LOCAL DEVELOPMENT DEPARTMENT
COMMUNITY WATER SUPPLY

RESEARCH ON RESERVOIR TANK CONSTRUCTIONS in NEPAL

Kathmandu, May 1979,
Prepared by

Frans Dubbeldam
member of
Appropriate Technology Group
of German Volunteer Service
Dilli Bazar
Kathmandu
P.O.B. 442

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1. Introduction.

Ten years the Local Development Department (LDD) has been constructing drinkwater systems for villages in rural areas.

The reservoir tanks built in the systems are of capacities from 2 m^3 up to 40 m^3.

While building a drinkwater system you have to meet several problems: lack of cement, transportation problem, lack of money and after constructio n the maintenance problem.

As a reservoir tank is an important element in a drinkwater system and for construction much material and labour are required, an up-dating has been made of the several constructions of tanks.

The target of the research is to collect information of the quality of the constructed reservoir tanks.

This information will be the basic to find constructing methods to decrease teh use of cement, to increase the function and to improve the construction.

Proposals for tests are given at the end of the report.

After studying this report criticism, recommendations or other ideas may arise to the reader. Please, don't bury them in your mind, but write them down and send them to:

AT- Group
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It is up to LDD what to do with the results.

2. Requirements for a [illegible]

- a good sedimentation function
- to store water; waterproof floor and walls
- a solid foundation
- a solid roof
- economical use of materials, skills and labour
- applied methods for construction
- easy to be maintained
- good protection of the valves
- possibility to enter the tank; a manhole
- protection against light
- air ventilation
- circulation of the stored water.

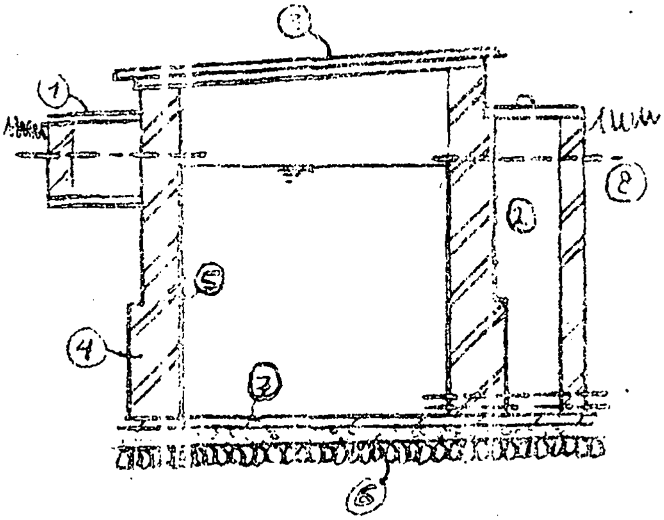
3. Constructed reservoir tanks.

3.1. Common water tank.

The most common water tank construction in Nepal is a square construction with masonry mortar stone walls (the exterior being stepped), concrate floor on a sand, gravel and stone foundation.
The walls are plastered with a waterproof cement-sand mixture (usually 1:2) on the inside. The roof is usually gabled, GI- sheets on atimber frame construction is used. GI- pipes are used for fittings. A separate valve box beside the tank contains the valves for supply lines and cleaning out pipe. An other box is for the inlet pipe.

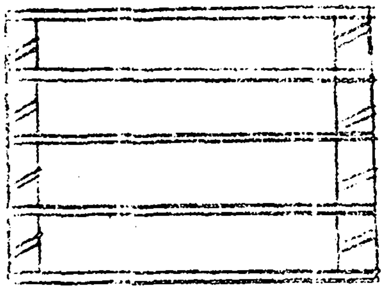
Corrugated

Outline of the common tank.

