go on and build tanks for water in their homes. They first tried brick tanks - but these were too expensive. Secondly they tries water jars for 2½ years, but it was a big burden on the women transporting sawdust from village to village.

Thirdly they moved on to the UNICEF type of ferrocement tank with corrugate iron moulds. However, they found that removing the mould cause cracks and leaks. Sot they began their own design of ferrocement tank using sisal poles for moulds. They checked the design with the Ministry of Water Development, but it was the artisans of the project who were the designers, and the tanks are still surviving. They build these tanks with capacities of 1,000 gallons (cost 1,400/=); 3,000 gallons or 5,000 gallons (cost 5,400/=).

Recently using the experience and designs developed in Utooni the project together with World Neighbors made a filmstrip which in over one hundred photograps describes the detailed construction of a 1,700 gallon ferrocement tank.

The filmstrip will soon be available from World Neighbors either in Nairobi or from Oklahoma City, U.S.A.

WORLD NEIGHBORS PRESENTS TWO NEW FILMSTRIPS ON

WATER MANAGEME[illegible]

SUB-SURFACE DAMS

A Water Catchment System Built By Villagers

Many villages lack an adequate supply of c[illegible] water throughout the year. This filmstrip tells of a project in Kenya that improved conditions in the community by building dams across dry riverbeds which can trap the rush of rainwater and silt during the rainy season. These sub-surface dams hold back rainwater that would otherwise run off, store it in the sand and silt that collects behind the dam and protects and filters the water, producing a source of easily collected drinking water year round. The filmstrip presents the techniques necessary to successfully build a sub-surface dam. How to select and prepare a site for dam construction is discussed. Dimensions and materials are suggested, and the step-by-step procedure for completing a sub-surface dam is given in detail. Although photographed in Kenya, the construction methods are applicable to all countries. This 83-frame filmstrip has a full-frame format and is produced in color.

forms must be s[illegible]urely on all

25 Drill holes in the rock bed to hold reinforcing bars The holes should be at least 1 inch deep, and be in two rows about 6 inches from each form In each row, the holes are about 4 feet apart

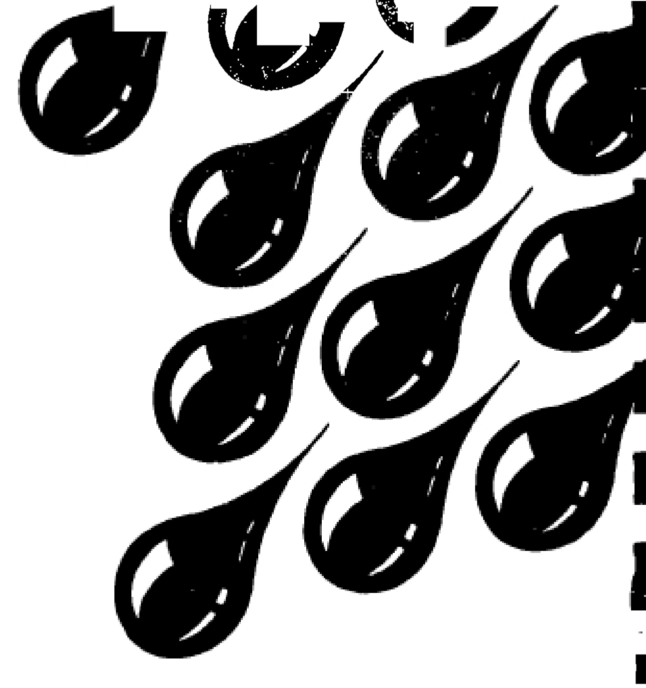
26 Cut pieces of ½-inch reinforcing bar Each piece should be 6 - 8 feet long

27 The concrete for the first level of the dam is made by mixing 3 wheelbarrows of sand with one bag of cement

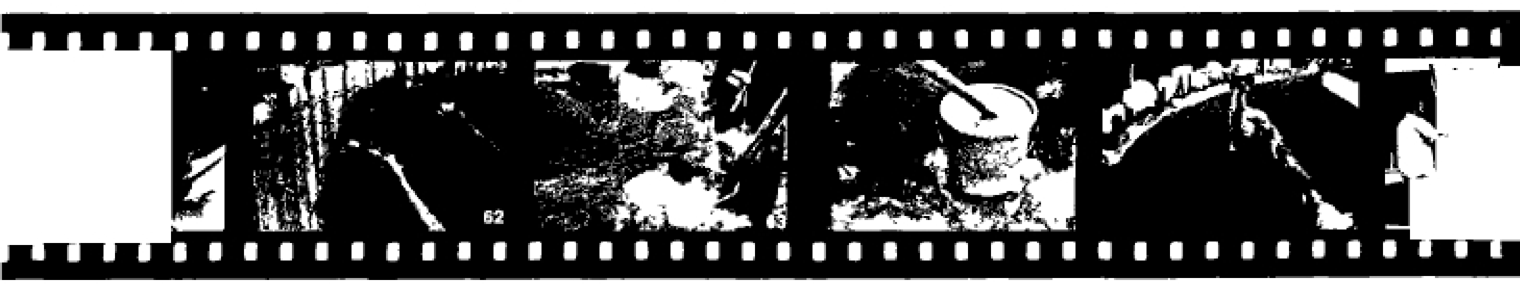
28 Some water is added

29 Before putting concrete into the f[illegible] sprinkle a layer o[illegible] cement onto the base This will he[illegible] concrete to stick [illegible] rock base

RAIN CATCHMENT FERROCEMENT TANKS



Rain water catchment tanks near the home are a solution to water supply problems for many village families. Built using ferrocement, these water tanks are capable of storing 1,700 gallons of water that can be gathered during the rainy season, and easily accessed when needed. This filmstrip tells of a project in Kenya that successfully adapted, tested and developed a technology for water tank construction. The filmstrip describes how to select the best site for a tank, gives dimensions and step-by-step instructions for construction, and explains what materials are needed. Although photographed in Kenya, this process of construction is applicable to all countries. The 106-frame filmstrip has a full-frame format and is produced in color.



Apply a layer of ster into the tank

62 Be sure to press firmly into the spaces between the steel wire mesh and the sisal poles

63 A final waterproof coating is needed to seal the inside wall and the floor For this coating, mix ½ bag of ordinary cement with ½ kg of waterproof cement and a bucket of water

64 The mixture should be like a thin porridge

65 Spread this mixture smoothly on the inside wall and the floor Let it dry overnight

66 The ne da the sisal po

Please send me the filmstrip(s) indicated below:

____ copy(s) of *SUB-SURFACE DAMS* with ☐ English/☐ French script. $10.00 (U.S.) each.

____ copy(s) of *RAIN CATCHMENT FERROCEMENT TANKS* with ☐ English/☐ French script. $10.00 (U.S.) each.

$ ____ (U.S.) total enclosed. (surface mail postage is included in the above prices)

Name ____________________

____

Address ____________________

____

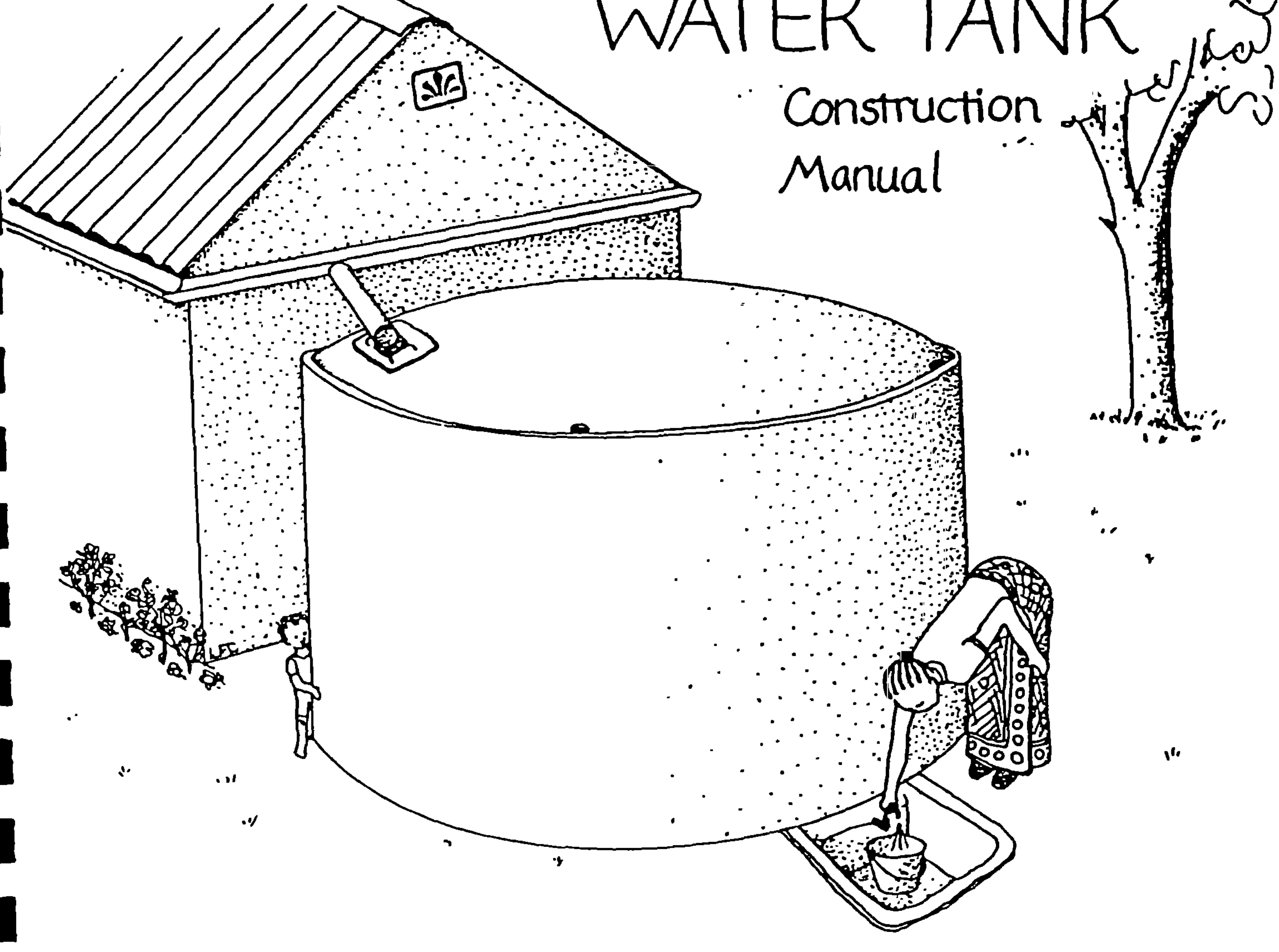
Country ____________________

Send to
World Neighbors Development Communications
5116 North Portland Avenue
Oklahoma City, Oklahoma 73112, U.S A

☐ Please send me additional information about World Neighbors

STANDING FERROCEMENT WATER TANK

Construction Manual



This tank is excellent for storing rainwater collected from roofs with gutters. It can alternatively be set up to store piped water. Because it is a standing tank, it is easy to withdraw the clean water by means of a tap in the floor of the tank.

The tank can be made in many different sizes, up to 50 cubic meters. The size described in detail here holds 20 cubic meters, or 20,000 liters, and has a diameter of just over three and a half meters. Dimensions and materials lists for larger and smaller tanks are found inside.

This construction manual is intended to be used by artisans who are undergoing or have completed a period of training in building the tanks.

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TECHNOLOGY SUPPORT SECTION
P.O. BOX 44145, NAIROBI, KENYA

TANK SIZING

Choosing the right size tank is very important and seldom obvious. You need to consider your budget, your needs for water, and, if using rainwater catchment, the amount and timing of rainfall and the roof area that can be utilised.

One way to choose is to calculate the supply available. For example, if you have a roof that is 5 meters wide and 20 meters long, then you have a catchment area of 100 square meters (100 m^2). If the area you live in averages 500 mm of rainfall a year, then you can calculate the average amount of water you would be able to collect in a tank. Multiply these two numbers, and take 90% of this figure (because only about 90% of the water that falls on the roof will make it into the tank).

$$100\,m^2 \times .500\,m \times .90 = 45\,m^3 = 45{,}000 \text{ liters storage.}$$

If the rainy season lasts for many months, then you can reduce the storage size by the amount of water used during that period. However, the likelihood of drought should be taken into account. If periodic droughts are expected, then it is advisable to be able to store excess water from heavy rain years to carry through drought seasons.

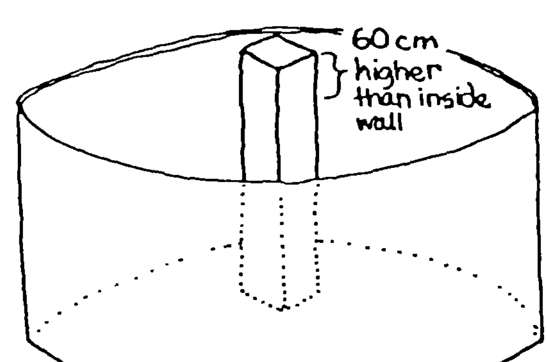
Alternatively, you can choose your tank size by estimating demand. If, for example, you have a large roof (or plan to extend in the future), and your family uses 100 liters per day, and the dry season usually lasts for 200 days, then:

$$100 \text{ liters} \times 200 \text{ days} = 20{,}000 \text{ liters} = 20\,m^3 \text{ storage.}$$

Try both methods and take the larger result if the budget can afford it. The cost of water per cubic meter is reduced with larger tanks.

The dimensions and numbers of bags of cement mentioned in the text refer to the 20 m^3 size, holding 20,000 liters. If a larger tank is desired, the radii and circumference will differ. Refer to the table on the following page for these dimensions. The thickness of the walls and the height of the tank remains the same.

Larger tanks will require more time to construct, and each step will require more cement than is noted in the instructions. Tanks of 40 m^3 and 50 m^3 will require a center post built of masonry to support the tank. The construction methods presented here will work for tanks as large as 50 m^3, but are not sufficient for larger tanks.



COMPARISON OF DIMENSIONS FOR STANDING FERROCEMENT TANKS

DIMENSIONS	10m³	20m³	30m³	40m³	50m³
Water capacity (liters)	10,000	20,000	30,000	40,000	50,000
Base diameter (meters)	3.02	4.10	4.95	5.70	6.30
Radius at mesh (m)	1.36	1.91	2.33	2.70	3.01
Mesh circumference + 30 cm overlap (m)	8.85	12.30	14.94	17.26	19.21
Height of wall (m)	1.80	1.80	1.80	1.80	1.80
Inside radius (m)	1.33	1.88	2.30	2.67	2.98

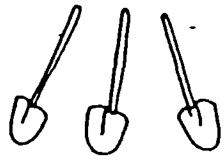
MATERIALS AND LABOUR FOR STANDING FERROCEMENT TANKS

ITEM	10m³	20m³	30m³	40m³	50m³	unit price	cost
Bags cement: tank	11	18	27	41	51		
roof	3	5	7	9	12		
total	14	23	34	50	63	____	____
Meters BRC weld mesh, 6"x6" mesh, 7' x 150' roll, no. 65 or 66	20.0	30.0	40.0	50.0	66.0	____	____
Rolls 3' x 100' chicken wire (1" mesh)	1.0	2.0	2.5	3.0	4.0	____	____
Kg binding wire 16 gauge	6	10	13	16	20	____	____
Pipe delivery/scour system, 3/4", each:	1	1	1	2	2		
1 elbow						____	____
1 bend						____	____
1 tee joint						____	____
2 15cm (8") sections threaded pipe						____	____
1 50cm (20") section threaded pipe						____	____
1 (locking) tap						____	____
1 threading plug						____	____
Cubic meters clean sand	1.5	2.5	3	4	5	____	____
Cubic meters 1" ballast	.8	1.3	2	2.5	3	____	____
Meters - 6 mm round bar	-0-	-0-	-0-	-0-	39	____	____
Bricks or concrete blocks	-0-	-0-	-0-	35	35	____	____
Drums water (estimate)	13	20	25	30	35	____	____
BUILDING TIME (days)	8	9	13	14	17	____	____
Man-days casual labourer	16	27	39	56	68	____	____
Man-days skilled artisan	16	27	39	56	68	____	____

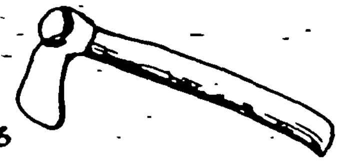
TOTAL COST: ________

TOOL LIST

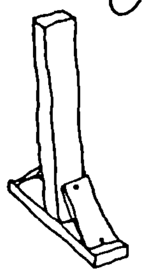
1. shovels



2. jembes/mattocks



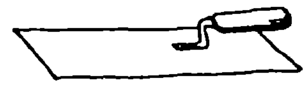
3. pimbo



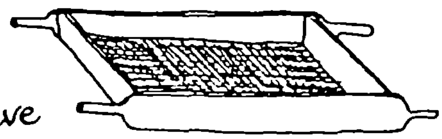
4. mason's trowels

5. wood floats

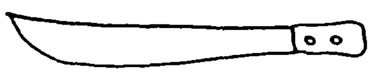
5. rectangular steel trowels



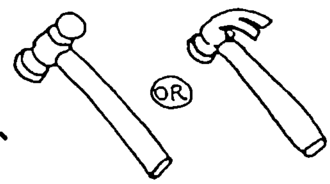
7. sand sieve



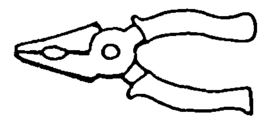
8. panga OR cold chisel



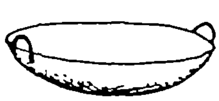
9. hammer

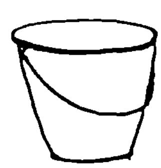


10. pliers

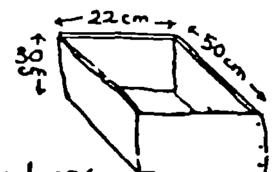


11. karais and buckets and/or measuring box

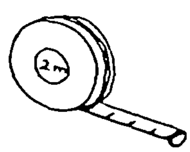




holds exactly 1 bag cement - for measuring sand proportions

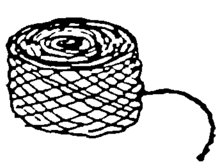


12. measuring tape



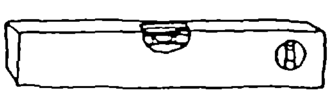
13. canvas sewing needles

14. 2 kg. sisal twine



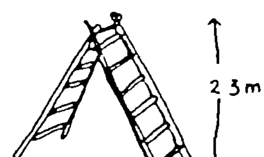
15. 2 pieces polyethelene plastic sheeting each 1.8m x 15m (20m for large tanks)

16. spirit level

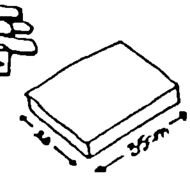


17. 25 large woven plastic sugar sacks

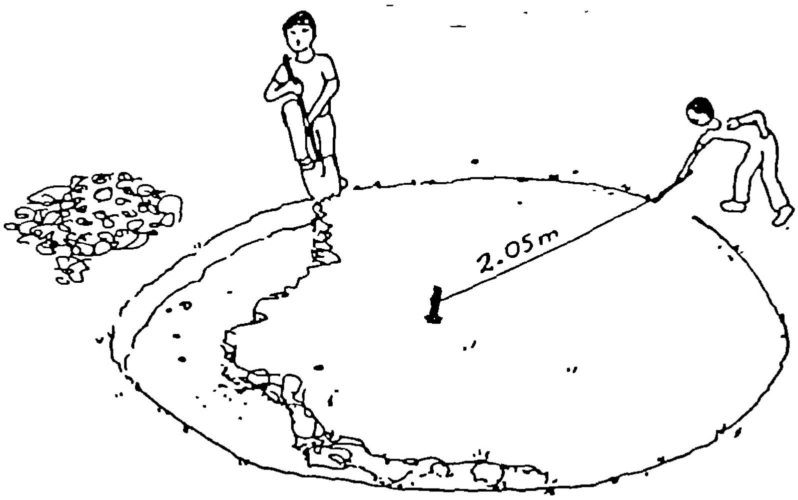
18. 2 ladders



19. scrap wood and poles



DAY 1:



JOBS IN BRIEF:

1. Excavate foundation
2. Cut BRC reinforcement for the floor,
3. for the wall,
4. and, if time permits, for the roof.

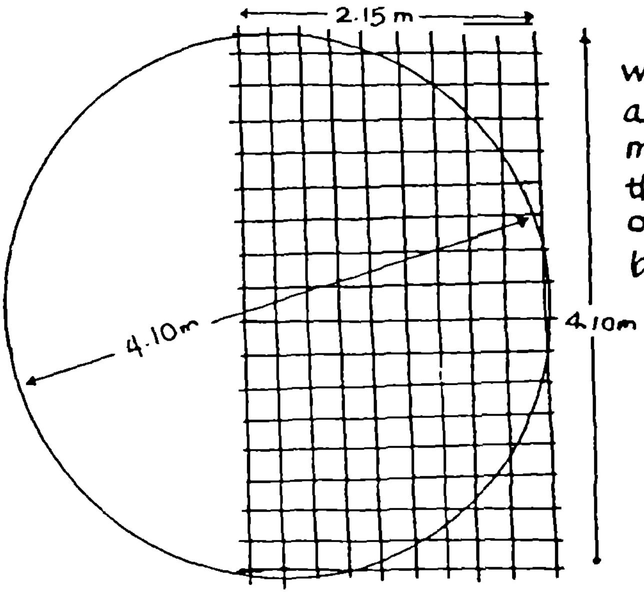
On a solid, level, well-packed area near the roof catchment area, mark out a circle of 2.05 meters radius, using a string and 2 sticks as shown. Dig a shallow cylindrical hole 10 cm deep.

If the area is sloped, dig first at the lowest end. After reaching a depth of 10 cm, proceed to dig the up hill area, ensuring that the foundation is level.

If the soil is very sandy or harbors white ants, dig another 60 cm down and fill with hardcore (fist-sized stones) and a final layer of ballast (to fill the holes between the larger stones).

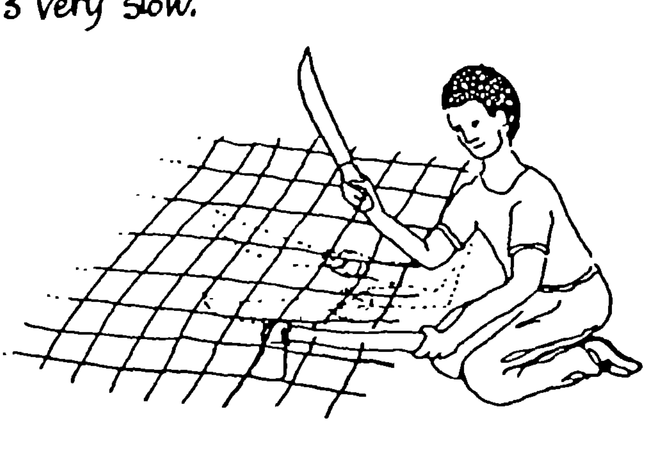
If you are building on a hard rock surface, then it is unnecessary to dig. Use boards, stones, or blocks to mark off the 2.05 m radius circle.

. Mark out another circle with a radius of 2.05 m nearby. Then cut a piece of BRC weld mesh 4.10 m long from the roll. Lay it out on the circle as shown. Trim off the corners lying outside the circle and save the pieces.

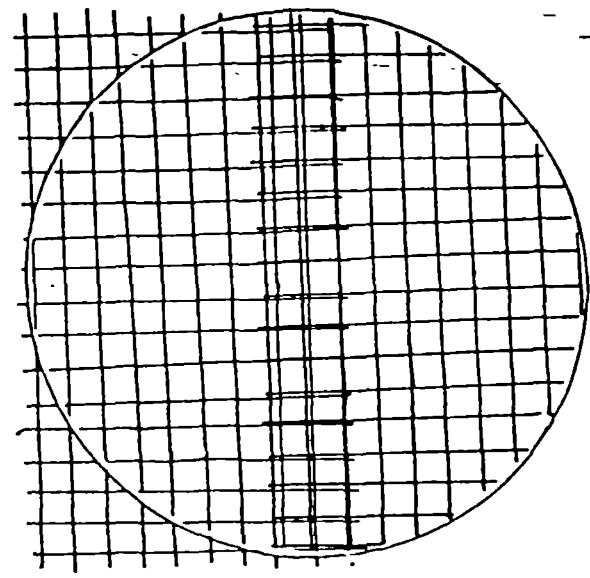


top view of BRC wire

BRC can easily be cut in a number of ways. The most efficient is to place a hard stone, or a large hammer or a mattock (shown) beneath the BRC, and then cut it using a cold chisel and hammer or a panga (shown). A hacksaw works, but is very slow.

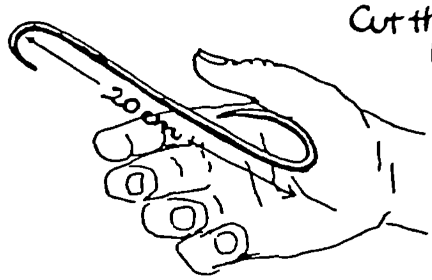


Cut another piece of BRC 4.10m long from the roll and lay it over the remaining part of the circle. Make sure the overlap between the 2 pieces is at least 1 full (15cm) square. Again, trim and save the pieces outside the circle.

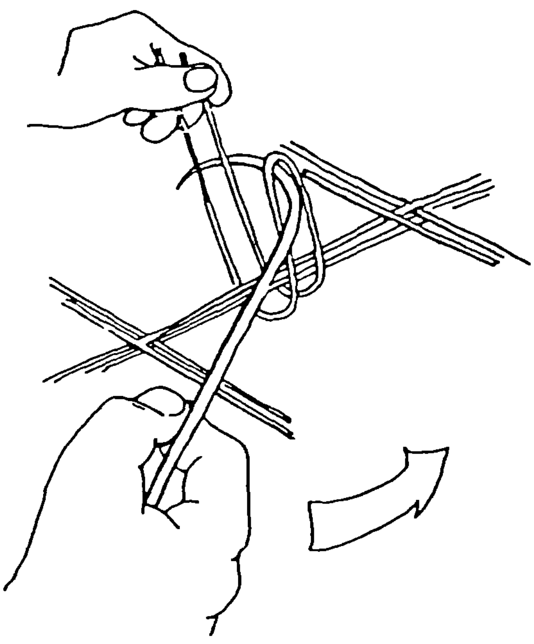


Tie the 2 pieces of BRC together with short pieces of 16 gauge binding wire. The final portion of circle not yet covered with BRC should be filled by tying the remaining corner pieces (cut earlier) to the last piece of BRC - again, make sure all overlaps are at least 1 full square. The floor reinforcement is now complete.

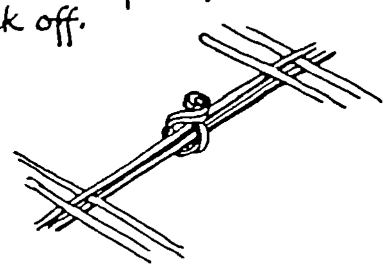
A simple method for tying the BRC with 16 gauge binding wire is to use an iron hook. The hook is made from BRC wire and shaped as shown.



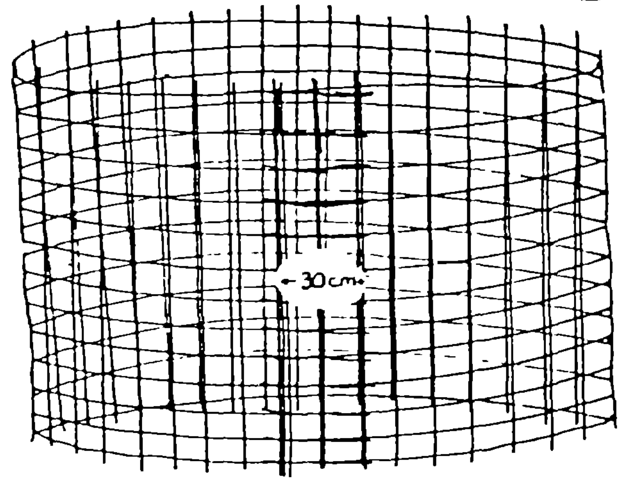
Cut the binding wire into many 10cm lengths and bend them into this shape:



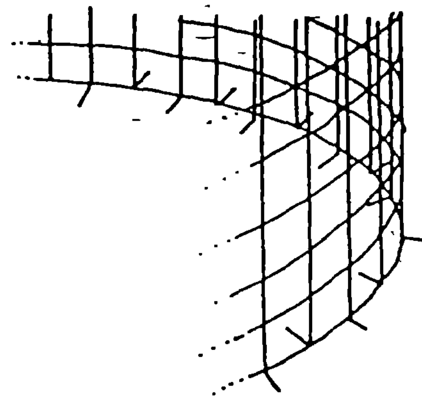
Hook the wire under the overlapped BRC and insert the tool inside and around the wire as shown.
Twist counterclockwise until the tops of the wires break off.

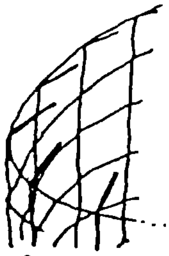


Now cut a 12.30m long piece of BRC from the roll. Stand the wire up and join the two ends together, using short pieces of 16 gauge binding wire as described above. You should have a cylinder with an overlap of 30cm (2 squares).
The circumference should be 12 meters, and the diameter should be 3.82 meters.



At the bottom of the BRC cylinder, bend the vertical wire segments horizontally. Bend every other one inside, and the ones between *outside* the circle, forming right angles. The wires will be tied to the floor reinforcement on Day 2.

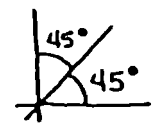




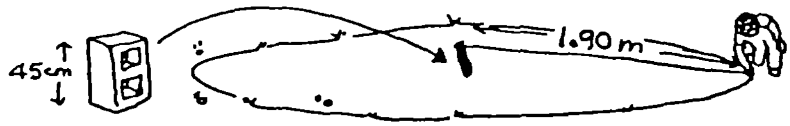
If any of the BRC wires have come loose, be sure to tie them back together, especially at the bottom. The most strength required of the tank wall is the bottom 60 cm.

Bend all of the top vertical <u>BRC</u> wires inwards to roughly a 45° angle.

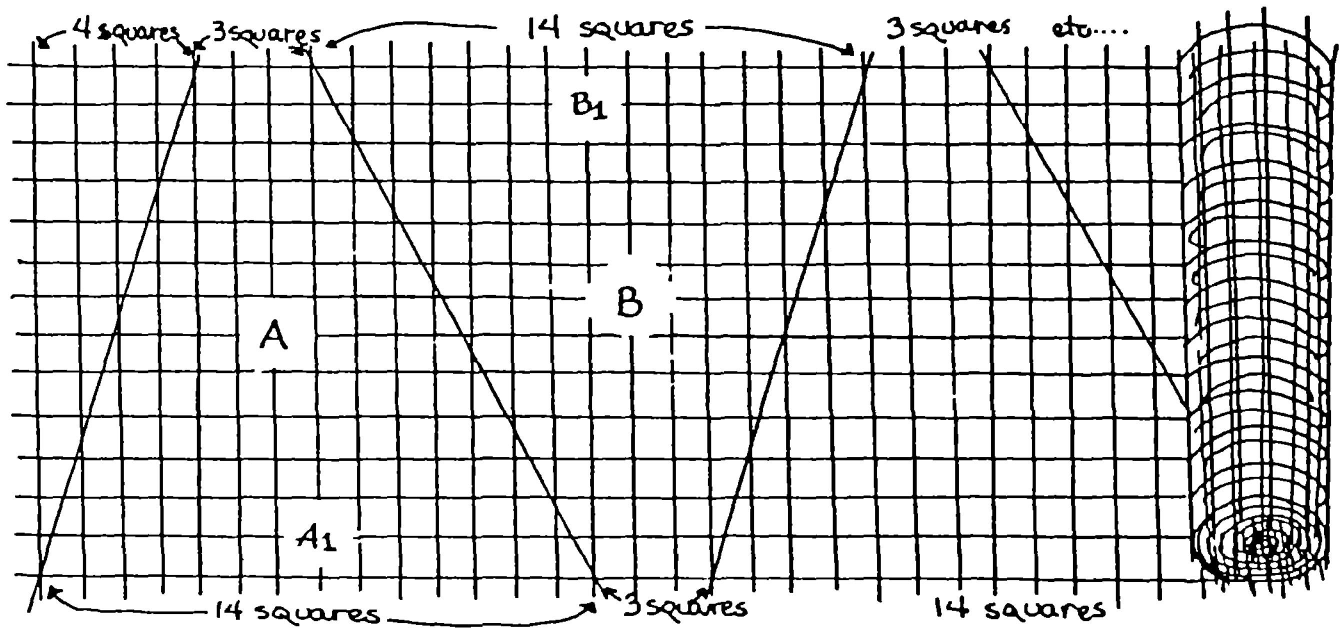
The wall BRC is now ready.



Mark out another circle with a radius of 1.90 m and place a 45 cm length cement block on end in the center. (Anything stable with a height of 45-50 cm can be used.)



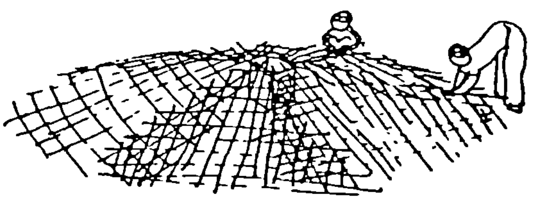
Unroll several meters of BRC weld mesh. You will cut triangular pieces from it and tie them together to form the roof reinforcement.
To start, count over 4 squares from the cut end and make a mark on the upper end, as shown in the diagram below. Count over 3 more squares and make another mark.

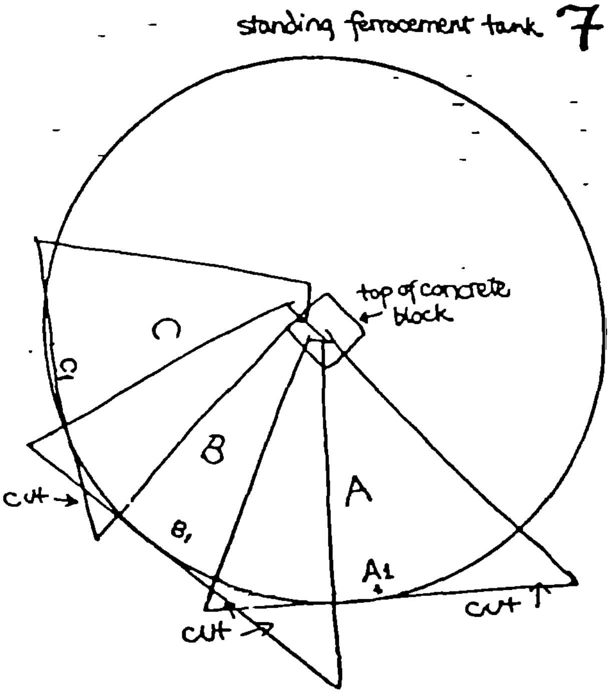


Cut the triangular piece marked <u>"A."</u> <u>Then</u>, laying that piece onto the remaining weld mesh, mark and cut <u>6 more</u> pieces identical to it. Cut every other one "upside down" as in "B". Use a cold chisel and hammer (or a panga) over a stone or mattock or hammer, as discussed before.

- Take one piece and place it on the circle so that the center of the bottom point labeled "A1") rests on the edge of the circle.

Continue to lay the pieces in the manner shown, taking care to overlap the pieces 2 full squares. Tie them tightly with 16 gauge binding wire.



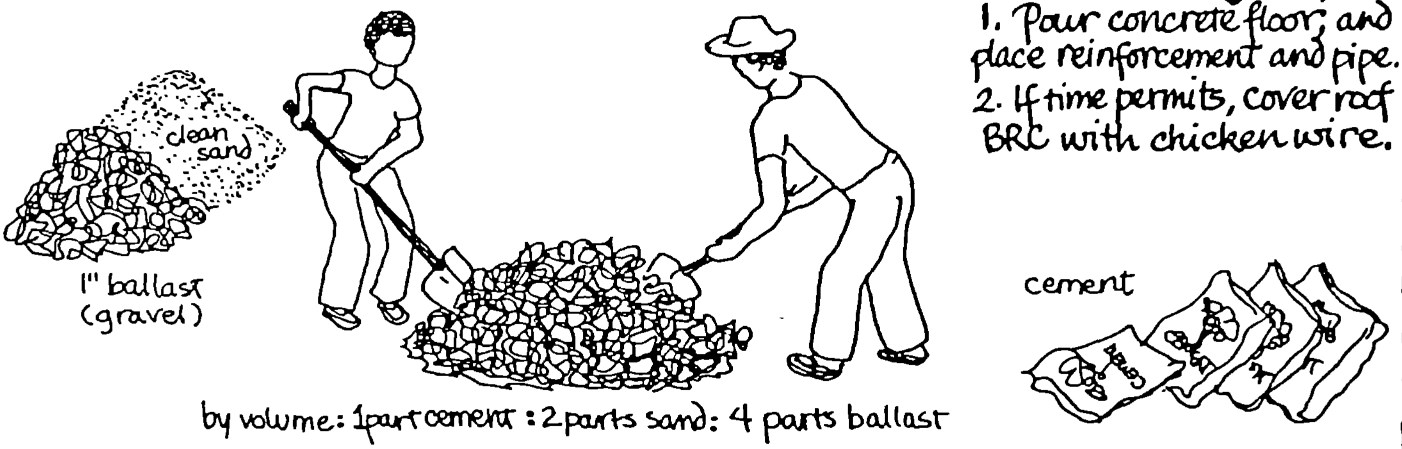


After all seven pieces are in place, measure out the eighth piece, including overlaps of 2 squares on each side. Cut it out and tie it in place. Cut off all pieces of the roof reinforcement lying outside the circle. The roof BRC is now ready.

DAY 2:

JOBS IN BRIEF:

1. Pour concrete floor; and place reinforcement and pipe.
2. If time permits, cover roof BRC with chicken wire.

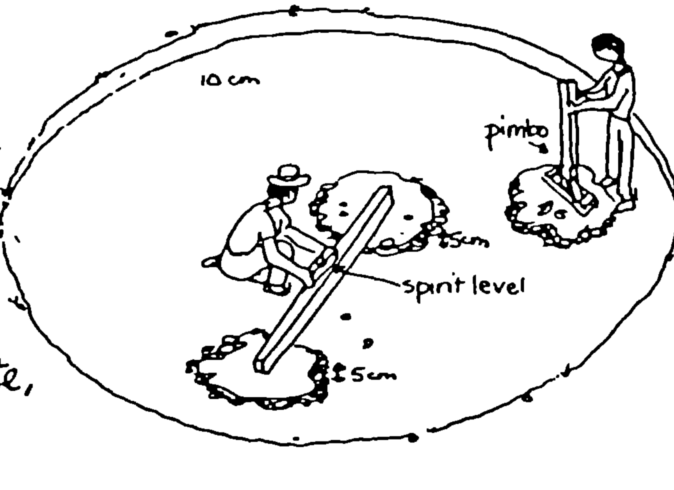


by volume: 1 part cement : 2 parts sand : 4 parts ballast

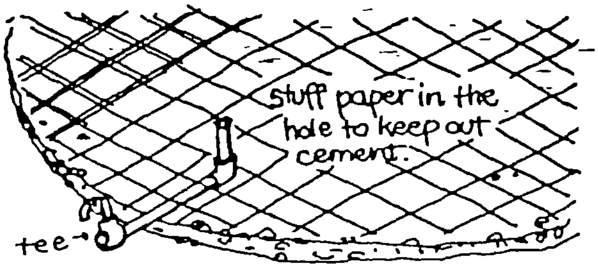
1. Concrete Floor

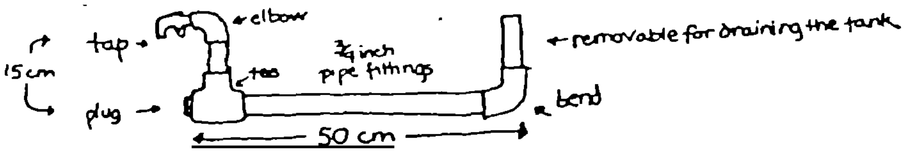
Mix 4 bags of cement with appropriate amounts of clean sand and then 1" ballast to yield a 1:2:4 (cement: sand: ballast) concrete. *Add only enough water to make the concrete workable.*

Thoroughly sprinkle water over the level, excavated hole. Then pour concrete into it, making small pads at first. Make sure they are at least 5 cm thick and level with each other. Pound them flat with a pimbo made from 2" x 4" boards. Then fill the spaces between the pads with concrete, making sure that all is level.



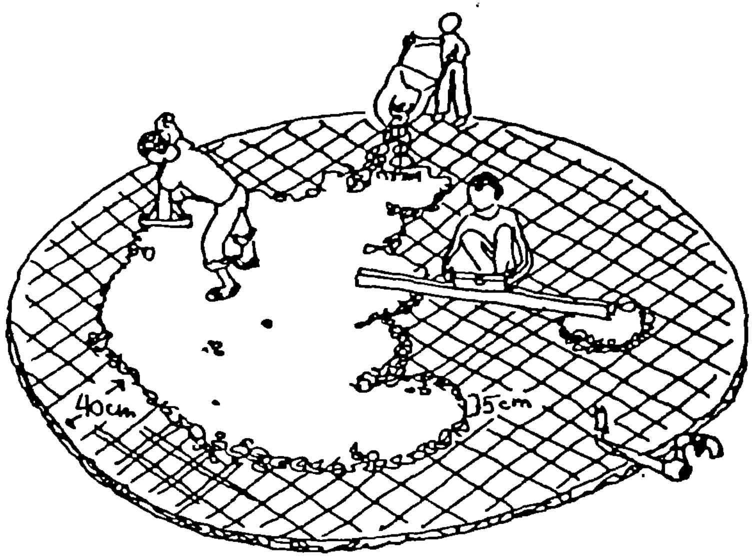
Next, bring the BRC floor reinforcement and place it on the concrete. Put the delivery/scour pipe in place just under the BRC so that the tee joint (with the tap) protrudes from the concrete outside the tank foundation.





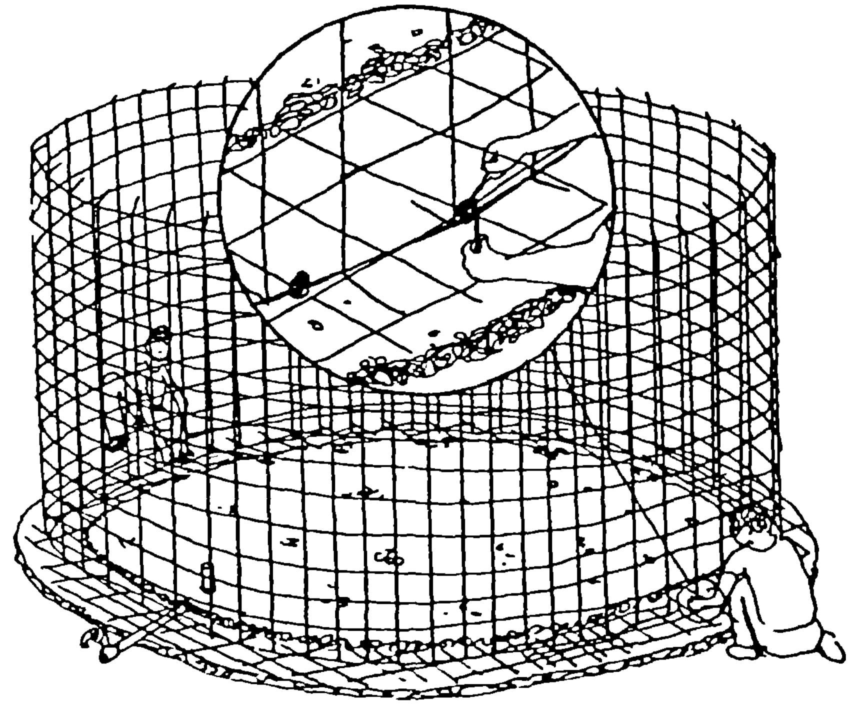
Then mix another 4 bags of cement with the same 1:2:4 proportions of sand and ballast. Begin pouring the 2nd layer of 5 cm thickness in the center of the foundation - always tamping down with the pimbo. Check to see that the surface is level.

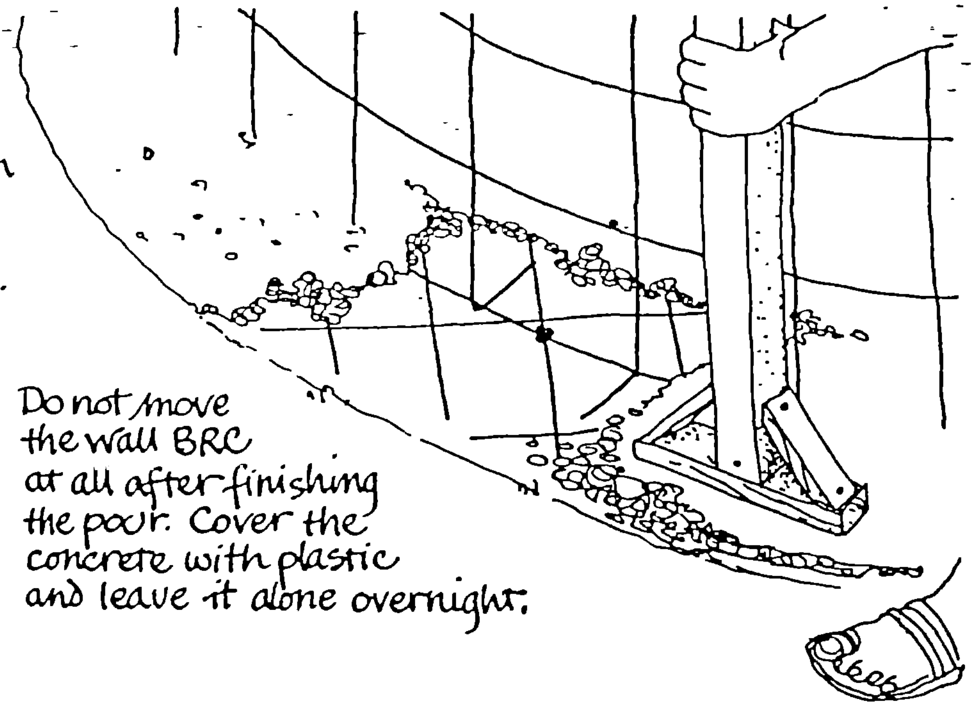
Pour the second layer of concrete leaving a 40 cm space around the edge of the tank floor without the second layer.



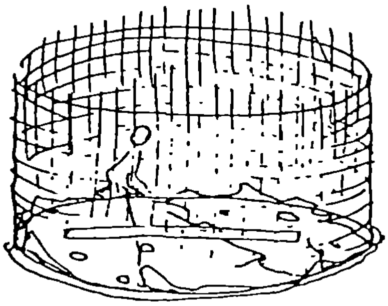
Keep the concrete damp at all times! After it has set, splash water on it. Never let it dry to a light grey color.

Bring the wall BRC reinforcement and place it on the exposed floor BRC so that a 15 cm space remains between the wall BRC and the wall of the excavation (the edge of the first concrete layer). Pull the cylinder so that it has a good circular shape. Tie it to the floor BRC with binding wire.



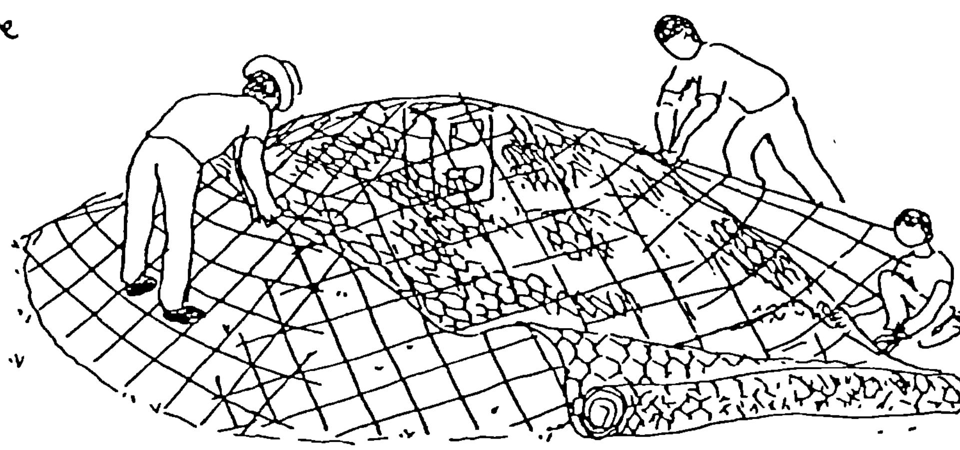


Then pour the last remaining concrete, filling in the space underneath the wall. Tamp the concrete down carefully and firmly.



Do not move the wall BRC at all after finishing the pour. Cover the concrete with plastic and leave it alone overnight.

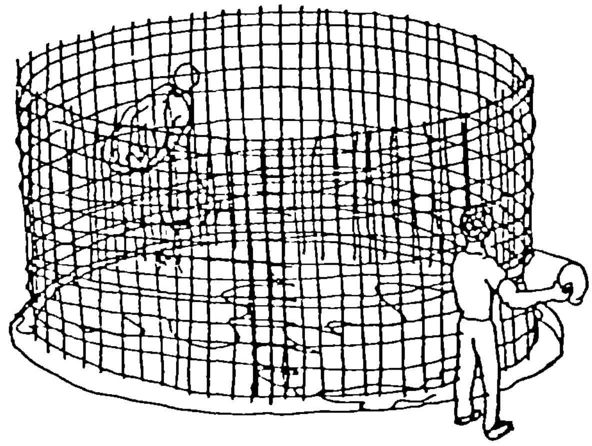
If time remains, cut pieces of chicken wire and tie them, one by one, onto the BRC roof – always keeping a 20 cm overlap.



DAY 3:

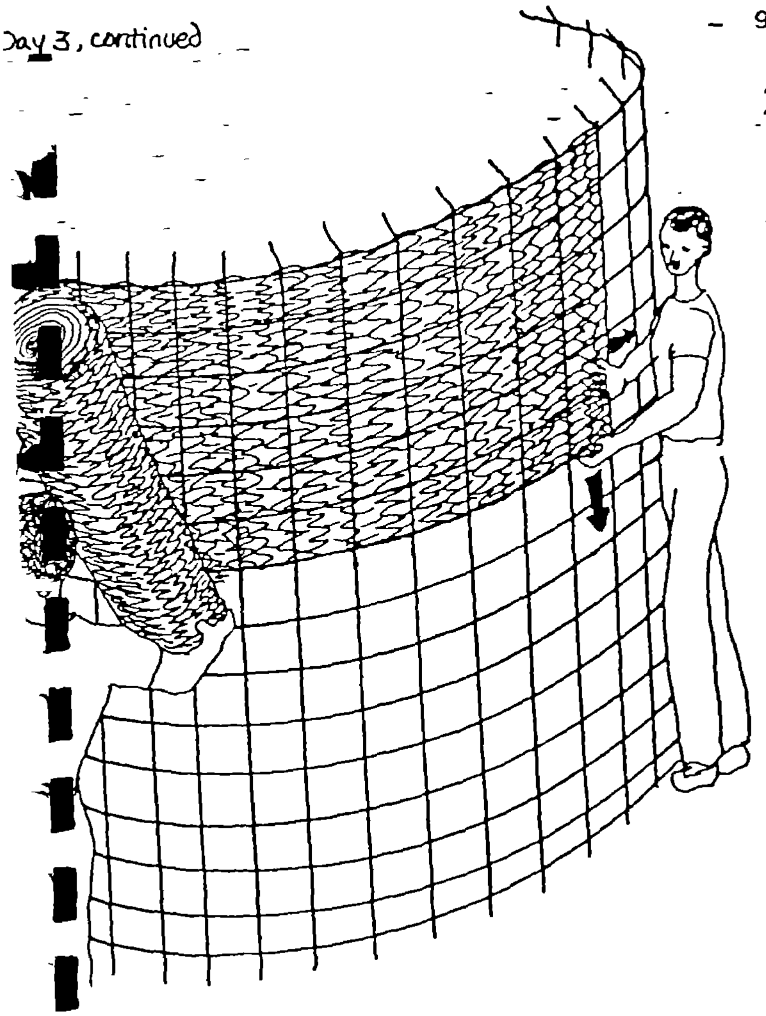
1. Begin by removing the plastic cover from the concrete and splashing it thorougly with water.