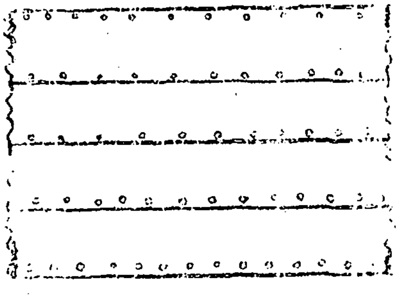


1- inlet valve box
2- supply and cleaning out valve box
3- GI- sheet roof and timber frame construction
4- cement mortar masonry wall
5- cement plaster
6- sand, gravel and stone foundation
7- concrete
8- overflow

Roof.



timber frame construction



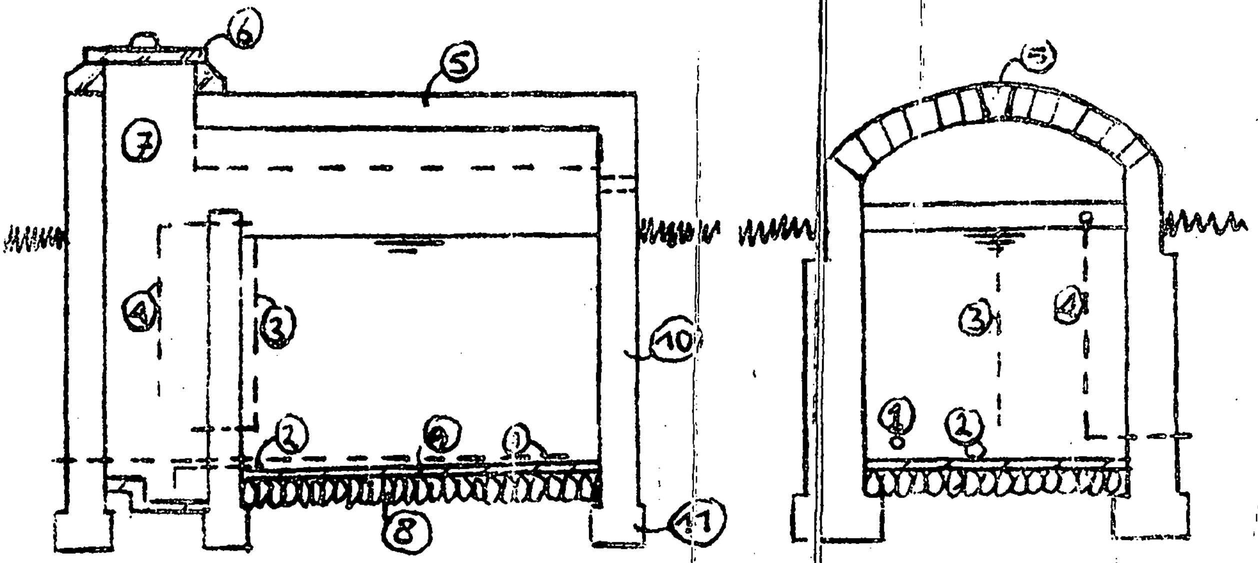
nailed GI-sheets

3.2. Stone arch tank.

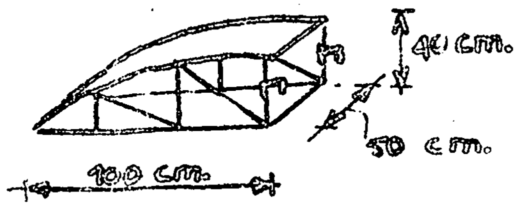
In Gandaki Zone a stone arch tank is being constructed. The tank has cement mortar masonry walls and is roofed with a stone arch. The construction includes an operation room, where people can operate all the valves for inlet, supply and cleaning-out pipes.

To construct the stone arch temporary support frames are required. Each iron frame (size: 100x50x40cm) weighs 25 kg.

Outline of stone arch tank.



1- inlet
2- cleaning-out
3- overflow
4- supply
5- stone arch
6- concrete slab
7- operation room
8- stone foundation
9- concrete
10- cement mortar masonry
11- masonry foundation