Do this throughout the day and throughout the entire job, four or more times a day.



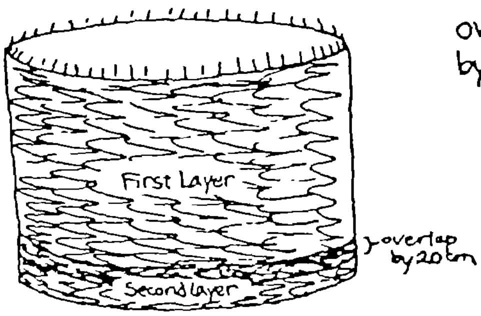
JOBS IN BRIEF:

1. Splash concrete floor with water 4+ times/day.
2. Wrap wall BRC with chicken wire and with binding wire.
3. Bind plastic sugar sacks on the outside of the wall.
4. Plaster the inside of the wall with 1:3 plaster.



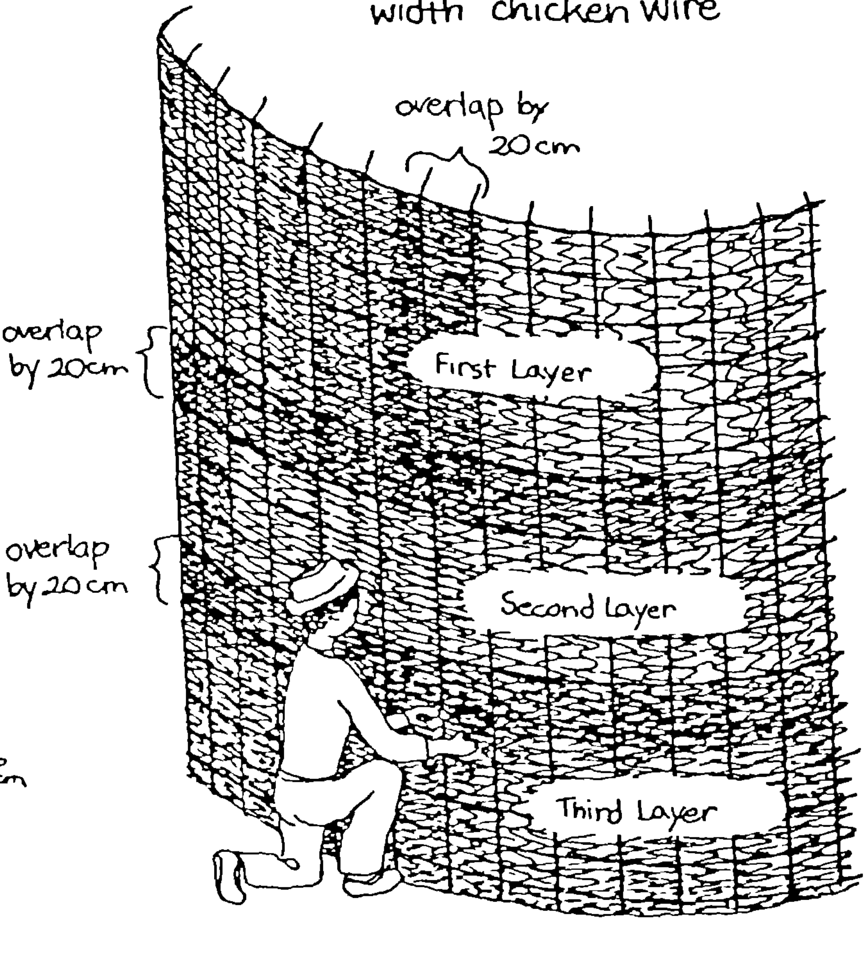
2. The next step is to wrap the outside of the wall BRC with a layer of chicken wire, from the uppermost horizontal wire to the concrete floor. Take the roll of chicken wire and push the upper long edge over the free vertical BRC wires. While continuing to encircle the BRC, constantly pull the chicken wire TIGHTLY in both vertical and horizontal directions. Overlap the two ends of the chicken wire by 20 cm.
Fasten the chicken wire to the BRC where necessary by twisting several mesh openings about the BRC wire using the iron hook ⟶ or pliers. It is not necessary to use binding wire to fasten the chicken wire onto the BRC.

If your chicken wire roll is 3 feet (90 cm) wide, then you will need to duplicate this twice more so as to cover all of the BRC with tightly fastened chicken wire.
If the roll is 6 feet (1.8 m) in width, only a narrow final piece will be necessary at the bottom.
Overlap each new wrap on the old by 20cm. Stagger the starting place each time so that the vertical overlaps occur in different places.



using 6 foot (1.8 m) width

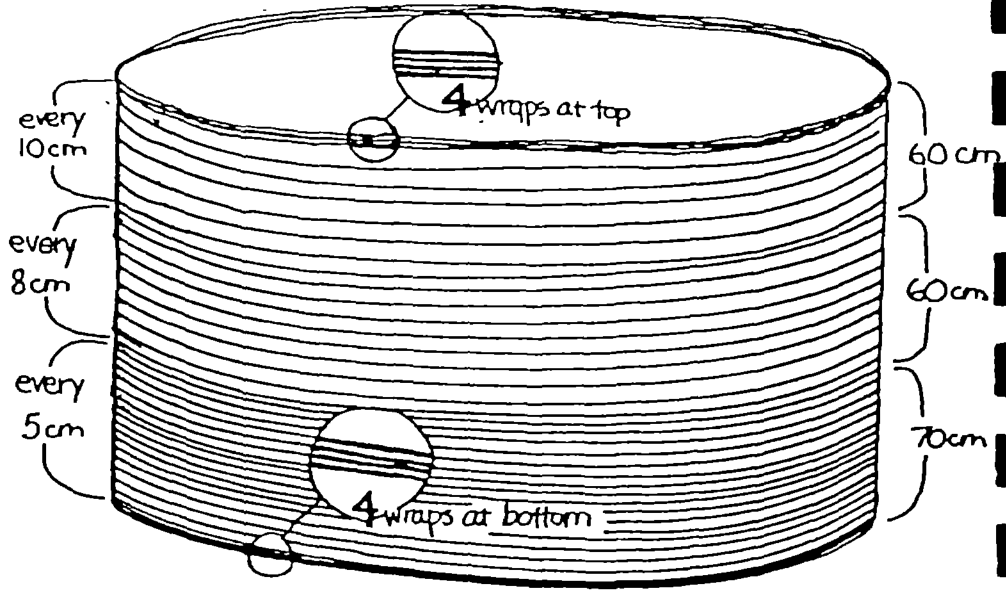
using 3 foot (90cm) width chicken wire



After the chicken wire wrapping is completed and all sags and bellies are tightened up, take a several kilogram roll of 16 gauge binding wire and wrap it 4 times around the very topmost horizontal BRC wire. This helps support the roof.

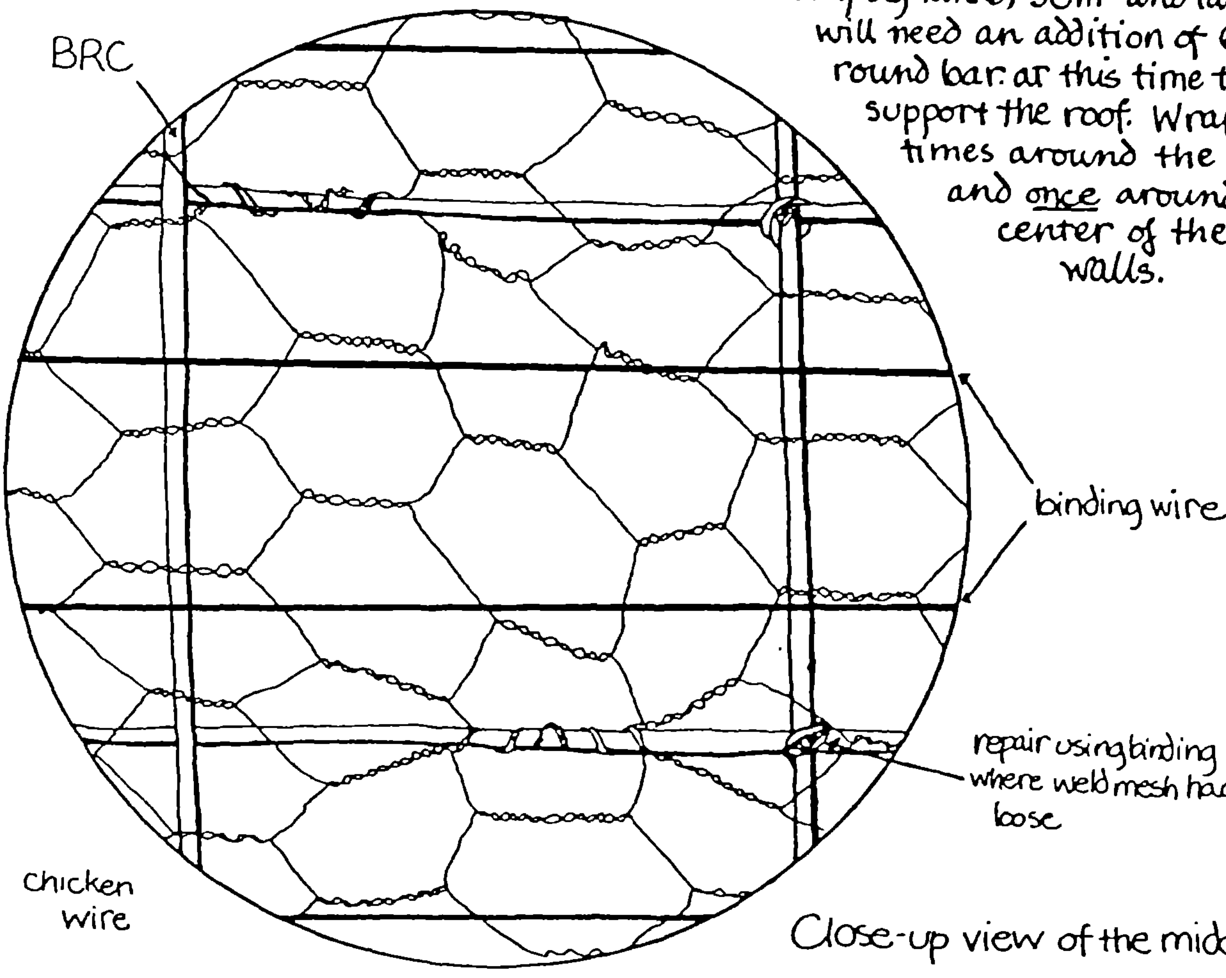
Then proceed to spiral the binding wire down every 10 cm for the next 60 cm of wall height, pulling it very tightly.

After you have completed wrapping the top 60 cm, then reduce the intervals between wraps to 8 cm for the next 60 cm.



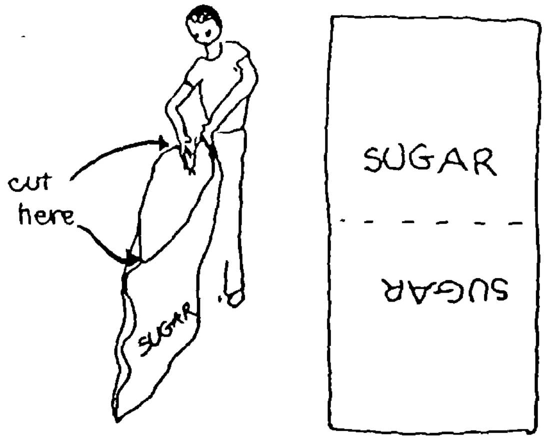
Finally, wrap it every 5 cm ~~for the~~ remaining 70 cm, to the very bottom of the tank. Then make 4 tight wraps around the bottom and tie the wire to the BRC. Ideally, use a continuous wire running from the very top to the bottom.

Very big tanks, 50m³ and larger, will need an addition of 6 mm round bar at this time to help support the roof. Wrap 2 times around the top, and once around the center of the tank walls.



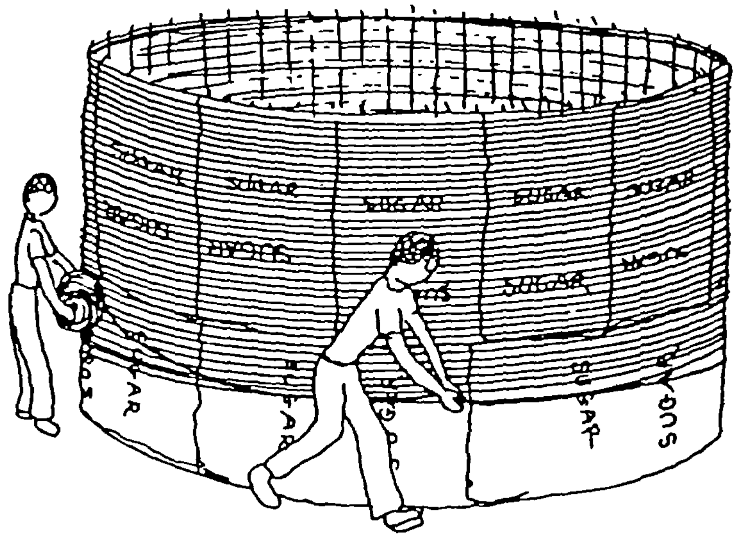
Close-up view of the middle section

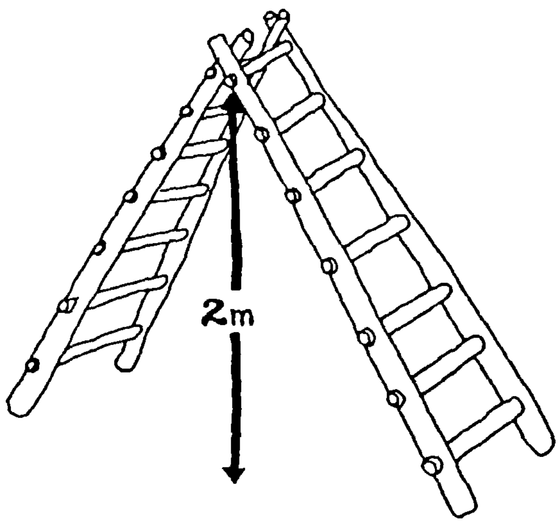
3. Next, take and cut the sugar sacks along each of the 2 long seams and open them out. (If you intend to build many tanks, sew them together in long rows.)



Sugar sacks in Kenya are made from nylon and are ideal for this job because they clean easily. (Burlap or hessian cloth sacks may be used instead, as well as reed mats, on the walls.)

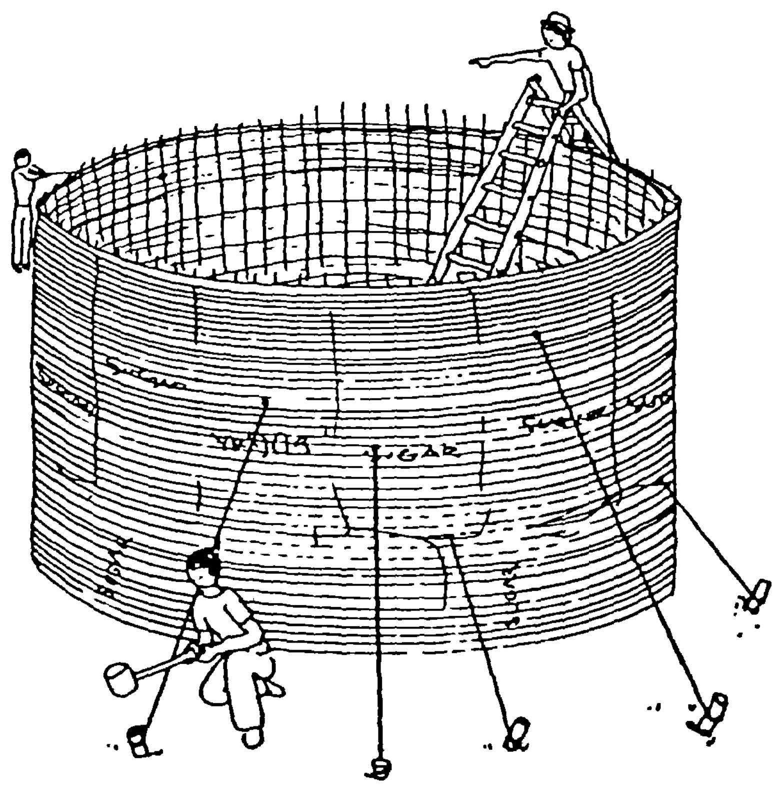
Starting at the top, tie them onto the outside of the reinforcement using wraps of sisal string at intervals of 5 cm. It is <u>very important</u> that the wraps are not more than 5 cm apart and that they are tied very tightly.

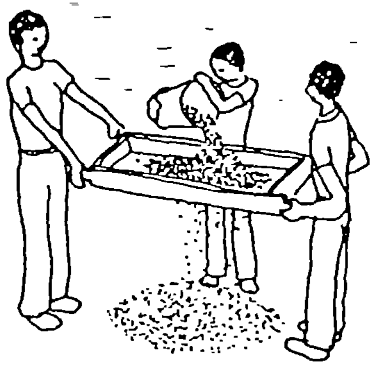




Nail and wire 2 ladders together, one inside the other, so that they stand over 2 meters tall. They must be stable and tall enough to stand free of the tank wall.

After the tank is completely wrapped in sugar sacks and twine, it may be necessary to adjust the wall to make it stand straight and in a good circle. The foreman climbs the ladder and inspects the BRC reinforcement to see where the wall is not a good, round, cylindrical shape. Adjustments are made by fastening lengths of binding wire to the BRC and tying them to stakes. Pull the wires just the right strength to remove any sags or bellies.

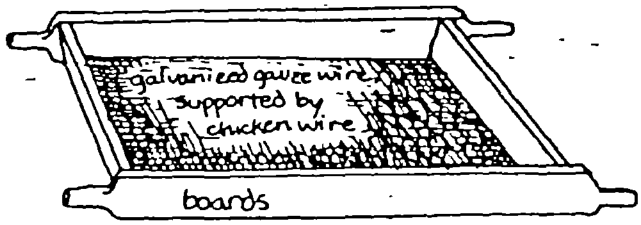




Sift the sand to remove any pebbles.

Check to see that the sand is clean. (See "Tips on Making Strong Ferrocement")

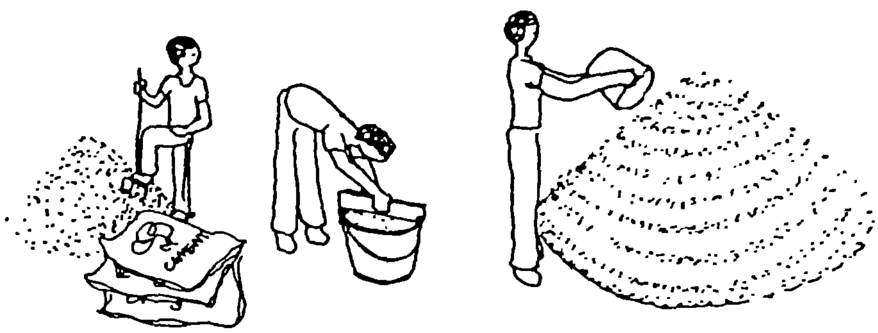
Rinse sand if needed.

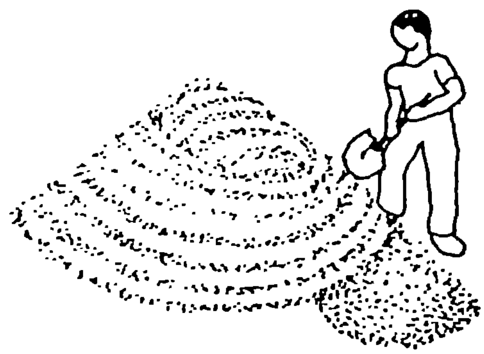


Sieve for sand

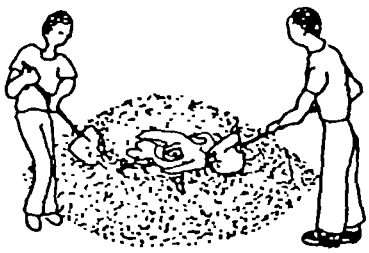
Then mix 3 bags of cement, all at once, with *three times* as much sand, by volume, to produce a 1:3 (cement: sand) plaster. Measure the sand and cement using a bucket or a wooden box.

Scrape the contents of the bucket or box level, to assure consistent measurements.



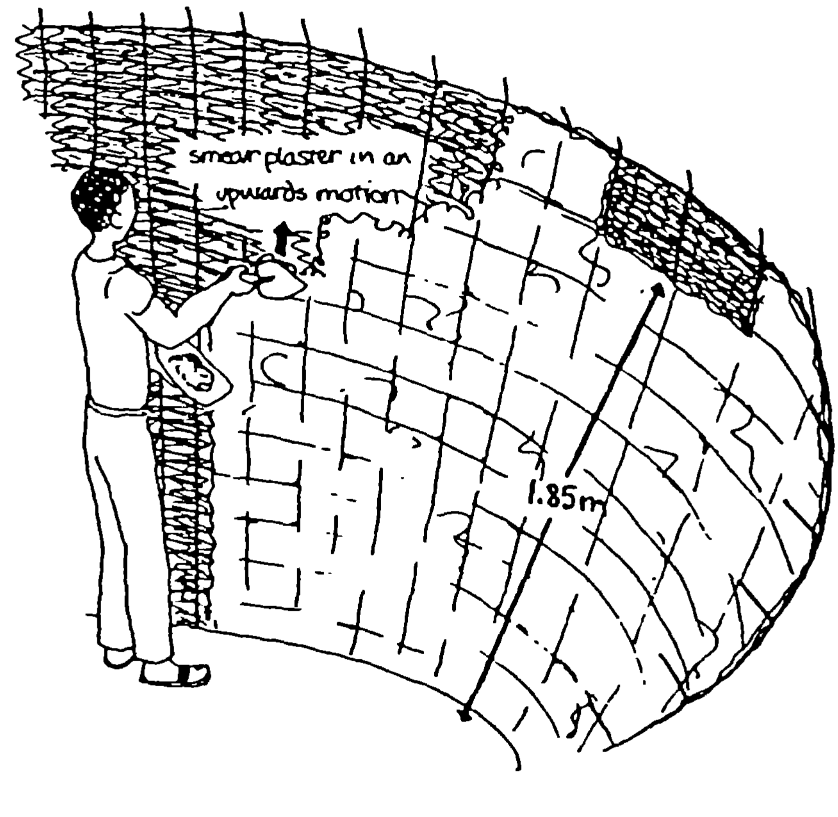


Shovel the sand and cement together, moving the pile back and forth several times, *until the mixture is all one color throughout.*

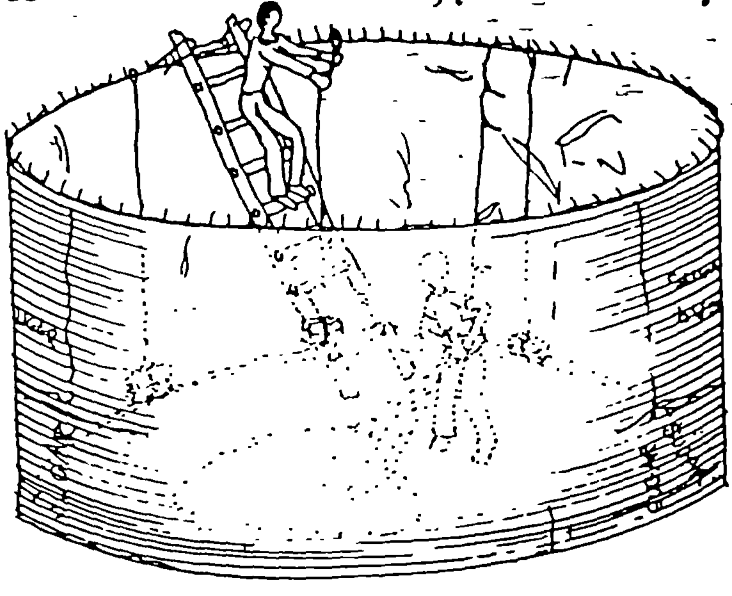


Add water carefully, until the plaster is just workable. There should never be water visible in the mixed plaster, even when it is left to sit.

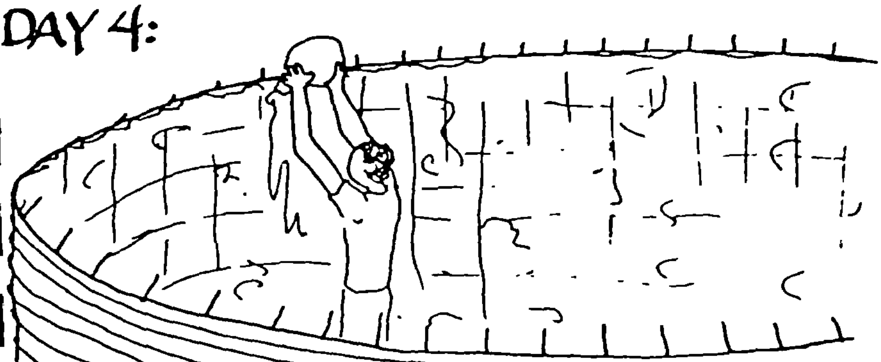
Push or smear the plaster onto the wires from the inside of the tank, starting at the bottom. No plaster should leak past the sugar sacks. Plaster in this way until you reach the top most horizontal BRC wire. However, leave 2 squares empty 1.85m *above the concrete floor* for constructing the overflow.



After plastering is finished, wrap polyethelene plastic sheeting inside the tank to protect the plaster from drying out. To cover it well, poke holes along the long edge of the plastic and hang it from the exposed BRC vertical wires at the top. Hang lines of twine with weights (such as stones or bricks) tied at the bottom to prevent the wind from tearing the plastic away. Splash water on the floor.



DAY 4:

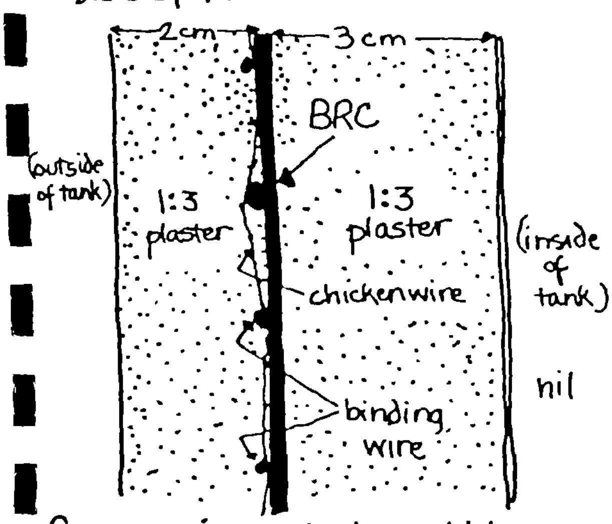


JOBS IN BRIEF:

1. Throw on a 1cm thick layer of plaster on the inside of the tank wall.
2. Throw a lighter plaster (less than 1cm thick) onto the outside wall.

On the morning of the 4th day, remove the plastic sheeting, but not the sugar sacks. Sprinkle water thoroughly on the floor and wall.

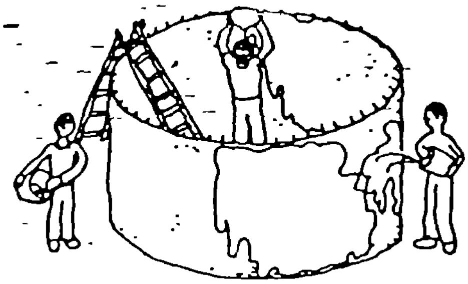
1. Mix 1 bag of cement into 1:3 plaster and throw it evenly onto the inside of the tank. A slightly wetter mixture is recommended, *but it should not be shiny!* Keep in mind that the wall thickness, when finished, is only 5 cm: 3 of which are on the inside of the BRC.



Cutaway view: actual wall thickness

DAY 5:

1. In the morning, remove the polyethylene sheeting and splash water onto the walls and floor.

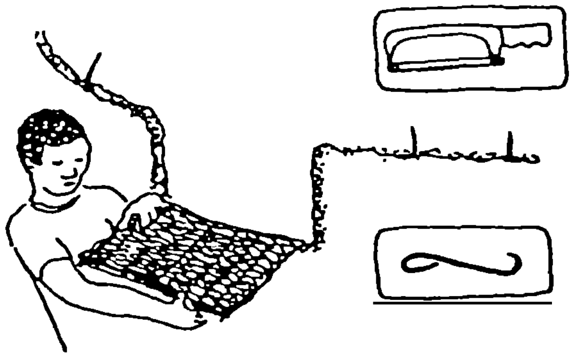


JOBS IN BRIEF:

1. Plaster smooth the outside of the wall
2. Begin sewing sugar sacks on the underside of the roof reinforcement.

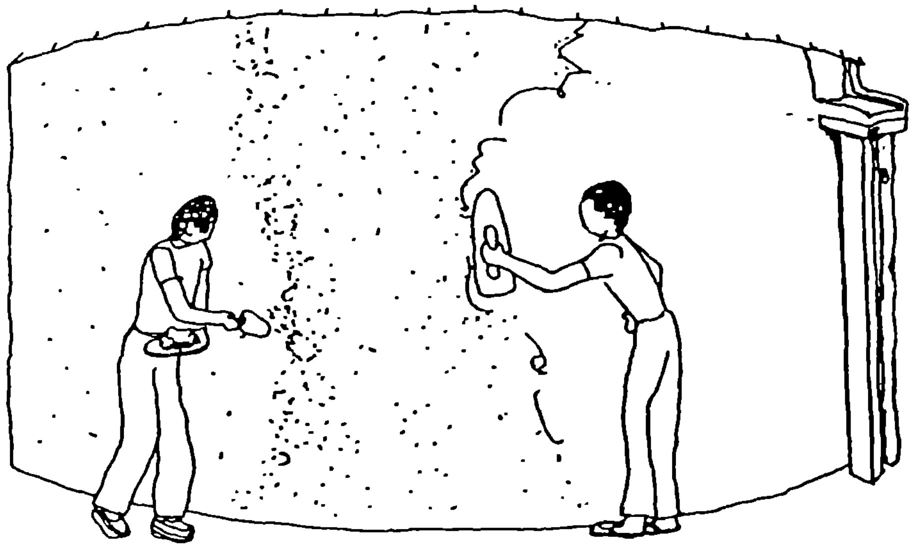
Cut the horizontal wire with a hacksaw, and bend down the two squares of BRC that were left open for the overflow. Wrap with several pieces of chicken wire.

Then mix another batch of 1:3 plaster using 2 bags of cement. Make it fairly dry.



Throw on a light coat of the plaster, about 1cm thick.

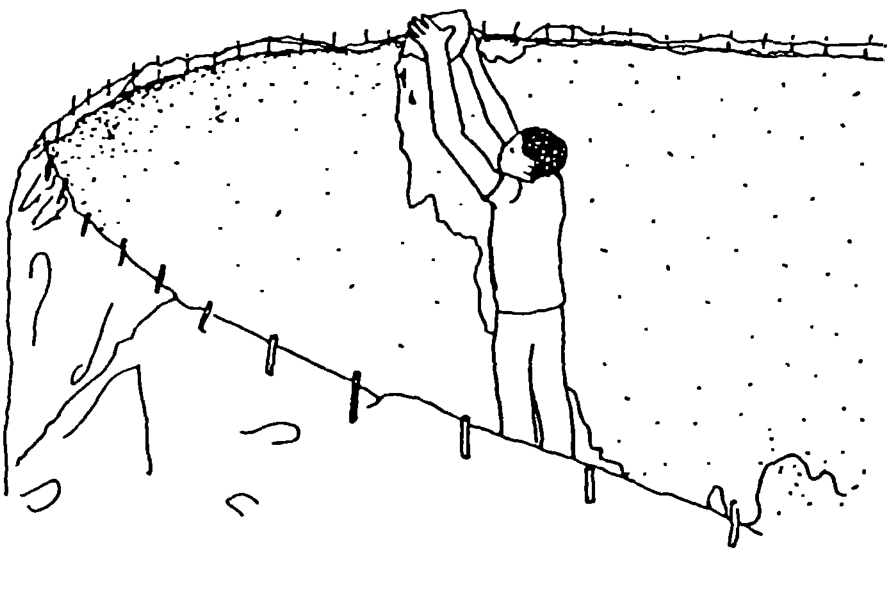
Then smooth it with a wooden float until the entire outside has a smooth, plumb wall.



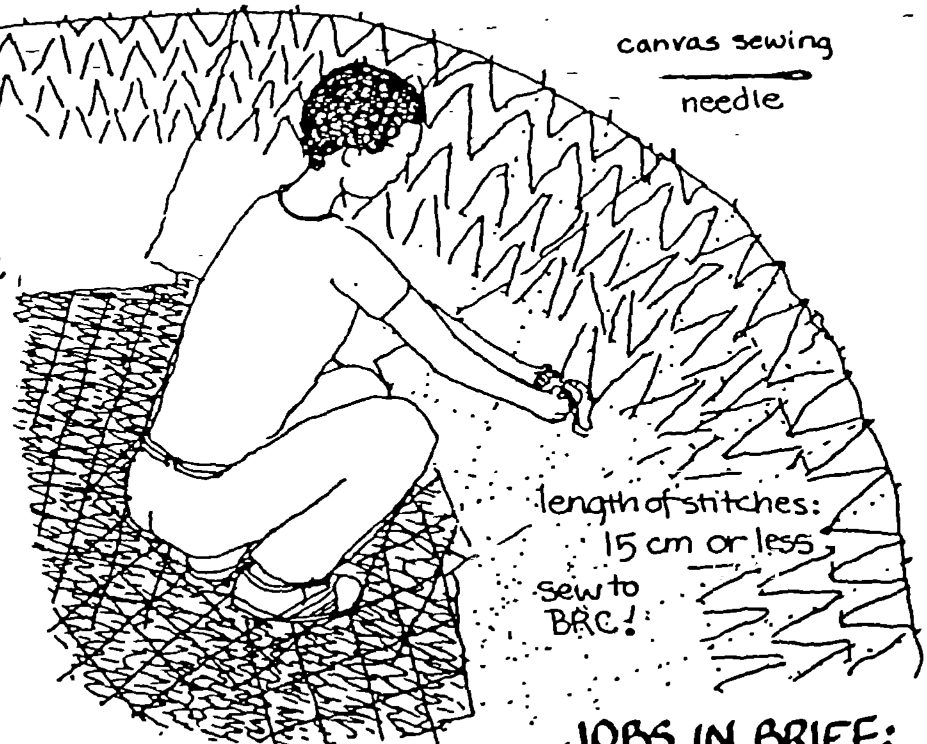
Place a flat board under the overflow and use one or two posts to support it. Plaster the top and smooth it.

Sprinkle water generously on the inside of the tank four or more times during the day.

When the plaster has set, wrap the outside of the tank with polyethelene plastic sheeting.



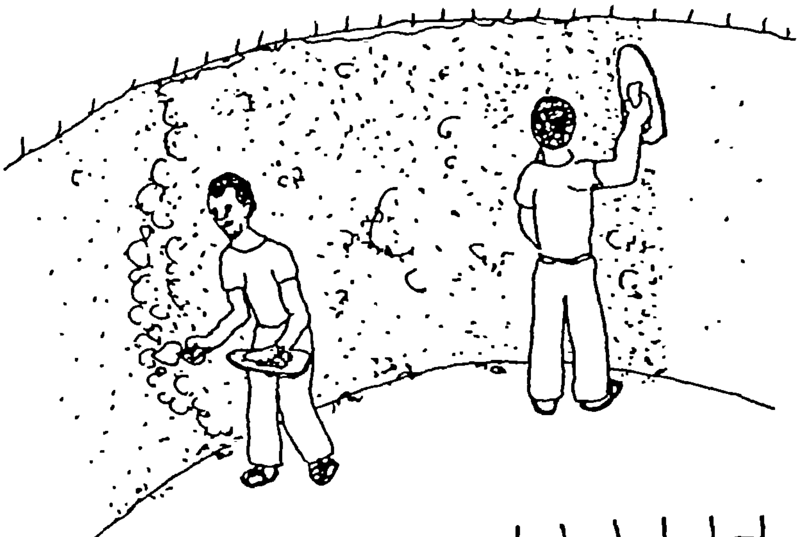
2.1 In the afternoon, turn the roof reinforcement upside down and begin sewing the sugar sacks *tightly* to the BRC wires on the underside of the roof. Use sisal twine in a zig-zag fashion starting at the outside rim. Make sure there are no bulges which will use excess cement and make the roof heavier without making it stronger.



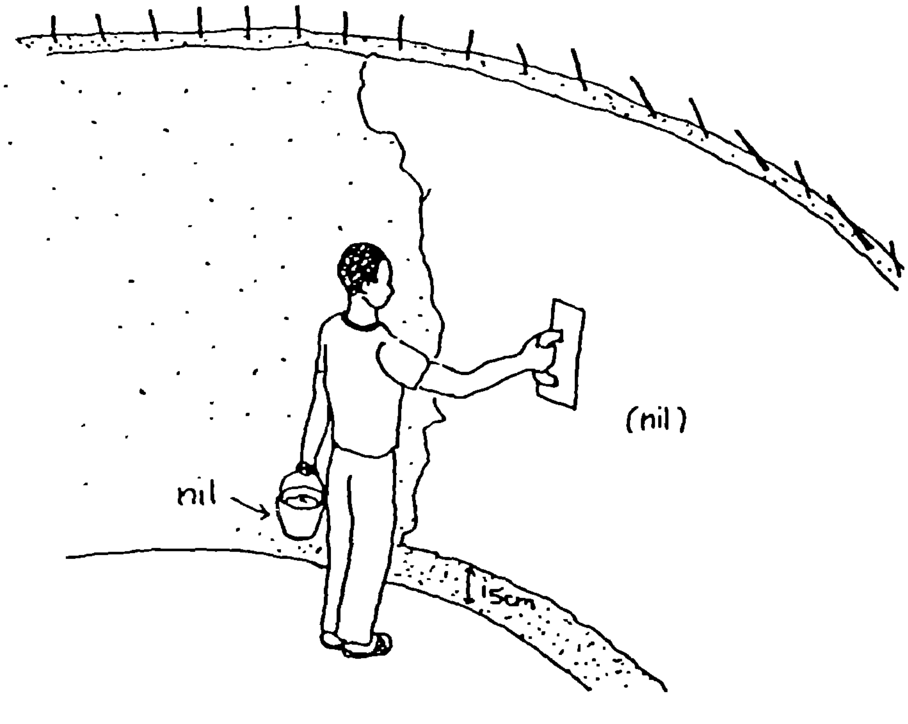
DAY 6:

JOBS IN BRIEF:

1. Plaster inside wall and floor of tank and trowel on nil coat.
2. Finish sewing sugar sacks onto roof reinforcement.

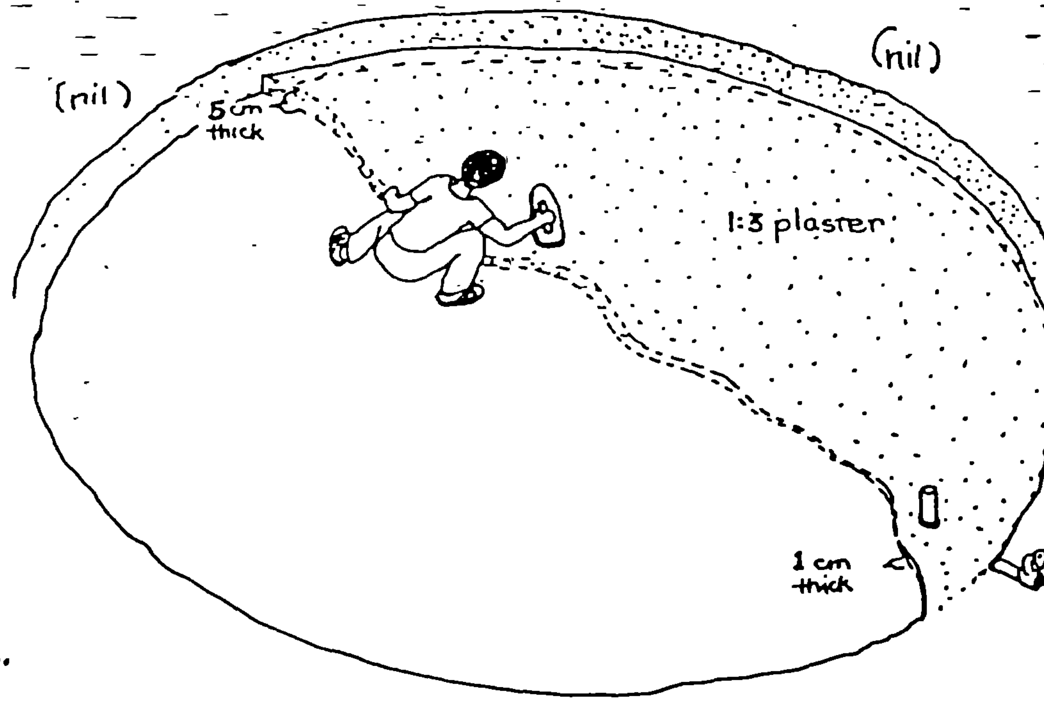


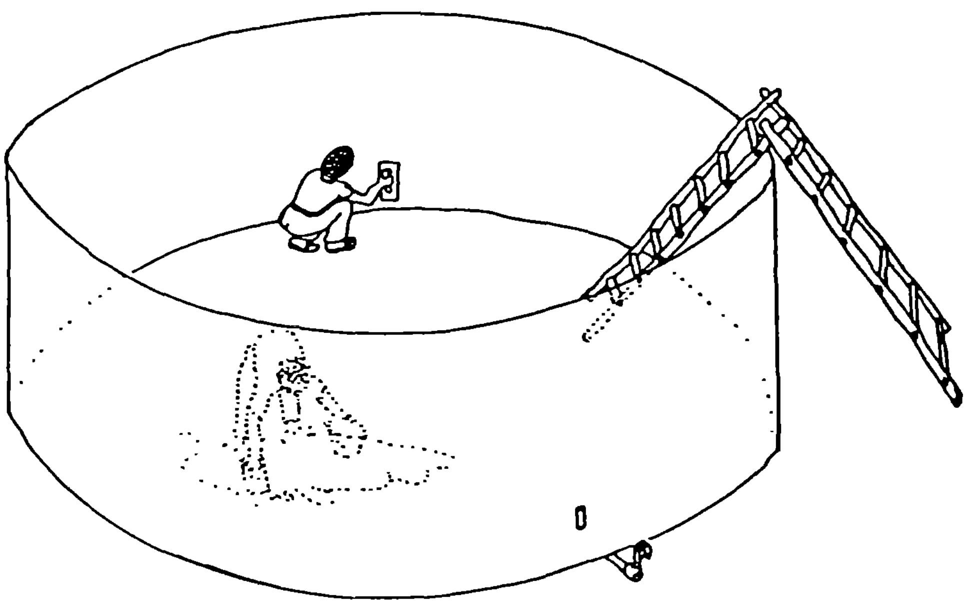
1. Mix and throw on the inside wall enough 1:3 (cement:sand) plaster to complete the 5 cm wall thickness. Smooth it with wooden floats.



Then mix cement in water until you have a thick soup (nearly equal parts of cement and water). This mixture is called nil. Using steel rectangular trowels, smooth it very evenly onto the new plaster. Leave a 15cm height around the bottom of the wall free of nil.

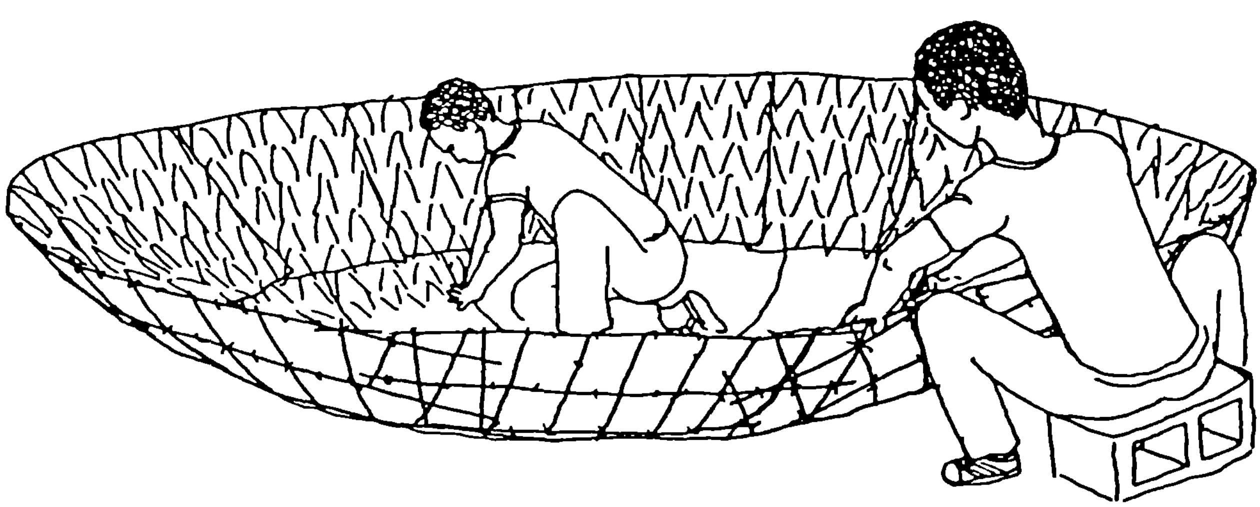
Then pack in 1:3 (cement:sand) plaster over the entire floor to create a slope down towards the pipe.
Start near the back, making the plaster 5 cm thick, and move toward the pipe, where the plaster should be 1 cm thick.
Smooth the plaster with wooden floats.



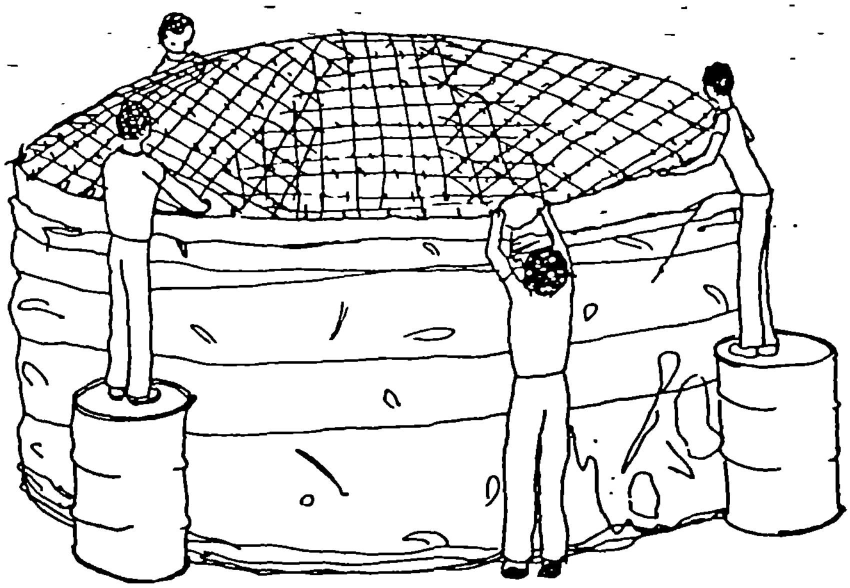


After plastering the floor, trowel on the nil over the complete floor and the remaining lower part of the wall. Use a rectangular steel trowel and press it on firmly. Nil the area under the ladder first, and then work back in that direction.
When set, cover with plastic sheeting.

2. Finish sewing the sugar sacks onto the roof reinforcement.



DAY 7:

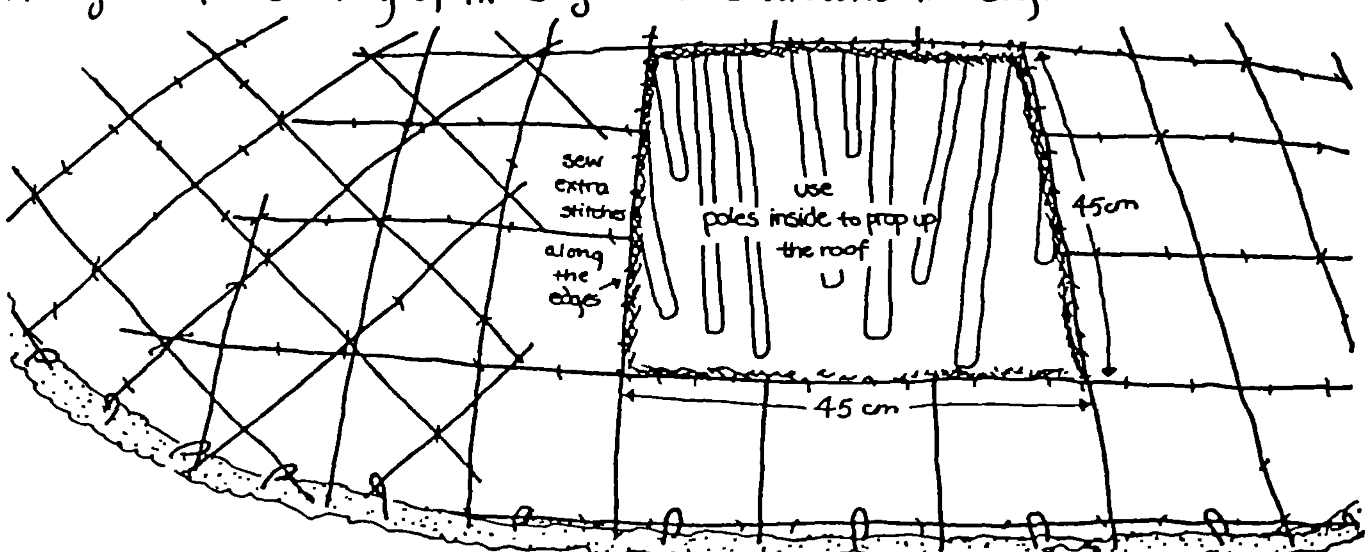


JOBS IN BRIEF:

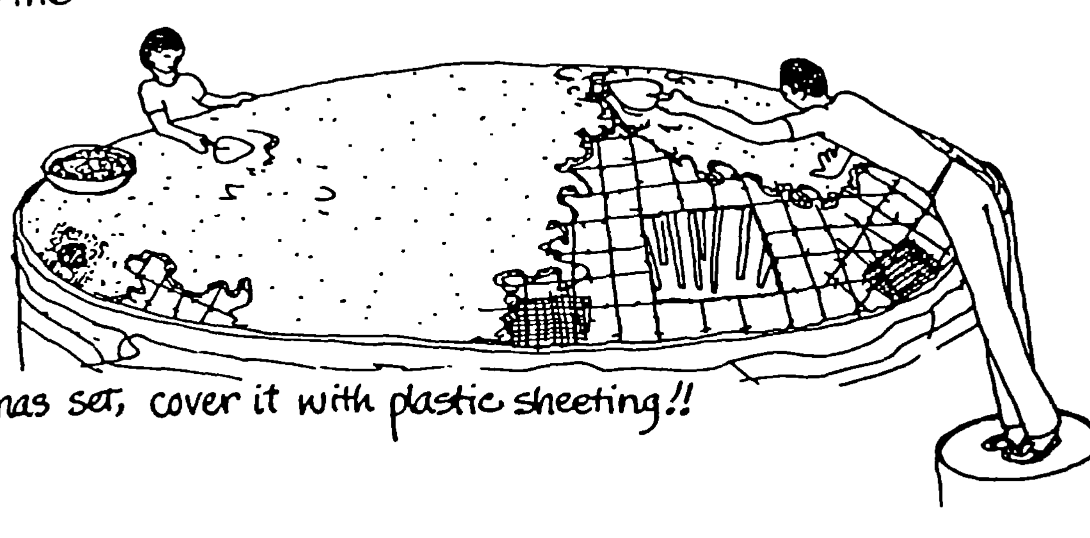
1. Tie roof reinforcement to BRC wall wires and plaster top with 1:3 mix
2. Dig hole beneath pipe and line with 1:5 plaster
3. Make tankhole cover.