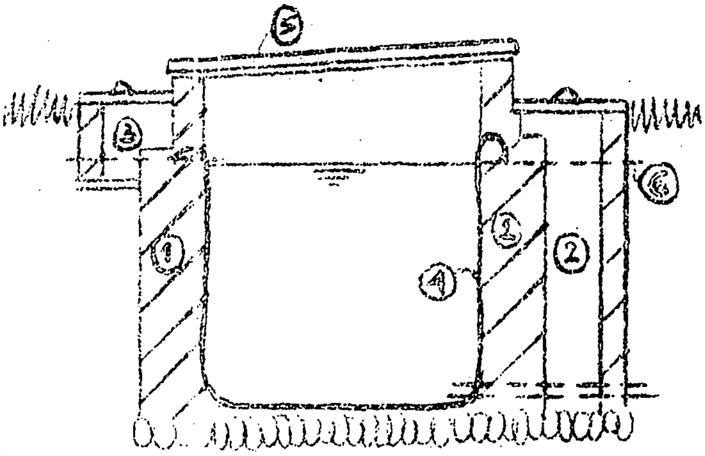


frame

3.3. Plastic sheet tank.

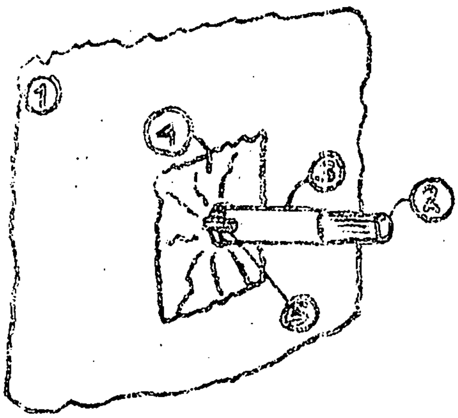
Only one tank has been constructed with plastic sheets. First, walls of mud masonry were erected. The walls were plastered with a mud plaster to give a smooth surface, the floors were treated similarly. Against this plaster the plastic sheets were laid to make the tank waterproof. To joint the plastic and GI- fittings a gasket (a hoseclamp) has been used.

Outline of plastic sheet tank.



1- mud masonry wall
2- supply and cleaning-out valve box
3- inlet valve box
4- plastic lining
5- GI-sheet roof
6- overflow

Outline of joint of plastic sheet and GI-pipe.



1- plastic sheet
2- GI-pipe
3- a piece of plastic fixed around the pipe
4- small square piece of plastic
5- gasket (hose clamp) to seal all the pieces together.

3.4. Mud wall tank.

Instead of cement mortar masonry walls are erected with mud mortar. The inside and outside of the walls are deep pointed with cement mortar (4 cm thick). The plaster is of the same mix as used with cement mortar walls.

3.5. Circular tankwall.

Not only square tanks have been built, also circular tankwalls are possible. In all other respects the tank is similar to type no. 1 above.

3.6. Stone slate roof.

In some areas the right stones are available to cut slates. In that case often skilled labour to place and to nail the slate is available.
A tank with stone slates looks like a small house. After building the walls wooden rafters are placed, on which the stones are laid in the tradional way. The roof has a slope of about 10%.

3.7. Wooden roof.

In the east of Nepal wooden roofs are constructed. Salwood, a hard wood, is found in Ilam district. The planks are laid beside each other and at the joints, battens are nailed.
The wood is painted against rotting.

4. Remarks on the constructed tanks.

The following remarks are based on site visits, on seeing photos and on discussions.

Remarks to no 3.1.: the most common tank , cement mortar masonry walls and GI-sheet roof.

Very often separate valve boxes for inlet, supply and cleaning-out pipes appear in bad condition. Sometimes not even valve boxes have been built (e.g. Birta Deurali in Kabre Palanchok district). In this case operating the valves is difficult or impossible. In fact the functioning of the tank has been impaired, because people can not clean out the tank.

Also the covers of the valve boxes are a weak point of the construction. They have often disappeared or been damaged. Anybody can enter the box and alter the valve setting.

More attention must be paid to these boxes and it is recommended a better cover and improved walls are provided. For improved covers see the test proposals.

An other important thing is the sedimentation function of the watertank. When the tank is nearly empty the incoming water runs directly to the deepest point of the tank bottom, where the cleanig-out pipe is situated. The supply pipe is usually placed only some distance above the cleaning-out pipe. The mud and other pollution doesn't have time or room to settle out. The best situation is for the inlet and cleaning-out pipe to be near each other and teh opening for the supply pipe as far as possible from the inlet pipe.

GI-sheets for roofing the tank are oxidizing after a few years, but even worse is the lasting of the fastenings. Holes between the wall and sheets and between the sheets themselves are hard to prevent. Dust, all kinds of insects or a dead animal on the surface of the water is quite common in such tanks. To improve the roof a ferrocement slab or arch can be used, if the tests are successfull. See proposals.

Remarks on no. 3.2.: Stone arch tank.

This of solid construction. It is like a bunker.
The attached operation room is a step in the direction of an advanced water system building, especially for maintenance.
This tank assured a maximum sedimentation of undesirable material in the water.
Instead of GI-pipe PVC or HDP pipe (diameter 3 inch) can be used as overflow.
The quantity of cement and labour for constructing is large. To decrease this, ferrocement slab or arch maybe is a possibility. See the test proposals.

Remarks on no. 3.3.: Plastic sheet tank.

The tank in Syang (Mustang district) has walls of about 90 cm. thickness and a capacity of 3mx2mx1½m= 9m^3. The plastic sheets (name: STAFF liner) were jointed together with glue. Sheets had been provided by UNICEF.
The GI-pipes are fixed with a gasket (hose clamp) to the plastic sheets. After two years the tank was not leaking.
To construct with plastic sheets is now a possibility.
The plastic lining has been well done. The valve box was in a bad condition and functioning of the tank was poor: no entry steps, the deepest point of the tank was not near the cleaning-out pipe, because the slope of the floor was in the wrong direction; proper cleaning-out was impossible. Also there was a sedimentation problem.
To improve this tank type, use of cement mortar for constructing the valve box is necessary to protect the valves, also between the plastic and the roof.
For the roof and sedimentation problem see remarks on no 3.1.

Remarks on no.3.4.: Mud masonry wall tank.

Mud masonry has been used in tanks in Mamling (Limbuana district), constructed in 1976, in Sattala (Dailek district), constructed in 1976, and in Durlung (Parbat district), constructed in 1977. The tanks in Durlung and Mamling seem to be without cracks and functioning well. However cracks appeared in Sattala.

A good drain around the tank is necessary. The walls have to be thicker than cement masonry walls to stand the water-pressure.

The tank in Durlung has a capacity of 5mx5mx1.3m= 35 m^3.

The wall foundation is 80 cm. thick, the walls are 60 cm below the earth surface and above they are 40 cm thick. Behind the wall big stones were placed.

Using mud masonry you decrease the cement-use by about 50%. In Durlung 57 bags of cement were used. Thicker walls mean more labour: transportation, cutting and masonry work. Less cement-use means less transportation of cement and sand and also less material cost.

Constructing with mud masonry is possible, only if large stones and skilled labour are available, because each stone has to contact the other stone properly. If not, the upper stones will move and cracks appear, as in the houses.

Water in the mud wall can destroy the sealing of the tank, because if thewater levels in the tank and in the mud wall vary too much, the water pressure in the mud wall can remove the plaster.

That is why it is not advisable to construct a water reservoir tank with mud masonry. It is better to use plastic sheets.

Remarks on no. 3.5.: Circular tank wall.

In Kolati (Kabre Palanchok district) such a tank was built in 1978. The exact cement-use is not known, but when you compare the surface area of the floor and walls of a square and of a round tank, you may conclude that the use of cement decreases by approximately 10%.
To construct the roof complications occur. In Kolati GI-sheets were used. A ferrocement roof should be considered.

Remarks on no. 3.6.: A stone slate roof.