Pour water on the sides of the tank 4 times a day. Keep the walls covered with plastic.

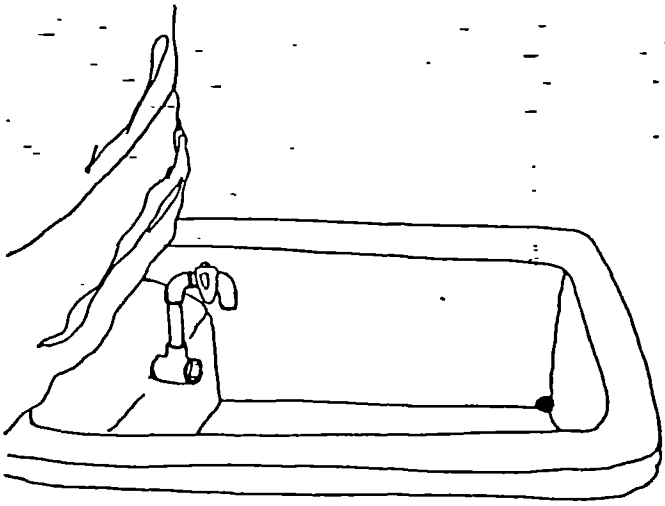
1. After completing the sewing, place the roof reinforcement on top of the tankwall and tie it onto the wall using the protruding BRC wires. Using a hacksaw, trim off any excess BRC wires. Cut a tankhole (45cm x 45 cm) in the roof wires off to the side where the roof gutters will bring water to the tank. Strengthen the sewing of the sugar sacks around the edge.



Prop up the roof from inside using poles. Completely covering the wires, smear on a coat of 1:3 plaster. While plastering, make 4 or 5 holes for rainwater to enter along the bottom of the tank roof. Place an 18 cm x 18 cm piece of galvanized gauze wire over a BRC hole. Leave a 10cm diameter hole unplastered within the gauze.



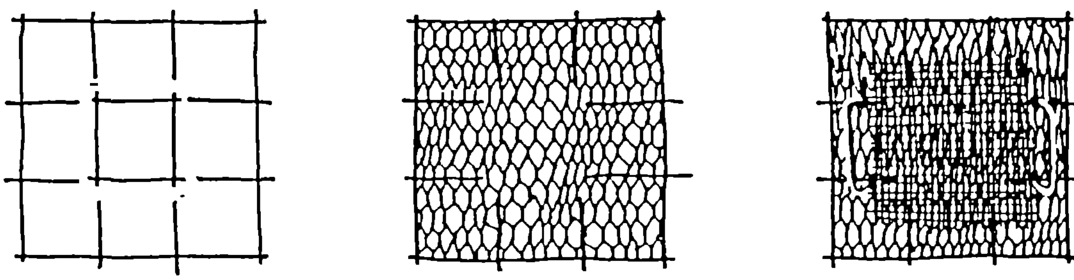
Once the plaster has set, cover it with plastic sheeting!!



2. Dig a hole underneath the pipe tap. Make it large enough to easily remove a full bucket or big cooking pot full of water.
Plaster it using one part cement to 5 parts of sand (1:5).

It is recommended to make a drain in one corner that leads to a rock-filled soak pit.

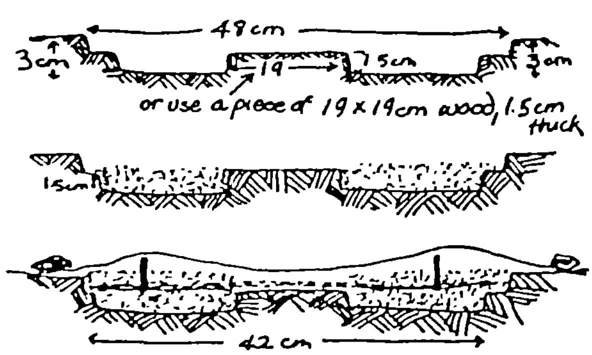
Cut pieces of BRC and chicken wire, 45 cm x 45 cm each. Cut a piece of galvanized gauze wire 25 cm x 25 cm. Cut out a 20 x 20 cm section in the center of the BRC, as shown. Tie the chicken wire and galvanized gauze wire to the BRC. Add 2 handles made from BRC wire.

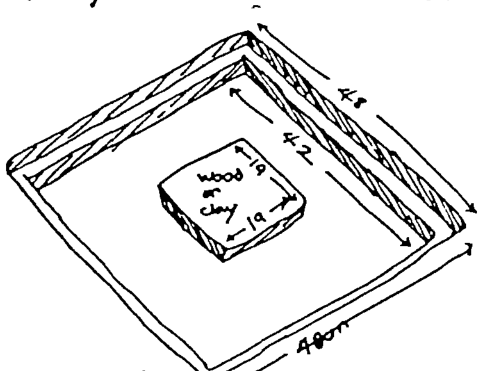


Dig a shallow hole in the ground as shown: Check that the reinforcement fits inside it.

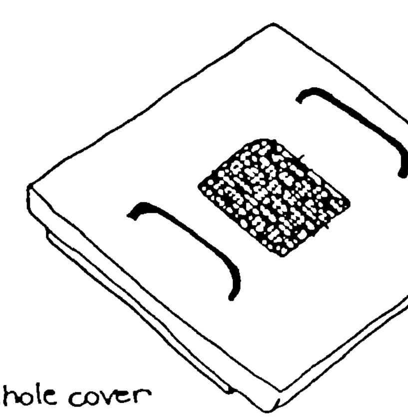
Fill the bottom section, just over the notch, with 1:3 plaster.

Immediately place the reinforcement, with handles up, in place. Fill the sides with another 1.5 cm of the plaster. *Cover with plastic! Keep it wet for at least one week!*



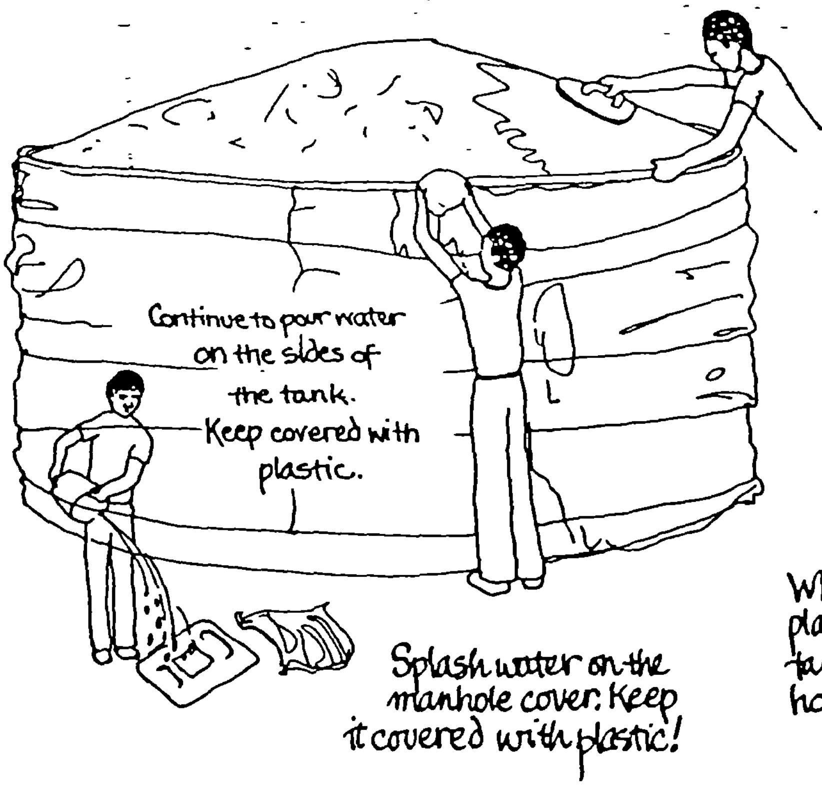


hole in ground


tankhole cover

DAY 8:

JOB IN BRIEF:
Make a smooth plaster coat on top of the roof.

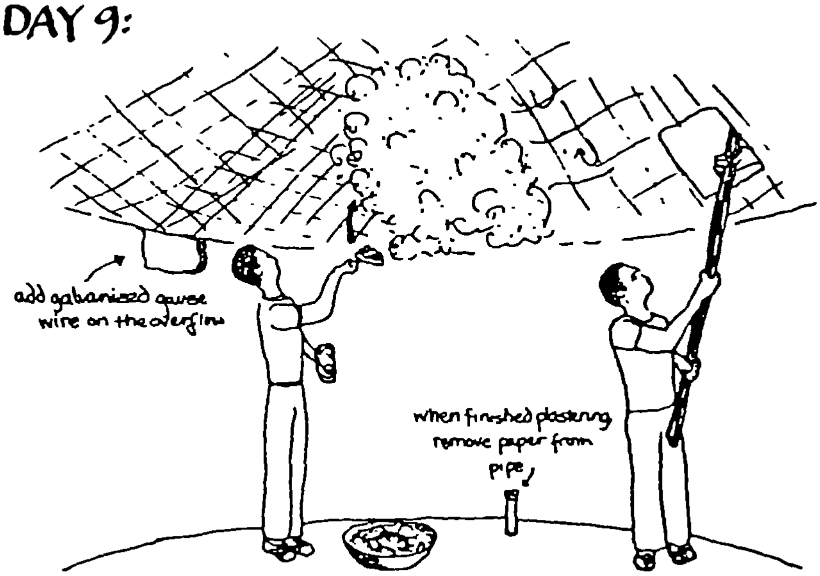


Mix 2 bags of cement into 1:3 plaster. Remove plastic sheeting from the roof. Trowel on a 1 cm thick layer of plaster, and smooth it with wooden floats. Also make a plaster rim around the edge of the roof.

When plaster has set, cover it with plastic sheeting. At this point the tank should be strong enough to hold water.

DAY 9:

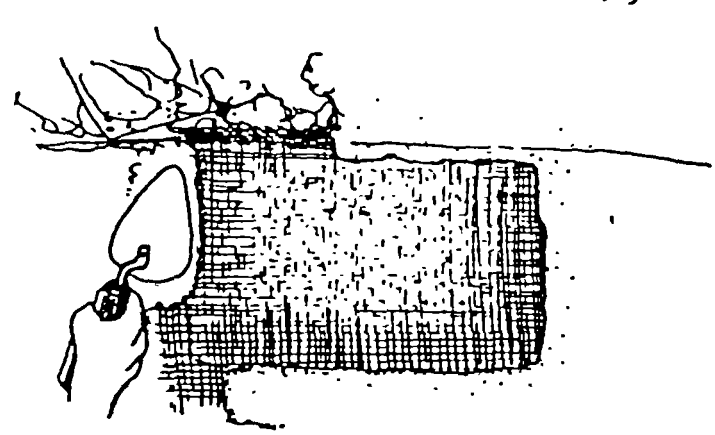
JOBS IN BRIEF:
Remove roof supports and sugar sacks. Throw a light coat of plaster to cover *all* reinforcing wires underneath.



Remove all support poles and the sugar sacks underneath the roof.

Mix a 1:3 plaster and throw it onto the underside of the roof, taking care to cover all wires. When plastering is finished, remove paper from inside pipe.

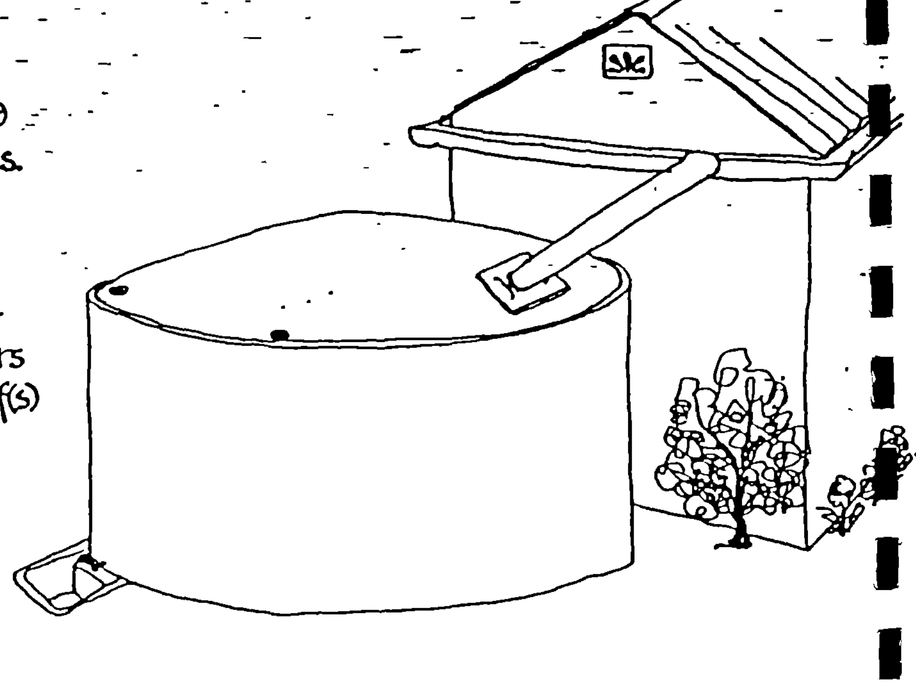
While plastering, cut a 25 cm x 40 cm piece of galvanized gauze wire and place it across the overflow and plaster the edges in place. This will help keep mosquitoes and other things out of the tank.



AFTER CONSTRUCTION:

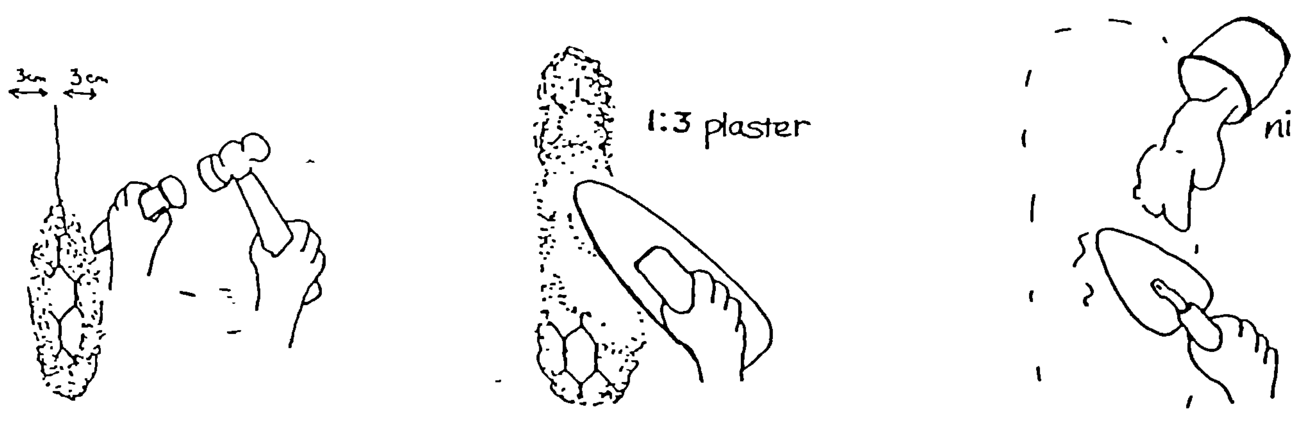
Keep the top and sides covered with plastic sheeting for 2 weeks. Or, fill it with water.

After the tankhole cover has hardened for a week, place it in position. Affix the gutters to bring water from the roof(s) into the tank through the opening in the tankhole cover. Rain hitting the roof of the tank will enter through the holes on the bottom edge of the tank roof.



If your tank is properly constructed and cured, it should last at least 30 years. Maintainance is minimal. Once every year or two, the tank should be drained completely and all accumulated soil removed. To drain the tank, climb inside and remove the short pipe nipple with a pipe spanner. Then, outside, remove the plug from the pipe tee and all the water will drain away. Any soil remaining on the tank floor can be removed with a shovel. This will assure that water taken from the tap is as clean as possible.

If the tank wall cracks and water leaks from it, it can easily be repaired. Using a cold chisel and hammer, cut away the plaster alongside the crack on the inside of the tank. Chisel away 3 cm of plaster on each side, down to the wires. Then mix a 1:3 (cement: sand) plaster and carefully fill in the cutaway section. Finish by troweling on a thick coat of nil (cement and water). Waterproofing cement additives may also be used. *Keep the repair damp as long as possible — at least 3 weeks is recommended.*



1. 2. 3.

Repairing a crack

TIPS ON MAKING STRONG FERROCEMENT*

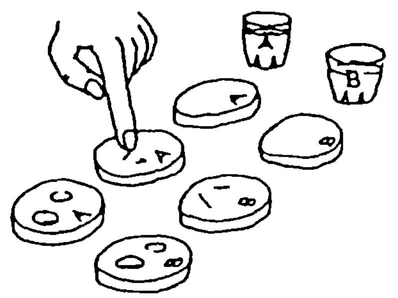
CEMENT:

Cement bonds and hardens in the presence of water. Therefore **careful storage** is critical to avoid moisture reaching cement before use. The bags of cement should be stored in a closely packed pile no more than 10 bags high. (More than 10, and the bottom bags will burst.) The pile should be on a raised platform in a room with little air circulation. In a room with open windows or doors, cover the pile with plastic sheeting.

As bagged cement ages and absorbs water from the air, it becomes lumpy. If lumpy cement is used, its proportion should be increased by half.

WATER:

"Water that is fit for drinking is usually fit for mixing cement." Clay, silt, salt, mica, or organic matter in the water will **weaken** concrete and ferrocement, as will certain invisible chemicals. You can **test** the quality of an unknown water by comparing it water known to be good. Using water of known suitability (such as drinking water), make three cakes of cement paste, each approximately 2 cm thick and 6 cm diameter. At the same time, make three identical cakes using the unknown water. Compare the setting and hardening times of the two types. Mark on your chart that the sample has set when you can no longer make an indentation with your fingertip. Test for hardening by marking whether or not you can scratch the sample with your fingernail.



water quality:		drinking water A	unknown B
setting time:			
hardening time: can you scratch with your fingernail after	1 hour?		
	2 hours?		
	3 hours?		
	4 hours?		
	24 hours?		
	48 hours?		

When mixing plaster or concrete, add only enough water to make the mix workable. It should **not be shiny.** Excess water will weaken the cement. If an extra 10% of water is used, then the strength of the plaster or concrete will be reduced by 15%. If an extra 50% water is used, then the strength is reduced by 50%.

Use as little water as possible mixing, but be generous with water once the plaster has set (≐4 hours) to assure hardening. Once plaster dries, hardening stops. This chart shows the relationship between the amount of time the concrete/plaster is kept wet and the hardness achieved. *To achieve full strength, the plaster/concrete must be kept wet for one full year.*

amount of time kept moist	percent of hardness
3 days	20%
7 days	45%
28 days	60%
3 months	85%
6 months	95%
1 year	100%

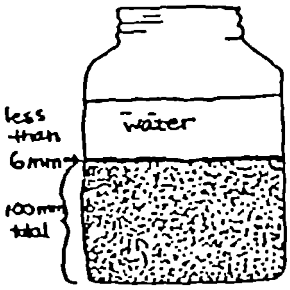
*Compiled from: Handbook of Gravity-Flow Water Systems, T Jordan, UNICEF Nepal, 1980
Reinforced Concrete Designer's Handbook, C Reynolds and J Steedman, Cement & Concrete Assn, UK, 1974
Ferrocement Water Tanks, S Watt, Intermediate Technology Publications, UK, 1978

SAND:

Sand should be **well-graded** (have grains of many sizes) so you may need to mix coarse and fine sand together. Sand must also be **clean**, because like water, it may have some impurities that weaken the cement bond such as clay, silt, mica, and organic matter. Dirty sand can be washed by repeatedly rinsing with water. There are two easy field tests for determining if the sand needs to be washed:

① Rub a moist handful of sand between your palms. Suitable sand will leave hands only slightly dirty.

② Fill a clear glass container halfway with sand. Then fill to 3/4 full with water. Shake the glass vigorously and then allow it to sit, undisturbed, for 1 hour. The sand settles immediately, and any silt and clay settle as a dense layer on top (usually darker than the sand). This layer should not be more than 1/17, or 6%, of the thickness of sand. Start with 100 mm sand for easy measurement.



When measuring sand, note whether the sand is damp or dry. Damp sand that contains 5-6% water may have an increased volume of over 30%. Additional water content reduces the "bulking," and saturated sand occupies nearly the same volume as dry sand. Therefore when using slightly damp sand, add an extra amount. Very damp sand, measure as if it is dry.

MIXING:

Measurement by weight is the most accurate, but measurement by volume is more practical at construction sites and will suffice **if done carefully**. Measuring by shovelfull is **not** accurate. A bucket should be used for measuring portions of sand and cement (and gravel, in concrete) in order to achieve enough accuracy for a strong and (relatively) homogeneous mix.

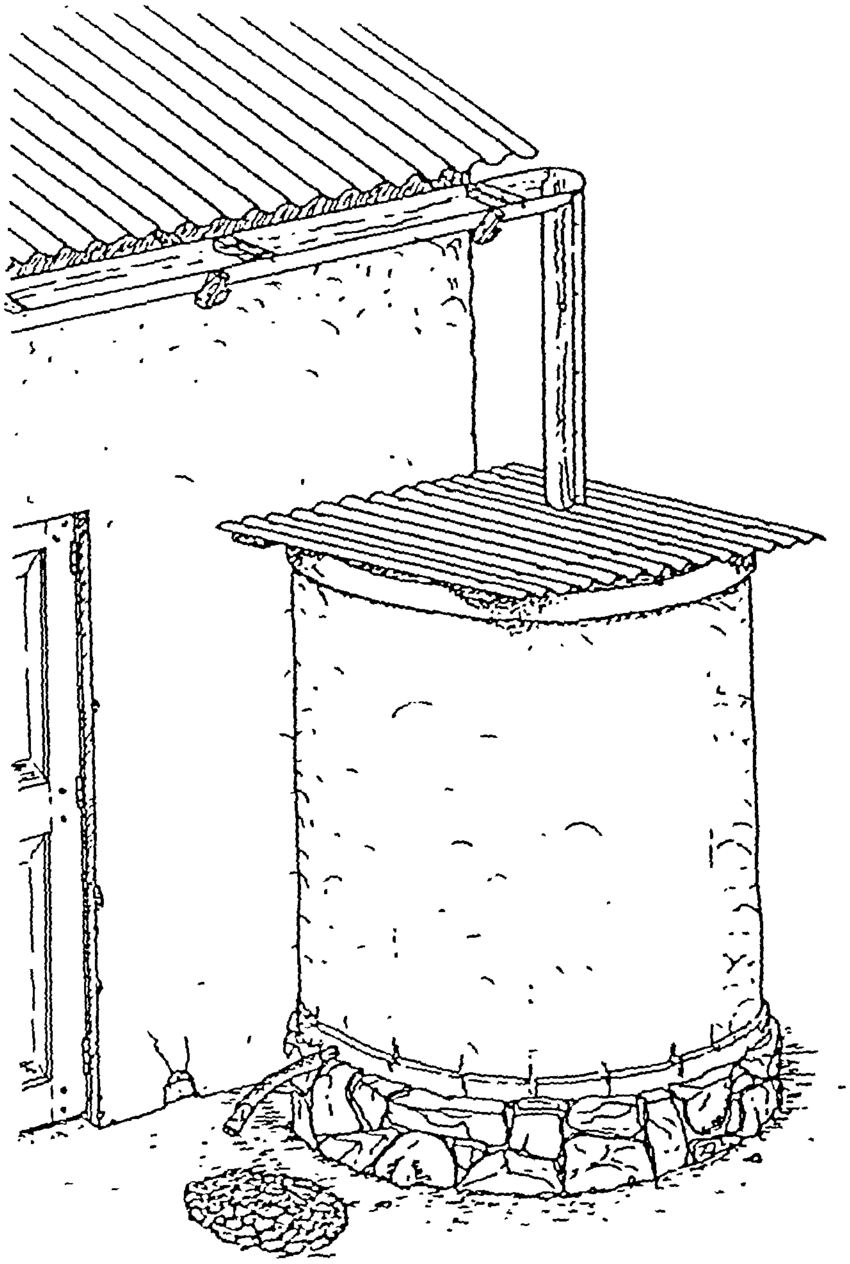
REINFORCEMENT:

The cement bond is easily broken by forces which pull it apart - tensile stresses. Thus it is necessary to use a material like steel inside the concrete or plaster for large water tanks. The weight of the water will stretch the tank walls. Barbed wire or weld mesh are heavy enough steel to withstand the stress and hold the tank together. (Straight wire can be used in place of barbed wire, but the barbs help grab onto the plaster, and the <u>two</u> twisting wires are stronger than a single wire.) The chicken wire helps hold the plaster together <u>between</u> the stronger wire.

Although the soil helps support the weight of the water, even the ground hemispherical tanks will stretch when full. Hard rocky soils provide better support, but loose or sandy soils should have more reinforcement (barbed wire) in the tanks.

Standing water tanks receive the most tensile stress in the bottom 1/3 of the wall and in the joint between the floor and wall. Extra reinforcement wires in the wall and joint, and thickening the plaster at the joint, have proven to prevent cracking at these points of stress.

The Bamboo Reinforced Water Tank



The Bamboo Reinforced Water Tank is an inexpensive family size rain water storage tank for roof catchments. Most materials can be found locally and the tank is easily constructed by a local mason. The bamboo framework can be substituted by any other suitable heavy wicker work and the tank size can be increased up to 4000 litres. A wooden or tin-sheet cover on the top and a simple screen inlet filter protects the tank from dirt, leaves and other potential pollutants.

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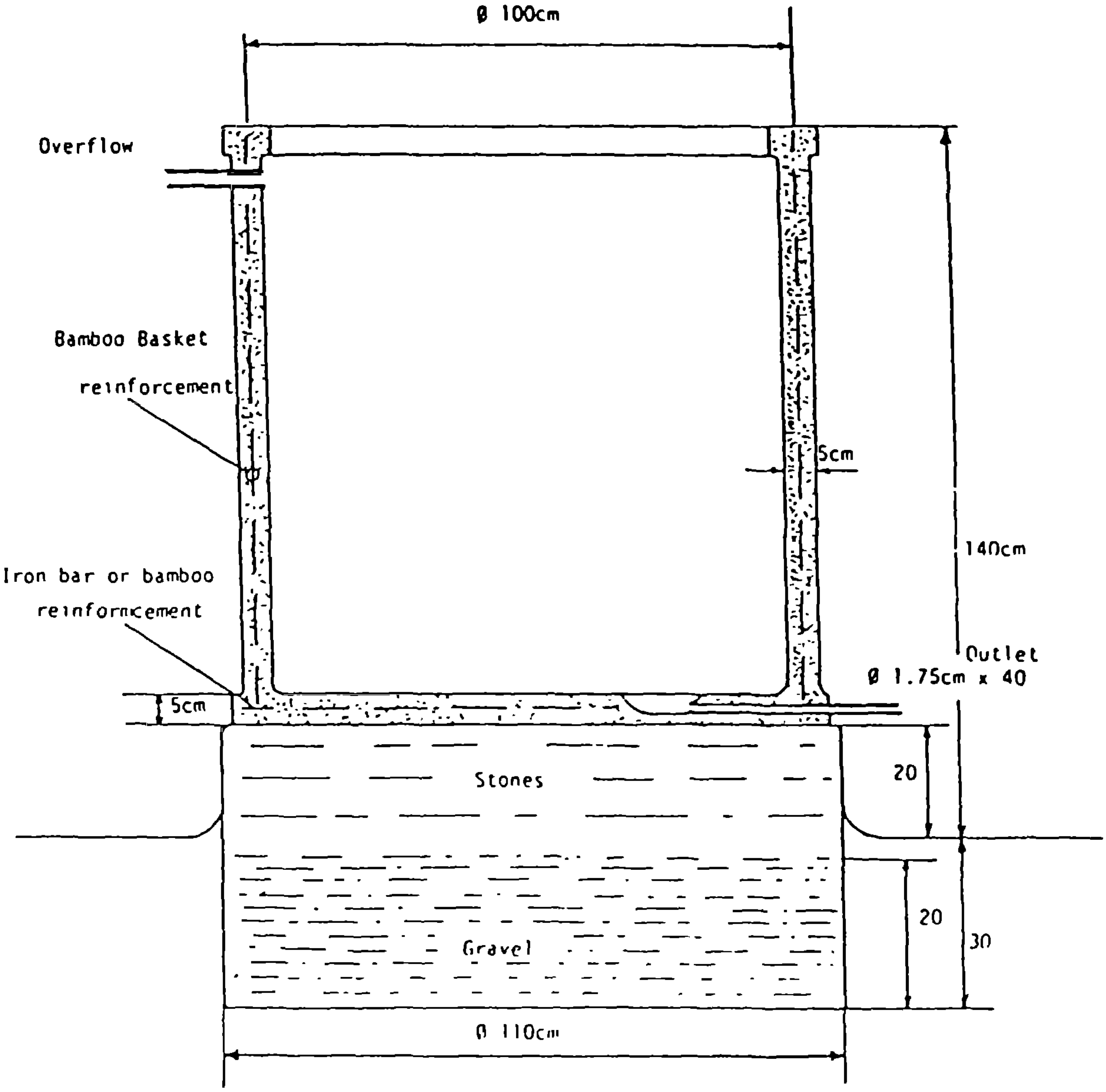


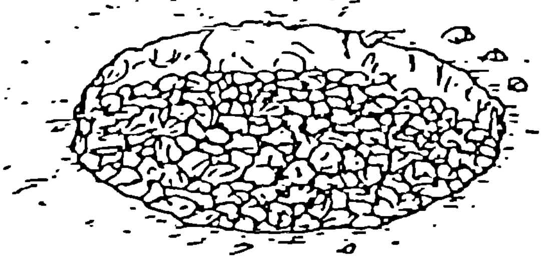
MATERIALS REQUIRED:

1. Two wheelbarrows of 3cm diameter gravel for the base of the foundation.
2 Large stones for the foundation.
3. Six wheelbarrows of sifted sand
4. One wheelbarrow of 1.5 cm diameter gravel.
5. Eight lengths of 6-8mm diameter reinforcing rod (split bamboo may be substituted if reinforcing rod is unavailable).
6. One piece 10 x 20cm of thin sheet-metal.
7. One piece of 1.75cm diameter water pipe 40cm long
8 One piece 2 5cm diameter plastic pipe 20cm long.
9. One loosely woven rigid bamboo cylinder 100cm diameter and 120cm high.
10 One baseplate ring 110cm diameter 5cm high (an octagonal wooden form may be used if metal is unavailable)
11. Tin sheet or wood planks for the tank cover.

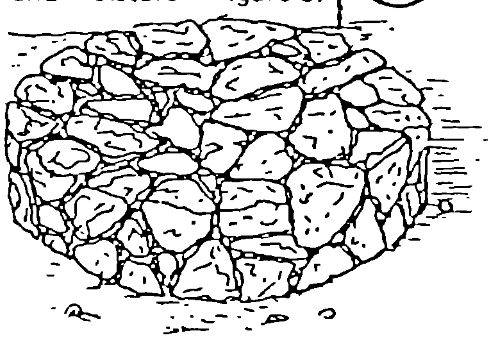
CONSTRUCTION: Site the tank at the corner of a metal or tile roofed building.

(1) Dig a circular hole 30cm deep with a diameter of 110cm figure 1

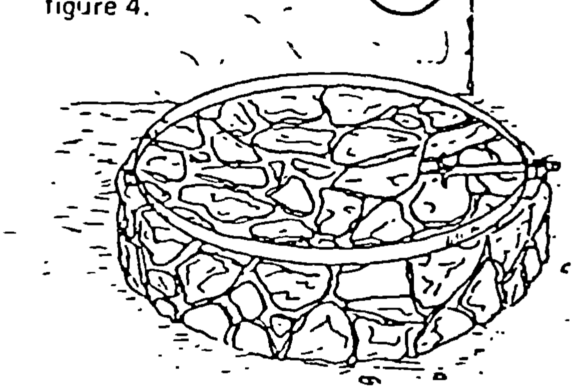
Fill the hole with 20cm of large diameter gravel and pack with a pole – figure 2. (2)

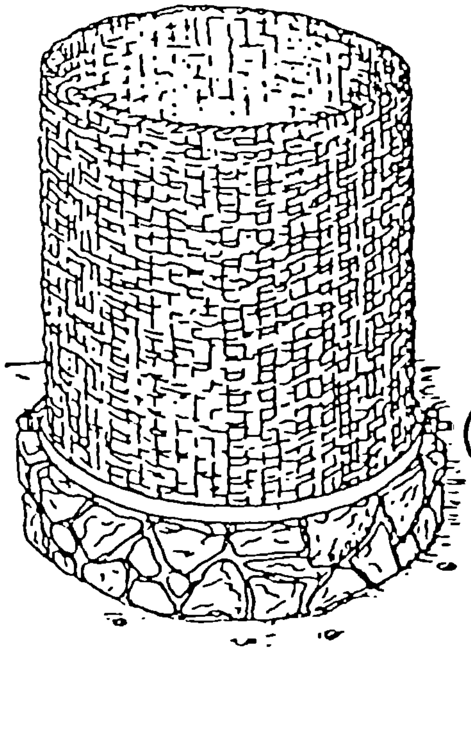


Construct a foundation of large stones mortared with a clay soil or cement to 20cm above the ground level. If a clay soil mortar is used, it will be necessary to point the seams with a cement/sand (1:3) mixture to protect against rain and moisture -- figure 3. (3)



Place the metal baseplate ring on the foundation and fix the outlet pipe as in the diagram – figure 4. Plug the inside end of the outlet pipe and cast 2.5cm, or half the thickness of the plate, with concrete (1:3:4 – cement, sand, gravel). Cut 8 pieces of reinforcing rod, hook the ends, and lay them on the concrete in a cross pattern – figure 4. (4)

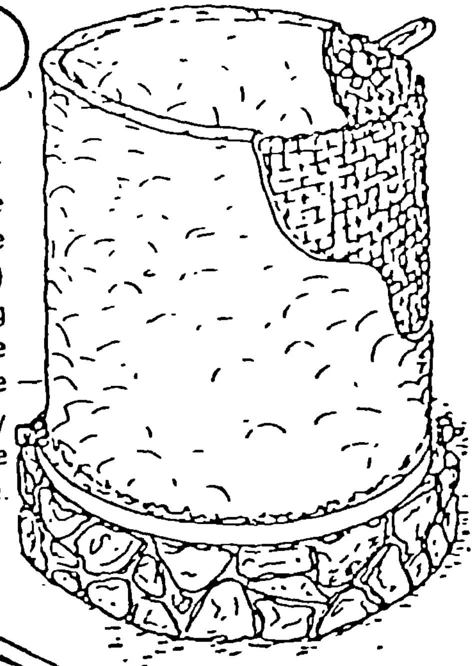


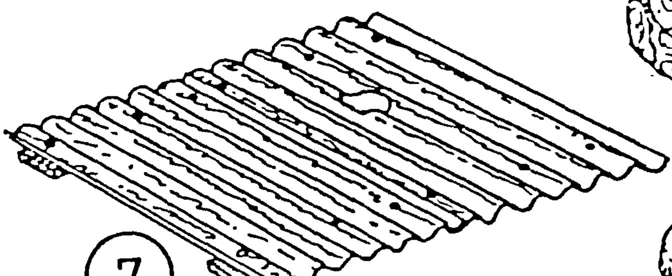


(5) Set the bamboo basket on the wet base plate and complete casting the concrete ensuring that the base of basket work is well bonded into the concrete – figure 5. It may be necessary to build a pole tripod over the tank to allow the mason to exit without touching the walls.

6

Cut a 10 x 20cm rectangle out of thin metal sheet and roll it into a tube for the overflow Cut six tabs 5cm long in one end of the tube and fold them back at a right angle. Cut a hole of the same diameter as the tube near the top of the basket and fit the tube attaching the tabs to the basket with wire or string Plaster a 1cm layer of cement (1:3) on the inside and outside of the basket working upwards from the base. Bond the base with the sides by building up a rounded curve on the inside edge. Allow the cement to set and apply a second layer of cement 1cm thick in the same way. Form 1cm thick collar along the top edge.





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Construct a tank lid from a corrugated metal sheet or wooden planks. Cut an inlet hole in the lid and fit the gutter pipe into it.

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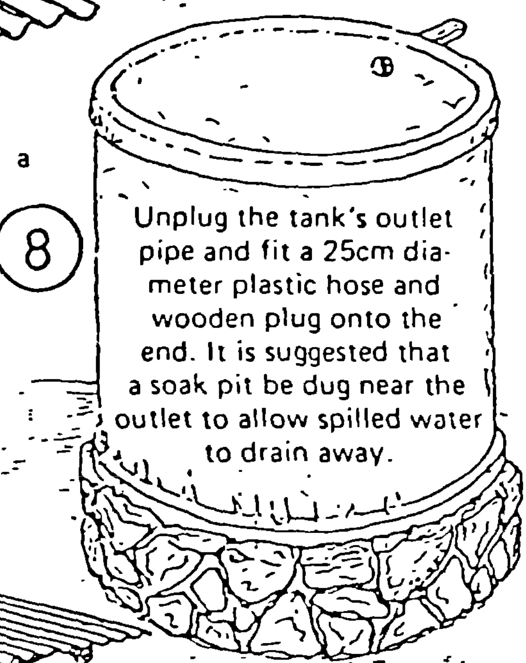
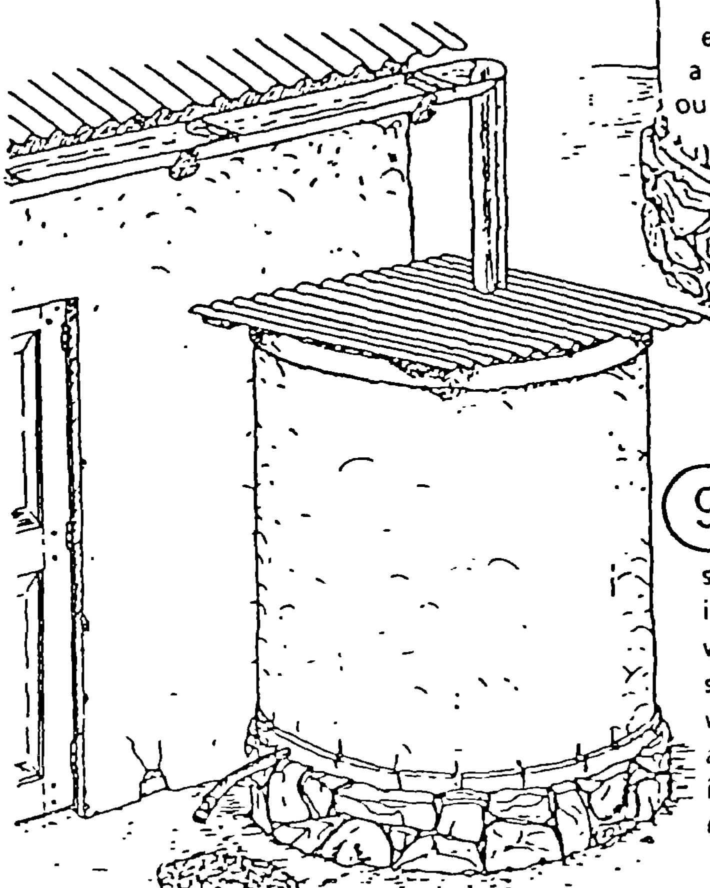


Unplug the tank's outlet pipe and fit a 25cm diameter plastic hose and wooden plug onto the end. It is suggested that a soak pit be dug near the outlet to allow spilled water to drain away.



IMPORTANT:

9

It is necessary to cure the tank for seven days to ensure maximum strength. This is done by laying wet sacking or grass on the walls as soon as the cement sets The tank can be filled with 30cm of water the day after construction. The sacking or grass should be kept moist and the tank protected from the sun for the entire seven day period

 1

GROUND CATCHMENT FERROCEMENT WATER TANK CONSTRUCTION MANUAL

This manual is intended to be used as a guide for artisan who have completed or are taking a training course. This technology has been in use in Kenya for 5 years. The version presented here shows the simplest silt trap. A section entitled "Tips on Making Strong Ferrocement" is included, as well as a quality control checklist and repair instructions. UNICEF welcomes comments and any information relelvant to this manual.

TANK CAPACITY: 52,000 liters or 11,400 gallons or 260 oil barrels

MATERIALS REQUIRED:	× Unit Price	= COST
35 bags of cement	______	______
2 rolls of barbed wire, 16 gauge, 25 kg each	______	______
3 rolls of chicken wire, 1 inch mesh, 3ft x 100ft	______	______
3 rolls of plastic sheeting, 35 m^2 each	______	______
15 drums of water (3000 liters)	______	______
5 tonnes of coarse sand	______	______
5 kg of 2½ inch nails	______	______
4 kg of 2 inch U-nails	______	______
100 large bricks	______	______
80-100 sisal poles, 3.5 → 4 meters long	______	______
wire, rope, and/or vines (to tie the roof)	______	______

Total Cost of Materials: ______

Cost of Transport: ______

LABOUR REQUIRED:

Excavation: 3 casual labourers, 15 days' work (varies according to soil type) . . . . ______

Construction: 3 skilled artisans, 9 days' work . . . . ______

4 casual labourers 9 days' work . . . . ______

Total Cost of Labour: ______

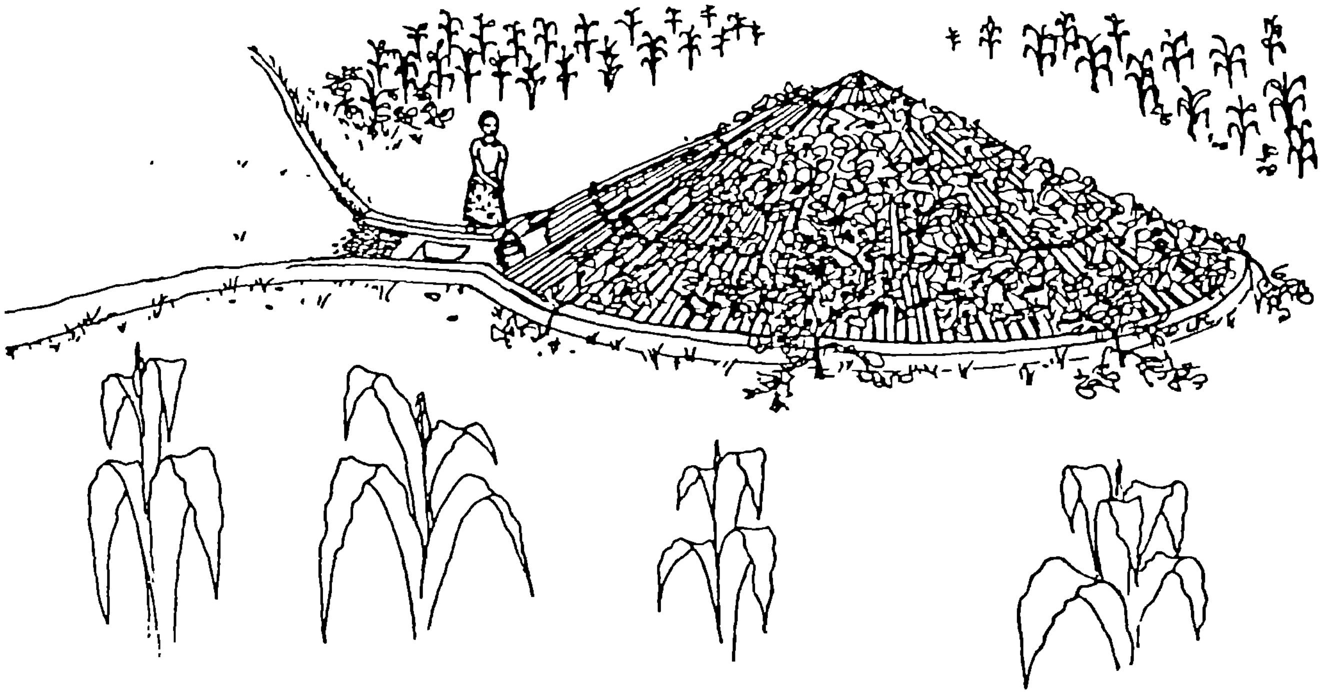
TOOLS REQUIRED:

Shovels, buckets, karais, cement floats, steel trowels, hammers, pliers or wire cutters, mattocks, ladder, spirit level.

(to cover tool depreciation and job security) Overhead: (30% of labour cost) ______

TOTAL PRICE: ______

GROUND CATCHMENT FERROCEMENT WATER TANK



This ground catchment water tank collects and holds 52,000 liters of rainwater runoff from the slope or road uphill. This catchment system is especially good for semi-arid areas with infrequent rains, as it often fills with only one rainstorm.

The catchment tank holds enough water for a family of 6 for a full year, allowing 25 liters per person per day. Or, it can irrigate 1/10 of an acre for a full year, or provide water for about 7 head of cattle. The tank provides a large amount of water at less than half the cost of other methods, and should last 20-30 years.

The tank is made by digging a hemisphere into the ground, 6 meters across and 3 meters deep. Layers of cement plaster are reinforced with barbed wire and chicken wire. The tank is roofed and shaded to reduce evaporation. Water is directed into the tank by means of two wide-angled soil wall "gutters." It runs through a simple silt trap which minimises the soil carried into the tank. Water can be drawn using a bucket on a rope or a simple handpump, or it can be gravity fed to an area downhill. The water is suitable for livestock and irrigation as is. If it is boiled, it can be used for human consumption.

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SITING:

The tank should be situated in the lowest part of the best catchment area: below a slope of rock or soil with vegetation is best. It should not be in a basin or a river bed. No trees should be growing near the tank, to avoid damage by roots. If the water will be used for irrigation, it is convenient for the tank to be situated above the garden to gravity-feed the water to crops without a pump.

Soil with a fair amount of clay in it is best. Rock is hard to dig out, but provides the strongest foundation. Soft sandy soil should be avoided if possible, otherwise use extra barbed wire reinforcement or BRC wire mesh. Lining the tank with mortared bricks *before* constructing the ferrocement will also strengthen it. Enlarging the concrete-filled reinforced trench around the perimeter of the tank will also provide extra protection from moving soil.

SEASONAL CONCERNS:

You will encounter different difficulties during the rainy season than during the dry season. Anticipate these.

The biggest problem in the **dry season** is having adequate water to keep the plaster wet, and protecting the plaster from the hot sun. Cement cures (hardens) in the presence of water, and if it dries prematurely, then the plaster never gets very strong and is likely to crack. (See "Tips on Making Strong Ferrocement.") Therefore in the dry season it is essential to have **extra water** at the construction site, and enough plastic sheeting to cover the entire surface of the tank. **Splash** water on the set plaster at least three or four times a day for **one month** - don't let it dry to a light grey color.

During the **rainy season**, you may have problems with seepage through the soil. If the dug hole is full or partially full due to a raised water table, then it is advisable to wait until the rains have stopped and the water table dropped to construct the ferrocement lining.

Also during the rainy season, it is advisable to use the excavated soil to **divert runoff** from the slope above from entering the tank before construction is complete. During excavation, the soil can be dumped in a wall formation around the tank with entrances on the downhill side. Any water or mud that does enter will need to be removed every day. Clay in the water will prevent the cement from bonding - likewise, if mud has coated one layer of plaster, then the next layer cannot bond to it.

Be extra cautious of soil caving in during the rainy season.

While the rainy season is of great benefit in keeping the ferrocement moist, care must be taken to protect fresh layers of plaster from **direct rainfall**. The fresh plaster should be covered with plastic sheeting if it is less than four hours old in the event of rain - otherwise it will wash away.

Extra **care** should be taken in **storing** bags of **cement** during the rainy season. The pile of bags should be on a platform in a well-sealed building, and covered with a tarp or plastic sheeting.

MAINTAINANCE REQUIREMENTS:

The silt traps should be **cleaned** before each rainy season, and periodically during the rains if the trap seems to collect alot of silt.

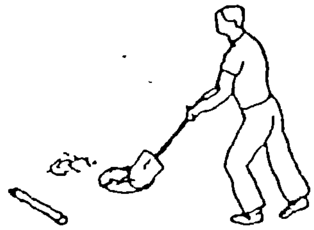
The roof should be repaired as needed. A good plant cover should be maintained to minimise evaporation, so keep the loofa or passion fruit watered. Up to 2 meters depth of water can evaporate in a year!

Each rainy season **inspect the soil wall "gutters" and rebuild them where needed**. Lengthen them if the tank fails to fill completely. Once the tank has filled, open the soil gutters and divert the water to keep extra silt from entering the tank. Close them to redirect water into the tank when the water level starts to go down. After any big rainstorm, inspect the gutters for places requiring repair.

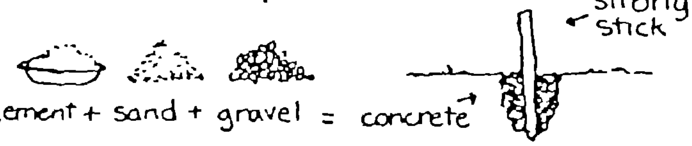
Keep grass **growing** on the catchment area to assure that the cleanest possible water flows into the tank.

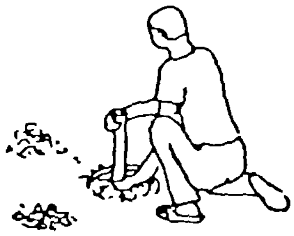
EXCAVATION

In the center of the chosen site, dig a hole 40cm deep.

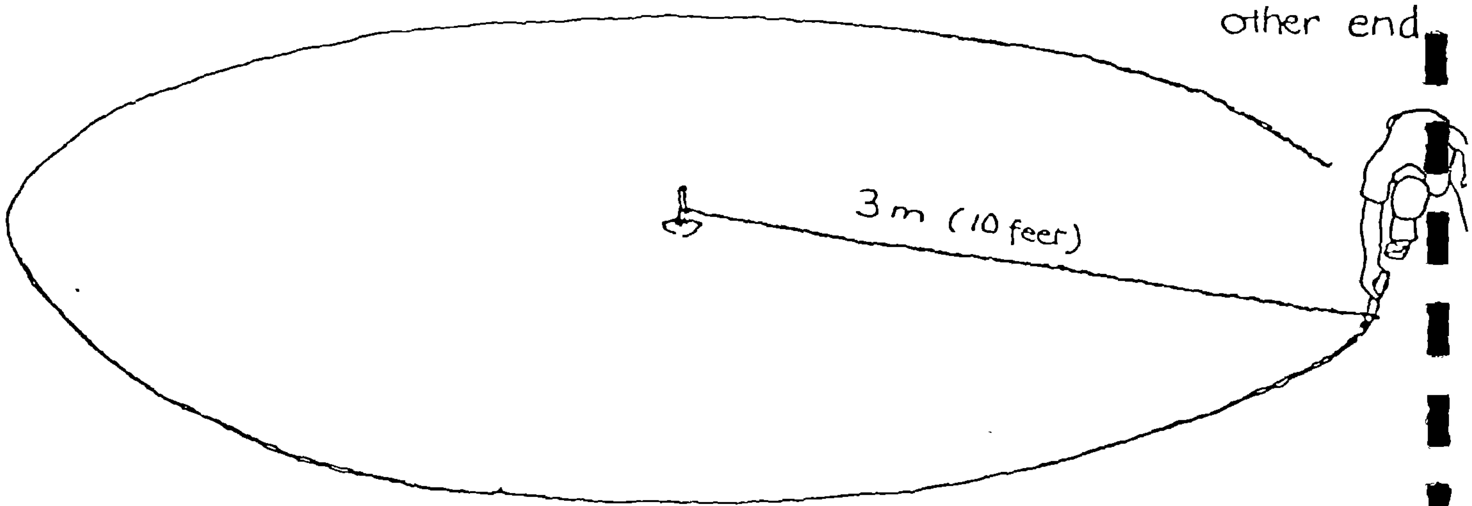


Put a strong pole, 80cm high, in the hole. Mix some concrete to put in the base to hold the pole in place.