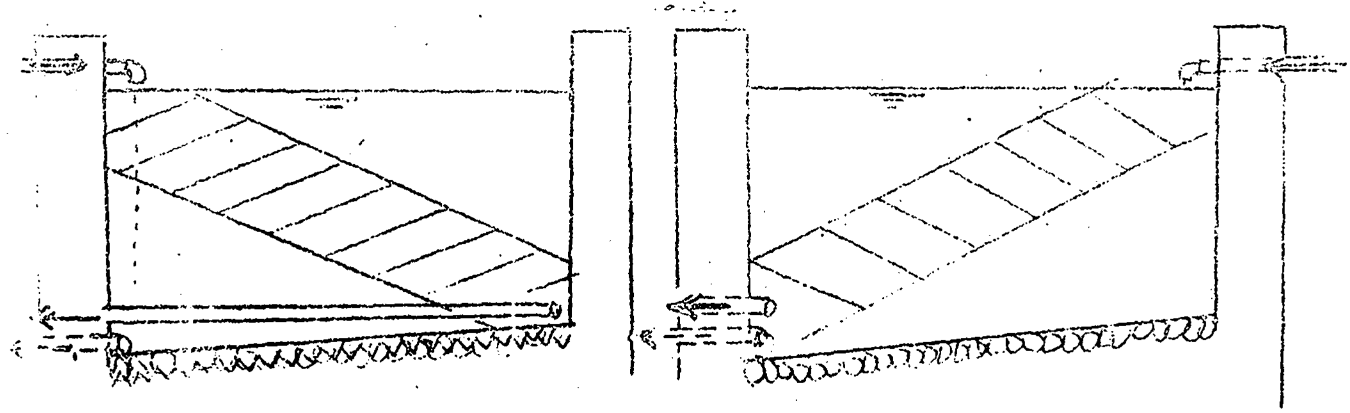
A stone slate roof seems to be a potential roof material (no oxidizing problem and strong). The price of the stone for 25 m^2 is about 600 Rs, transportation and placing are extra. It needs special skills to nail them.

Remarks on no 3.7.: A wooden roof.

A hard wooden roof will last as long as a GI-sheet, if the wood is well maintained. If hard wood is available the roof will be cheap. Cheap in the sense of money, but realising the very fast decrease of wood resources in Nepal, in real terms the opposite can be concluded.

5. Sedimentationfunction of the watertank.

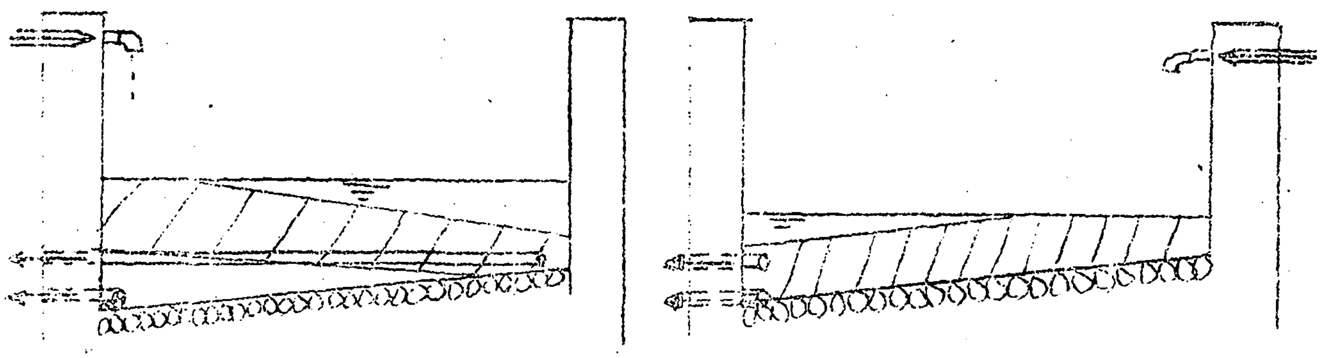
Right situation of pipes. Wrong situation of pipes.



⇒ = inlet

——> = supply

- - - -> = cleaning-out



- inlet near the cleaning-out
- cleaning-out in deepest point
- supply pipe far from inlet and deepest point.

- if the tank is half filled, the incoming water runs into the supplypipe directly
- no room and time for mud to settle out.

6. <u>Where to find drawings and design details?</u>

Cement mortar masonry and GI-sheets or wooden roofs

LDD- Biratnagar is using the UNICEF booklet: 'Village Water System'. Based on this booklet drawings have been made. The sizes of tank capacity are nominally: 4, 8, 12, 16.......up to 40 m^3.

Stone arch tanks:

LDD- Pokhara is using: 'Standardization Rural Water Supply', including all forms for hydraulic calculation and cost estimate. In the 'Technical Training manuals: no 1, 2, 3, 4 and 5' detailed information is given about designing a system and construction.