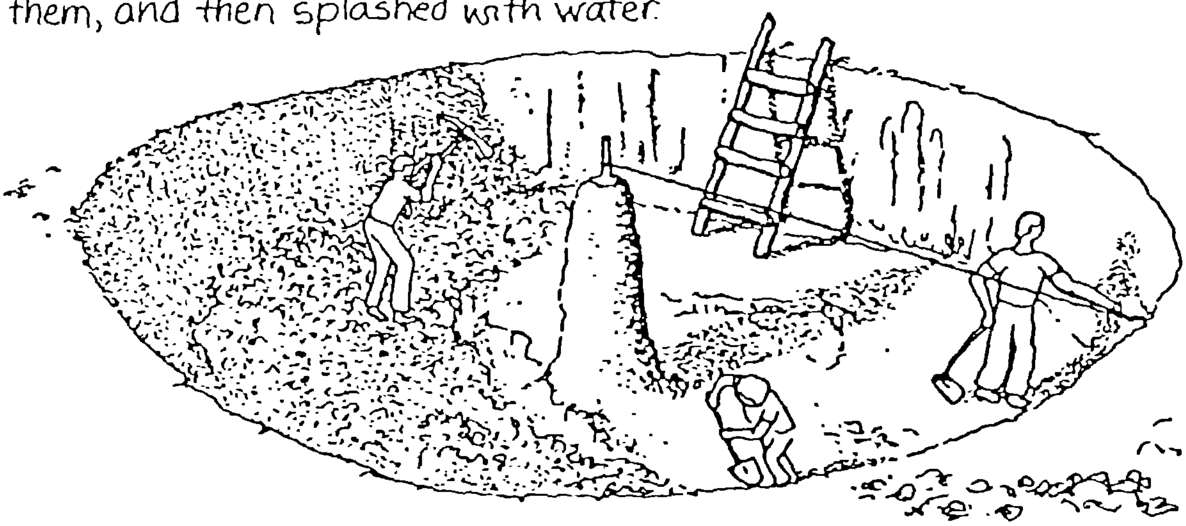


Tie a string 3 meters (10 feet) long onto the pole and tie another stick to the other end.

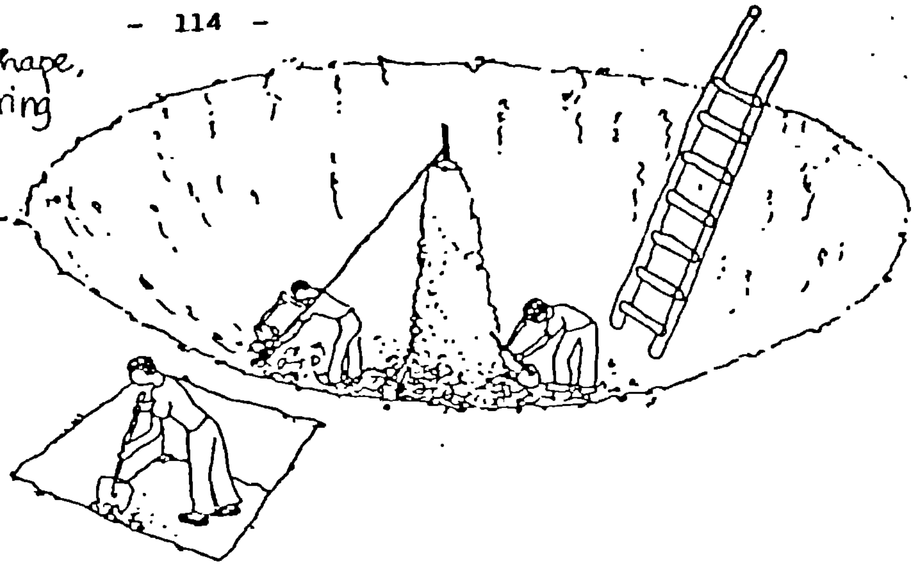


Then, pulling the string taught, mark the circle in the soil.

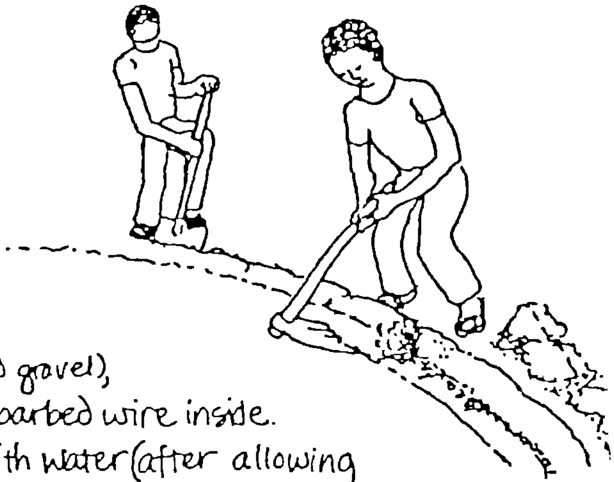
Next, dig within the circle, removing a 2-foot layer of soil at a time. Leave the soil under the center post and use the string to measure the radius. A layer of rock is usually easier to remove if firewood is burned on them, and then splashed with water.

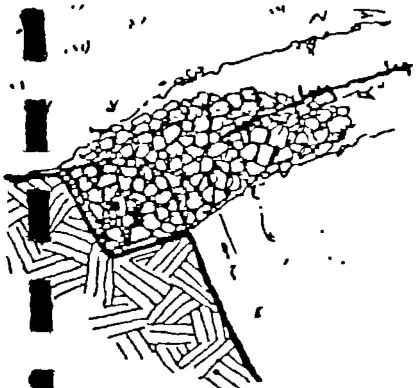


Excavate a hemisphere, a bowl shape, of a 3 meter radius. Use the string until the shape is attained. Then, remove the center pole and the remaining soil. On the uphill side of the tank at the place where water will enter the tank, dig a h le approximately 1m x 1m x 1m. This will be a silt trap to allow soil carried by the water to settle before the water enters the tank.



At the same time, if soil is firm enough, dig a trench wide and 10 cm deep around the perimeter of the tank. Make the trench deeper toward the outside. (If soil is not firm enough to hold this shape, then make the trench <u>after</u> plastering.)





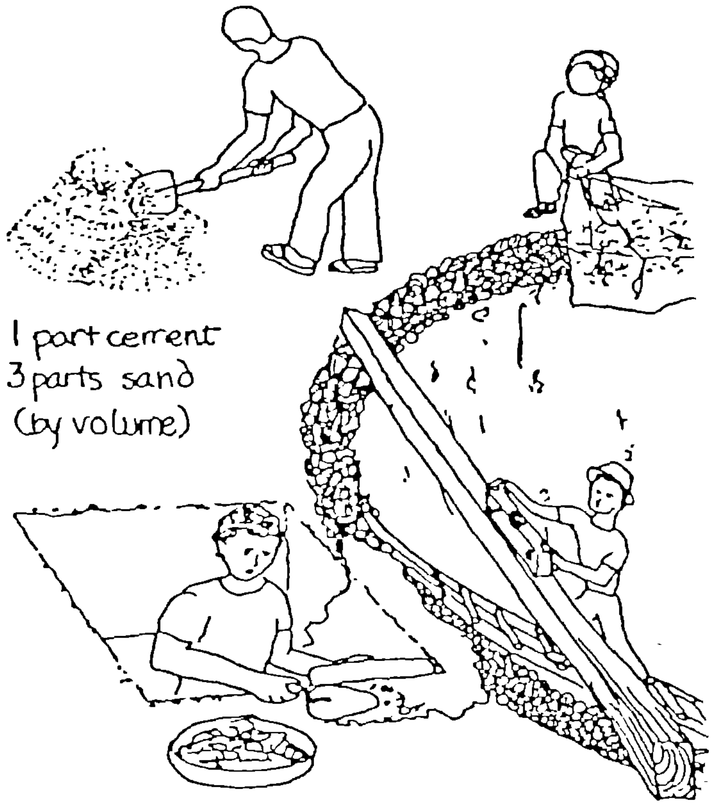
Fill the trench with 1 : 2 : 4 concrete (cement sand gravel), reinforcing it with a strand of barbed wire inside. Keep it damp by splashing with water (after allowing 4 hours setting time) and then covering it with plastic sheeting. *Check that the surface is level all around the tank. Add more concrete, or stones and mortar, where needed.*

PLASTERING

The tank and silt trap are plastered with a 1.3 cement: sand mixture. Plaster the silt trap first and, after 4 hours, fill it with clean water. This can be stored for convenience during construction.

The strength of the tank depends largely on:
- *careful and thorough mixing of plaster;*
- *using only enough water to make plaster workable;*
- *curing the plaster by keeping it damp for 4 weeks.*

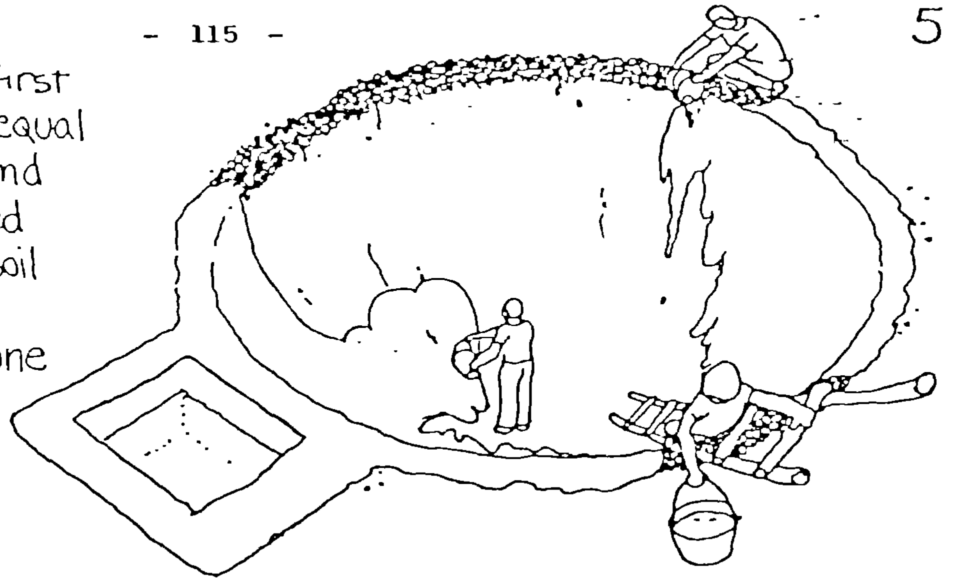
Read the section entitled "Tips on Making Strong Ferrocement" at this time.



The tank is coated first with "nil," a mixture of equal amounts of cement and water It can be poured or brushed onto the soil

This step must be done all in one day Keep the nil moist.

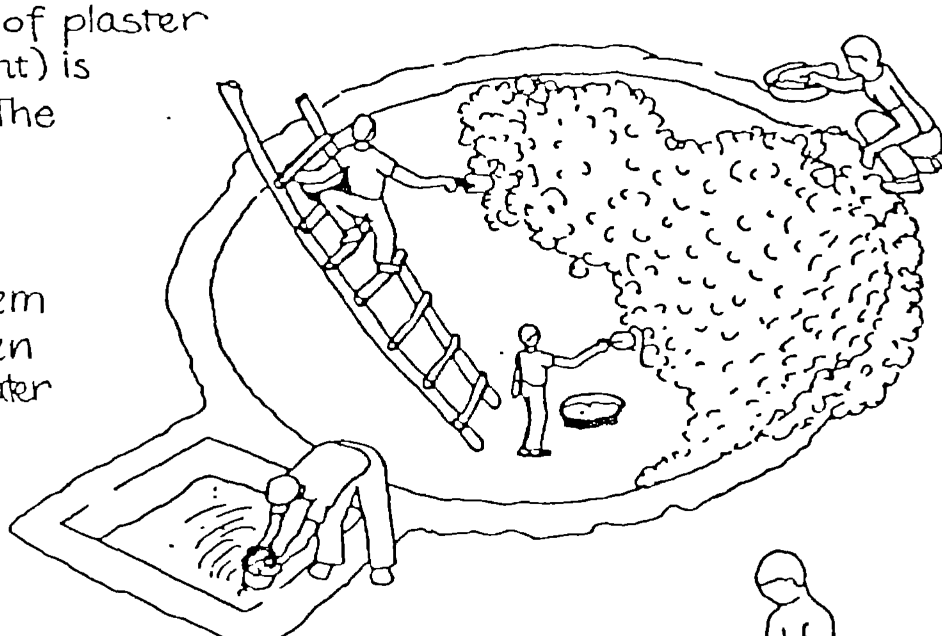
(If cement is very expensive, then the mixture can have more water to make it thinner.)



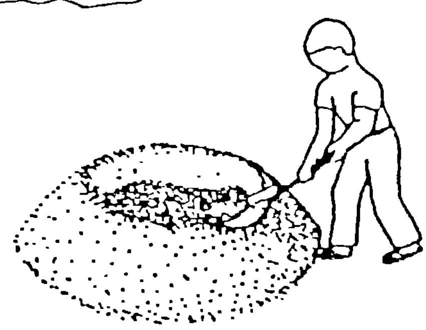
Clean water is stored here for use in constructing the tank.

1 part cement, 1 part water

Next day, a 2-3 cm layer of plaster (3 parts sand, 1 part cement) is thrown onto the tank. The surface is left rough.



Measure the sand and cement carefully. Mix them dry until the color is even throughout Then add water carefully. The plaster should be fairly stiff. If it is too wet, the tank may crack later on.



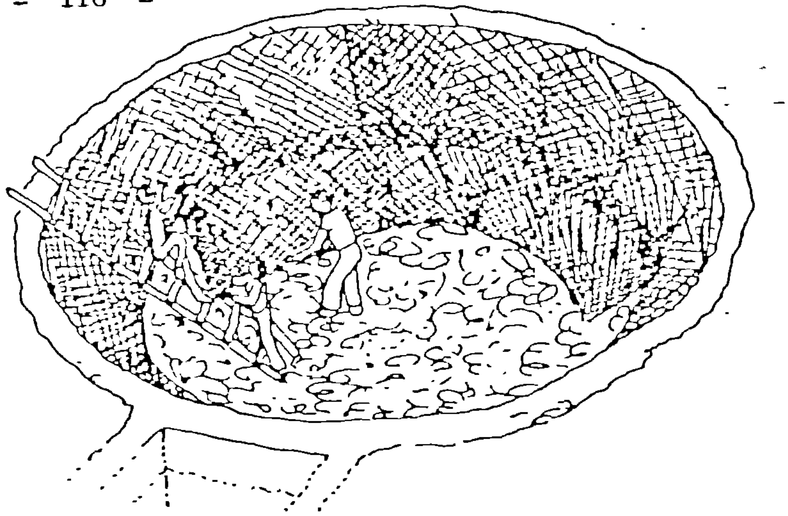
3 parts sand
1 part cement

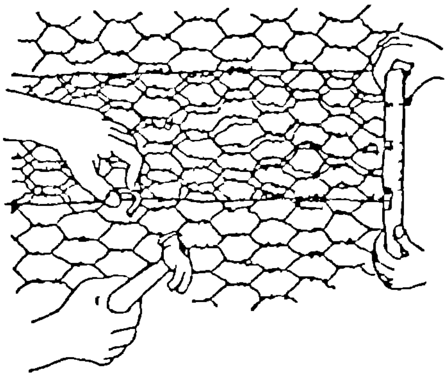
This layer must be done all in one day, and kept moist. Do not let it dry to a light grey color . Four hours after plastering, splash water on it, and cover with plastic sheeting.

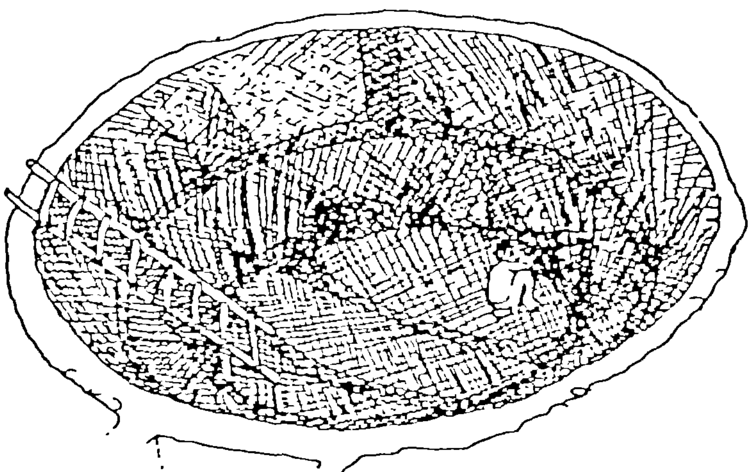
Using more cement in the plaster will not make it stronger.

6

The next day the plaster is strong enough to hold nails. Starting at the top, unroll chicken wire around the tank and nail only the top edge, using either U-nails or straight nails. Then carefully pull and fold the bottom edge of the chicken wire to conform to the bowl shape and nail it in place. Do a second row, overlapping the chicken wire by at least 15 cm.

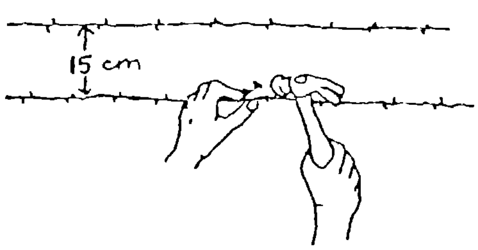


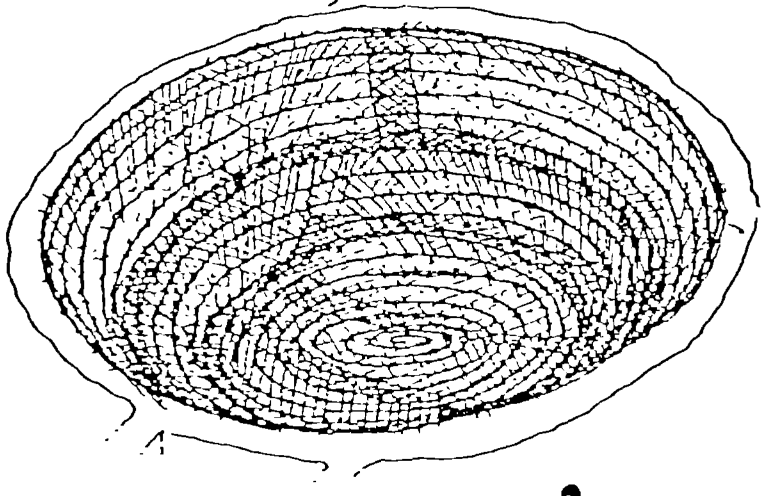




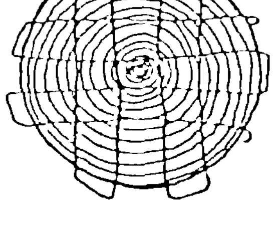
Cover the bottom with large patches of chicken wire. Always overlap by 15 cm or more for good reinforcement.

Then, starting at the top, roll out barbed wire and nail down 2 rounds at the top. Continue in a descending spiral at intervals of 15 cm.



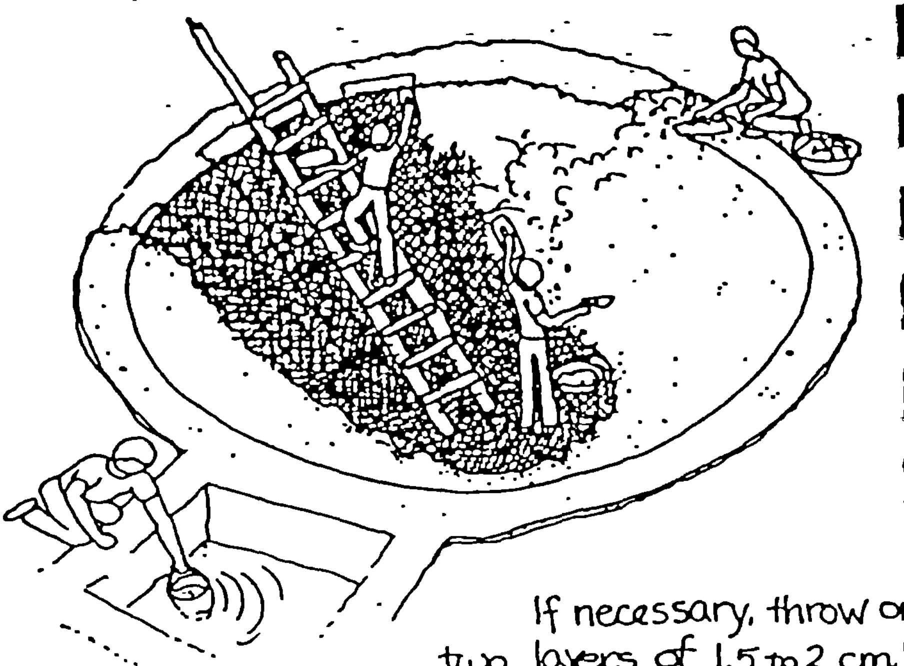


Then nail down barbed wire in a pattern that will take up vertical stresses. This makes the tank much stronger



top view of barbed wire

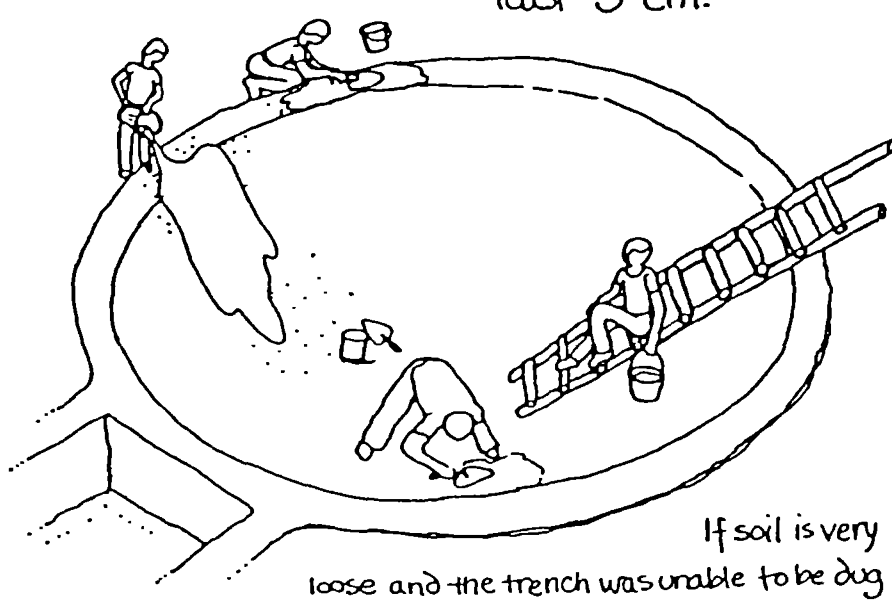
The second coat of plaster is 3cm thick. This layer is thrown on and troweled smooth. This step must be done all in one day.



Keep the plaster damp! Cover with plastic sheeting!

If necessary, throw on two layers of 1.5 to 2 cm to make a final coat of at least 3 cm.

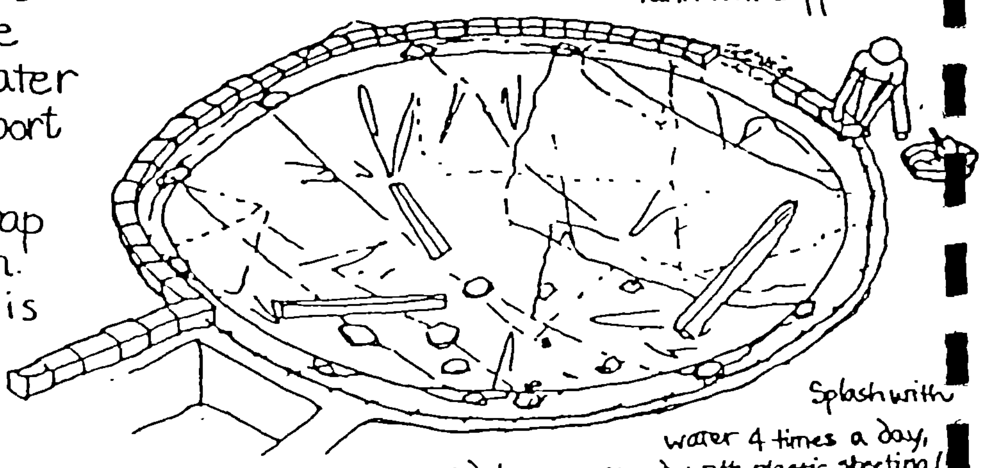
A final coat of nil (1 part cement, 1 part water) is poured on and pressed onto the surface with a steel trowel. The layer of nil should be 1mm thick.



Keep the tank damp by splashing with water and covering with plastic sheeting

If soil is very loose and the trench was unable to be dug before plastering, then do it now. Fill with 1 2 4 concrete and barbed wire. The wall of the tank will support it.

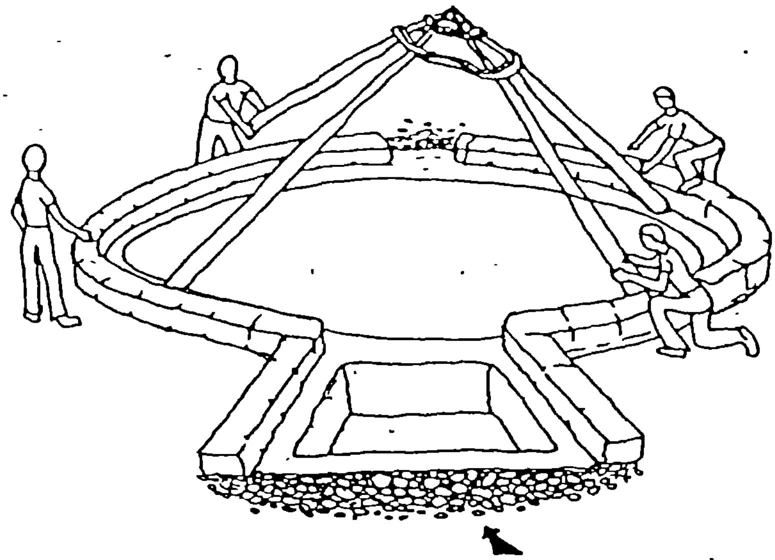
Reinforced with a ring of barbed wire, one or two courses of bricks are laid around the edge to prevent unfiltered water from entering and to support poles for the roof. The span between the silt trap and the tank is left open. Directly opposite, a gap is left in the bricks to direct overflow water out the back.

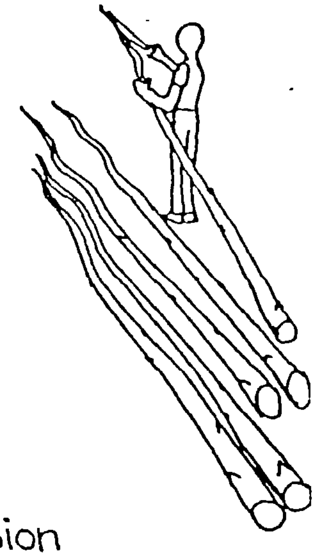


Splash with water 4 times a day, and keep covered with plastic sheeting!

THE ROOF

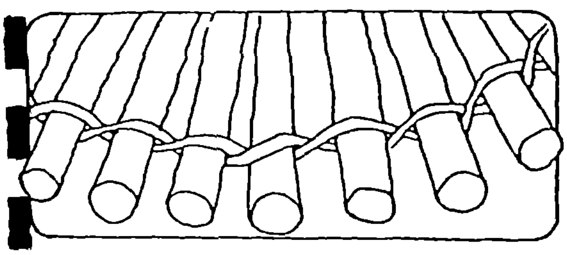
The roof is begun by tying 4 sisal poles together at the small ends. Four men then lift them in place. They rest on the rim of the tank against the mortared bricks.

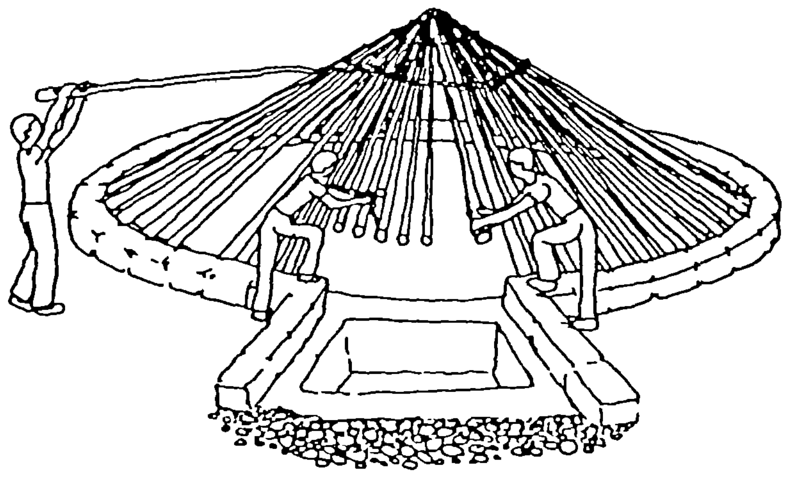




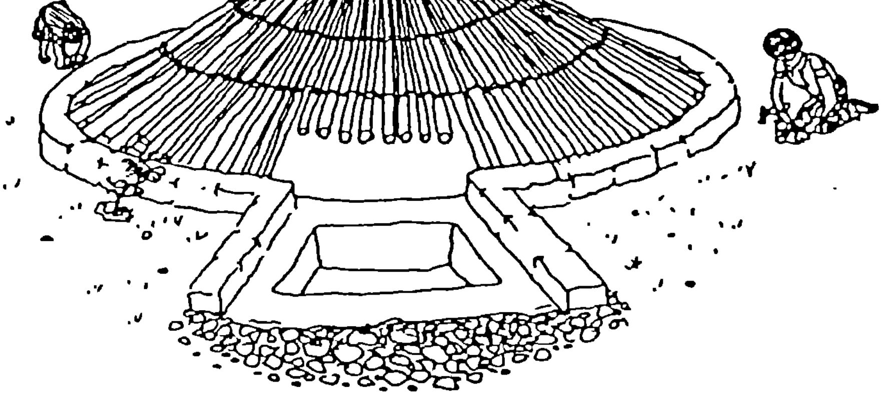
Place stones here to retard erosion

Add another 80-100 poles to form the roof. Strong vines or wires can be used to join the poles using a traditional basket weaving technique.





The roof is essential for shading the tank. In semi-arid areas, 2 meters depth can evaporate in a year's time. Green creeping plants, such as loofah or passion fruit, can be planted to grow up the poles. Their shade will reduce loss by evaporation.

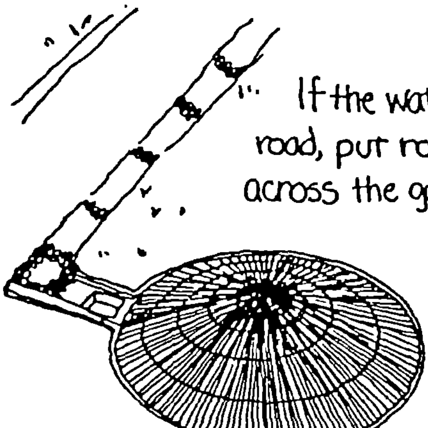


The roof also helps to prevent animals or children from falling in. For maximum safety, fence the tank.

SILT TRAPS AND CATCHMENT SYSTEMS

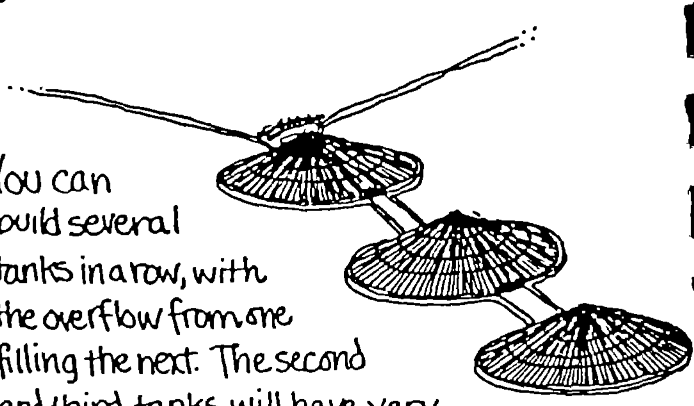
The purpose of a silt trap is to remove silt that is carried by water entering the ground catchment tank. Silt can take up a significant volume in the tank, reducing the amount of water it holds. In addition, bacteria tend to cling to soil particles.

Simply by slowing down the water, silt will drop. The silt trap must be easy to clean. The simplest effective silt trap is the one shown throughout the manual: a settling pond, about 1 cubic meter, excavated and plastered. More complicated setups can be built, but by far the most effective way to keep the water as clean as possible is to take care of the catchment area. Dirt that enters the ground tank is the product of soil erosion.



If the water is runoff from a road, put rows off stones across the gutters to slow the erosion during rains. Turn a corner to slow the water down.

You can build several tanks in a row, with the overflow from one filling the next. The second and third tanks will have very clean water.



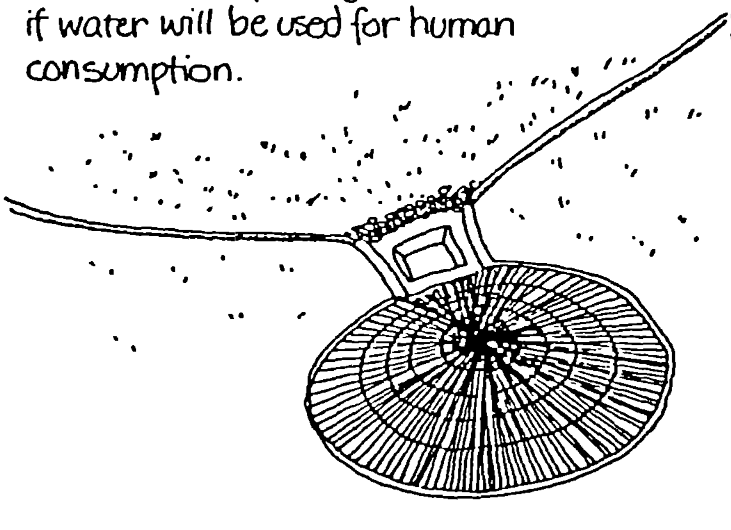
For catching runoff from a slope other than a road, make fairly wide soil gutters to direct water into the tank. Use the excavated soil, making short "walls" up to 100 meters in length.

Their angle depends on slope. If the hill is rocky, then the "gutters" should rise 1.5 cm per meter of length. If the hill is soil, the slope should be steeper: about 2 to 3 cm per meter of length.

Repair the gutters as needed. If too much water comes in at once, shorten them. If the tank fails to fill with water, lengthen them. Once the tank has filled, temporarily divert the runoff.

Runoff from stone will be cleaner than soil runoff. Flat stones can be mortared vertically to create durable masonry gutters.

On soil catchment areas, plant grass! Fence it to keep out grazing animals if water will be used for human consumption.



QUALITY CONTROL CHECKLIST

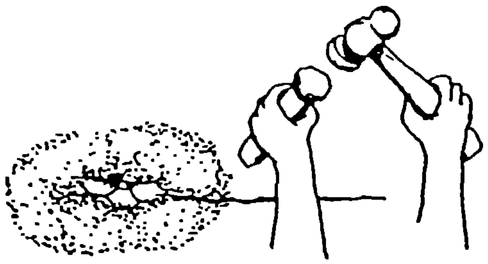
These questions must all be answered "yes." Each points to a particular cause and prevention of cracking

- [ ] Was the tank carefully sited in firm, stable soil?
- [ ] Was the cement stored on a platform, covered, in a shed, protected from moisture?
- [ ] Were there no lumps in any of the cement when the bags were opened?
- [ ] Was the sand used in the cement plaster clean?
- [ ] Were the cement and sand mixed thoroughly, until the mixture was all one color, before adding water?
- [ ] Was the water used in the cement plaster clean?
- [ ] Was the plaster fairly dry, with just enough water added to make it stick together?
- [ ] Was there no more plaster mixed than could be used within one hour?
- [ ] Did the chicken wire overlap by at least 15 cm?
- [ ] Were the intervals in the barbed wire spiral 15 cm?
- [ ] Was the final coat of plaster trowelled on smooth?
- [ ] Was the final coat of nil pressed on firmly with steel?
- [ ] Is there no metal reinforcement, such as barbs, protruding from the finished plaster?
- [ ] Are there no cracks in the nil layer larger than 5 cm after one week of curing?
- [ ] Was the tank splashed with water 4 hours after each coat of plaster or nil, and covered with plastic sheeting, and kept moist, never allowing the cement to dry to a light grey color until curing for at least 4 weeks?

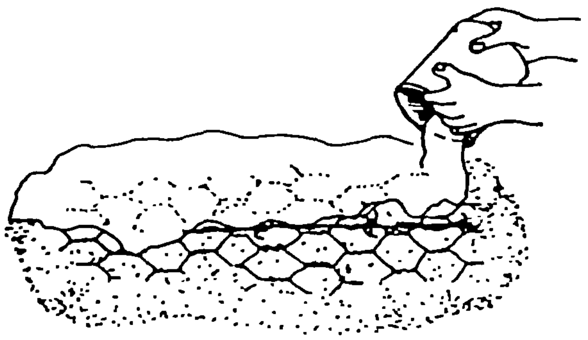
REPAIR

- Structural cracks, when they occur, usually appear the first time the tank is full of water. They are the responsibility of the artisans to repair because they are, in most cases, due to poor craftsmanship rather than a fault in the materials.

However, enough water must be at the site to splash on the tank three times every day. Artisans cannot guarantee full strength of the tank without being able to cure it properly.

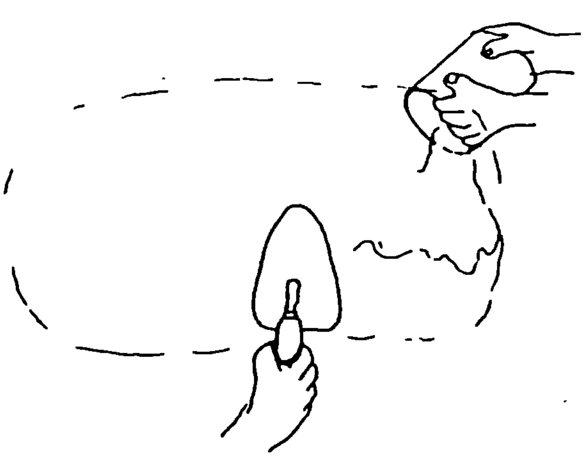


1. Chisel away all plaster within 15 cm of the crack.



2. Coat the area with nil (1 part cement : 1 part water).

3. Fill the area with plaster (1 part cement: 3 parts sand). The plaster should be well-mixed and only have enough water added to be able to work it. It should not be shiny.



4. Coat the area with nil and press it on with a steel trowel.

   Keep it damp for three weeks - even as long as a year for full strength.

If the crack reappears, or water still leaks out, a new ferrocement tank must be built inside the old one.

TIPS ON MAKING STRONG FERROCEMENT*

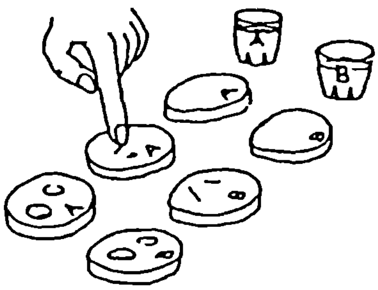
CEMENT:

Cement bonds and hardens in the presence of water. Therefore careful storage is critical to avoid moisture reaching cement before use. The bags of cement should be stored in a closely packed pile no more than 10 bags high. (More than 10, and the bottom bags will burst.) The pile should be on a raised platform in a room with little air circulation. In a room with open windows or doors, cover the pile with plastic sheeting.

As bagged cement ages and absorbs water from the air, it becomes lumpy. If lumpy cement is used, its proportion should be increased by half.

WATER:

"Water that is fit for drinking is usually fit for mixing cement." Clay, silt, salt, mica, or organic matter in the water will weaken concrete and ferrocement, as will certain invisible chemicals. You can test the quality of an unknown water by comparing it water known to be good. Using water of known suitability (such as drinking water), make three cakes of cement paste, each approximately 2 cm thick and 6 cm diameter. At the same time, make three identical cakes using the unknown water. Compare the setting and hardening times of the two types. Mark on your chart that the sample has set when you can no longer make an indentation with your fingertip. Test for hardening by marking whether or not you can scratch the sample with your fingernail.



water quality:		drinking water A	unknown B
Setting time:			
hardening time: can you scratch it with your fingernail after	1 hour?		
	2 hours?		
	3 hours?		
	4 hours?		
	24 hours?		
	48 hours?		

When mixing plaster or concrete, add only enough water to make the mix workable. It should not be shiny. Excess water will weaken the cement. If an extra 10% of water is used, then the strength of the plaster or concrete will be reduced by 15%. If an extra 50% water is used, then the strength is reduced by 50%.

Use as little water as possible mixing, but be generous with water once the plaster has set (≐4 hours) to assure hardening. Once plaster dries, hardening stops. This chart shows the relationship between the amount of time the concrete/plaster is kept wet and the hardness achieved. *To achieve full strength, the plaster/concrete must be kept wet for one full year.*

amount of time kept moist	percent of hardness
3 days →	20%
7 days →	45%
28 days →	60%
3 months →	85%
6 months →	95%
1 year →	100%

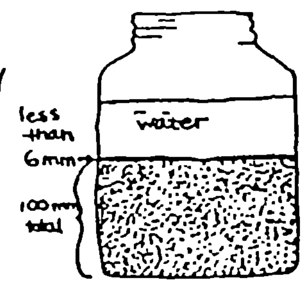
*Compiled from: Handbook of Gravity-Flow Water Systems, T. Jordan, UNICEF Nepal, 1980
Reinforced Concrete Designer's Handbook, C. Reynolds and J. Steedman, Cement & Concrete Assn., UK, 1974
Ferrocement Water Tanks, S. Watt, Intermediate Technology Publications, UK, 1978

SAND:

Sand should be **well-graded** (have grains of many sizes) so you may need to mix coarse and fine sand together. Sand must also be **clean**, because like water, it may have some impurities that weaken the cement bond such as clay, silt, mica, and organic matter. Dirty sand can be washed by repeatedly rinsing with water. There are two easy field tests for determining if the sand needs to be washed:

① Rub a moist handful of sand between your palms. Suitable sand will leave hands only slightly dirty.

② Fill a clear glass container halfway with sand. Then fill to 3/4 full with water. Shake the glass vigorously and then allow it to sit, undisturbed, for 1 hour. The sand settles immediately, and any silt and clay settle as a dense layer on top (usually darker than the sand). This layer should not be more than 1/17, or 6%, of the thickness of sand. Start with 100 mm sand for easy measurement.



When measuring sand, note whether the sand is damp or dry. Damp sand that contains 5-6% water may have an increased volume of over 30%. Additional water content reduces the "bulking," and saturated sand occupies nearly the same volume as dry sand. Therefore when using slightly damp sand, add an extra amount. Very damp sand, measure as if it is dry.

MIXING:

Measurement by weight is the most accurate, but measurement by volume is more practical at construction sites and will suffice **if done carefully**. Measuring by shovelfull is **not** accurate. A bucket should be used for measuring portions of sand and cement (and gravel, in concrete) in order to achieve enough accuracy for a strong and (relatively) homogeneous mix.

REINFORCEMENT:

The cement bond is easily broken by forces which pull it apart--tensile stresses. Thus it is necessary to use a material like steel inside the concrete or plaster for large water tanks. The weight of the water will stretch the tank walls. Barbed wire or weld mesh are heavy enough steel to withstand the stress and hold the tank together. (Straight wire can be used in place of barbed wire, but the barbs help grab onto the plaster, and the two twisting wires are stronger than a single wire.) The chicken wire helps hold the plaster together between the stronger wire.

Although the soil helps support the weight of the water, even the ground hemispherical tanks will stretch when full. Hard rocky soils provide better support, but loose or sandy soils should have more reinforcement (barbed wire) in the tanks.

Standing water tanks receive the most tensile stress in the bottom 1/3 of the wall and in the joint between the floor and wall. Extra reinforcement wires in the wall and joint, and thickening the plaster at the joint, have proven to prevent cracking at these points of stress.

AMREF EXPERIMENTAL FERRO CEMENT

WATER TANK

WOODHOUSE FEB 87

Basic Method

BRC 610 mesh is set into a circular concrete foundation. The BRC forms a circular wall 2m high. The BRC wall is then covered with a single skin of 1" chicken wire. The outside of the BRC is shuttered using sacking, papyrus mats or similar and a 1 : 3 plaster applied from the inside. After removal of the shuttering the outside is also plastered. The inside is finished with a cement slurry (nilo).

dimensions

Dia 2m Volume = 5.5 M^3
Height 1.8m
Foundation 0.1m thickness
Wall thickness (top and bottom) 0.05m
Design Thickness (0.04 /0.06 to ⅓ of height)

Material cost estimate (rough)

MATERIAL	UNIT	UNIT PRICE	AMOUNT	COST KSHS
Sand	Ton	100	1	100
Aggregate	Ton	150	0.75	110
Cement	Bag	85	6	510
Chicken wire	M^2	10	12	120
BRC 610	M^2	11	17	187
Plumbing	Misc.			100
			TOTAL	1,127

NB Doesn't include roofing or delivery area slab.

Comments

first tank was built in Nairobi at AMREF in 1983. It required bitumen painting inside to prevent leaking. After 3 years it has no major structual weaknesses, some minor cracks have appeared on the outside. Also some salt deposits have leached onto the outside wall.

A good tank is very dependant upon high quality sand, workmanship and curing. Models of this tank have been copied extensively by the Ministry of Health Training Schools in Uganda.

Section VII

The MAIN ISSUES that arose during our discussions and sharing were (not in order of importance)

Large capacity tanks for communal use are only suitable in institutions where the water use can be controlled, and maintenance can be more easily organised.

Cracking is a common problem with all tank designs (and in particular the 750 gallon water jars) but is easily repaired.

Leakage from cracking is normally small and no tanks or jars have collapsed.

The cement/sand mix is critical

Curing is often a problem and poor curing is often the main cause of cracking. It is difficult to ensure that the cement has been cured in exactly the right way.

Tanks are often drained completely dry thus causing cracking. It is hard to dissuade the owner.

Water jars have limited capacity and the transport of the filler material is expensive and difficult.

BRC 610 at 950/= per roll (11/= per m^2) is much cheaper and as good as weld mesh for reinforcement.

The larger the tanks the less appropriate for those most in need of water storage and collection.

Water within the compound is a majority benefit to the family (especially the women) and is the mumber one advantage of the tanks.

Because of the high individual cost, tanks are more appropriate for the more affluent members of a community.

A successful system of financing of tanks which can help the poorer people have tanks and also ensures that the construction continues after the finance has ended has yet to be proven.

It is essential that costs are kept low.

The group/community organisation is an essential prerequite and is the main factor in ensuring continuation of construction.

When decisions are made by all members together greatly enhances the groups strength and motivation.

In what order members are to get the tanks is/main decision to be made. /the It alone can make or break groups.

Intervisits between groups is a very useful way to exchange ideas, create a view of the possible and stimulate motivation.

Pot filters are not being used in practice although they are technically sound.

There is no one ideal tank design for Kenya. The best design for each locality can only be descovered through local experimentation of existing designs.

There is no need to develop new designs as there are many proven designs. It is just to experiment with each design to find the most appropriate (construction, size, cost) for each locality).

Section VIII

WORKSHOP EVALUATION

- what was the most helpful topic?
- which session did you enjoy most?
- which topic was least helpful?
- which session was least enjoyable?
- which ideas from the workshop will you be able to use in your own work?
- what do you think still needs to be discussed?

Happy	Confused	Unhappy
18	0	0

Workshop Evaluation

Most helpful:

- how to construct different tanks (6)
- social and general approach (4)
- how to supply enough water to people
- individual presentations - sharing experiences (3)
- group presentations (2)
- thatch roofs collection
- to know where to construct tanks
- checklist

Most enjoyable session:

- group discussion (3)
- individual presentations (5)
- all
- checklist
- Saturday
- tank designs (3)
- training women fundis
- group presentation (1)

Least helpful topic:

- how to reach the poor
- none (7)
- too many topics - no time to discuss fully
- surface catchment (2)
- ferrocement water tanks
- group work presentation
- thatch roofs (2)
- community organisation (2)
- late night movies

Least enjoyable sessions:

- none (9)
- evening session
- film (3)
- thatched roofs (3)
- reaching the poorest (2)

Which ideas useful in own work:

- tank construction (2)
- how to reach the poorest
- help groups to become self reliant
- new approach to groups, community organisation (6)
- give women training and support
- decision making about construction
- hearing new ideas that have been successful
- grass roofs (2)
- using cheapper materials in present design
- groups to come up with own ideas
- committee decisions
- checklist (2)
- references (2)

List of Topics To be Discussed

- How to reach the poor with tanks (2
- Why are people poor
- None
- Working with communities where no established groups or committee?
- Training women fundis (3)
- Cheap water tanks (2)
- Alternative water sources (2)
- Practical work - in construction
- working with communities (2)
- Relationship between techcal and social issues
- How we cna best use what we have learn
- Quality of water
- More on technology
- networking

WHAT NEXT?

What should we consider to follow on from the workshop?

1. Another workshop after some time to discuss what have done in meantime
2. Networking and communicating between each other e.g. on specific problems
3. Shorter follow up meetings every 6 months
4. A report of this workshop will be circulated, including materials presented, names and addresses of participants
5. Need more women next time e.g. women fundis, women's groups extension workers - increase number of women
6. Part of next workshop cintinue on tanks and part on alternative water sources
7. Field visits - hold workshop near site
8. Invite relevant Ministries (this time 4 Ministry of Water Development people were invited but didn't come)

LIST OF PARTICIPANTS

1.	Jefferson Kilonzo	Utooni Development Project P.O. Box 81, Kola Machakos
2.	Eliud Ngunjiri	Oxfam P.O. Box 40680, Nairobi
3.	Sebastian Mutua	Kamujine Farmers' Centre P.O. Box 674, Meru
4.	Patrick Kasyula	Diocese of Machakos P.O. Box 640, MACHAKOS
5.	Francis Gray	Diocese of Kitui P.O. Box 300 Kitui
6.	Joel Mbiti	- do -
7.	Robert M.	- do -
8.	Daniel Mwayaya	World Neighbors P.O. Box 14728 Nairobi
9.	Mwakari Mathuva	Utooni Development Project P.O. Box 16, Kola, Machakos
10.	Julius Chokera	Diocese of Meru Small Scale Water Scheme P.O. Box 553, Meru.
11.	Heinrich Gorfer	- do -
12.	Karen Iles	Kamujine Farmers Centre P.O. Box 674, Meru.
13.	Patrick Mutia	- do -
14.	Alfred Oluoch	CARE (K) P.O. Box 1167, Embu.
15.	Stephen Muroki	CARE (K) P.O. Box 202, Voi.
16.	James J. Tumkou	Chepareria Youth Poyltechnic P.O. Box 206 Kapenguria.
17.	Alphonce Atisa	Mutomo Soil & Water P.O. Box 125, Mutomo.
18.	Gikonyo J. K.	- do -

19.	Melvin Woodhouse	AMREF P.O. Box 30125, Nairobi.
20.	Joshua S. Mukusya	World Neighbors P.O. Box 16 Kola, Machakos
21.	Keith Wright	World Neighbors P.O. Box 14728, Nairobi.
22.	Patrick W. Gacheru	Mukaa Mukuu Farmers' Training and Polytechnic Centre P.O. Box 1281, Thika
23.	John Lennox	- do -
24.	Frans Klausen	UNICEF Technology Support Unit P.O. Box 44145 Nairobi.
25.	Martin Fisher	Action Aid Technical Support Unit P.O. Box 42814 Nairobi.
26.	Nicky May	Oxfam P.O. Box 40680, Nairobi

WORKSHOP

PARTICIPANTS