The capacities of the tanks are: 2½, 9, 16, 30 and 38 m^3.

Circular tank wall:

Designs of round tanks (12½, 25 and 50 m^3) are in the files of LDD- Pulchok and also in a CWS file of the German Volunteer Service, Dilli Bazar, Kathmandu.

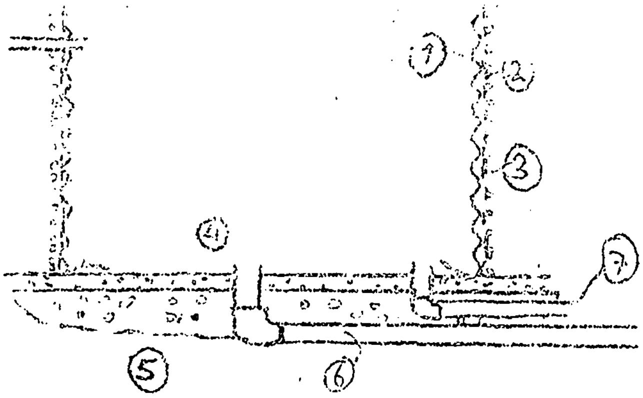
7.1. Ferrocement watertank.

A circular ferrocement watertank has been built in several countries, e.g. Thailand, New Zealand, Mali, Rhodesia, Bangladesh and USA.
The construction materials are Portland cement, sand, reinforcement steel, chicken wiremesh and formworks.

Construction.

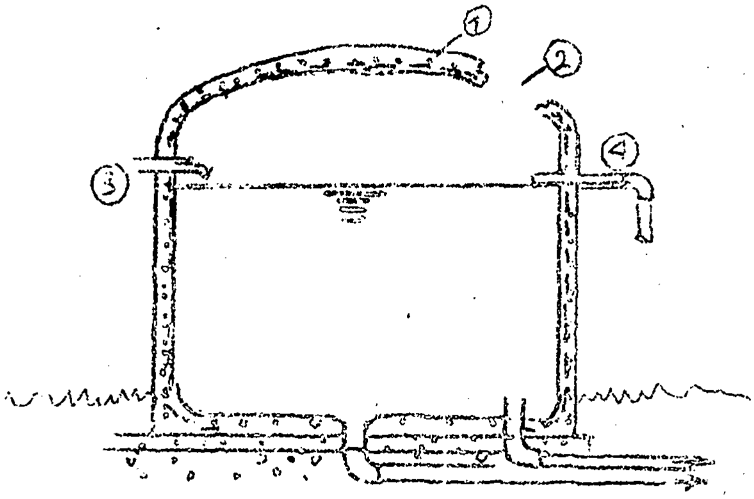
A circular area is cleared at the required site for the tank and excavated for the foundation. A 10 cm thick layer of sand and gravel is laid evenly over the excavation and 7½ cm layer of concrete laid on the top of this. A concrete mix of 1:2:4 (cement:sand: gravel by volume) forms the foundation slab under the tank.
Into this foundation is cast the clearing-out and supply pipe.
When the concrete floor slab has hardened the corrugated galvanised iron formwork for the tank wall is erected, by passing the bolts through the iron angles and wedges and fixing them the four forms are tightened together in rigid circular form. The forms are cleaned free from dirt and cement, oiled and the wire netting wrapped around it to a single thickness and under the forms.
To form the hoop reinforcements, the 'straight' galvanised iron wire, 4 mm diameter, is wound tightly around the tank form. The first meter from the bottom the irons have a relative distance of 5 cm, above the first meter the relative distance between the irons is 10 cm.
After fixing the wires against the formwork cement mortar from a mix of 1:3 (cement:sand by volume) is trowelled in the reinforcement, and as soon as this first layer has begun to stiffen a second layer is trowelled onto cover the reinforcing wire a depth of 15 mm.
The surface is finished smooth with a wooden float.
After two days the formwork is dismantled by removing the holding bolts and by pulling the wedges out which will leave the shuttering free to be stripped away from the inside mortar wall. The sections are lifted clear of the tank to be thoroughly cleaned of any mortar or cement.

Ferrocement tank



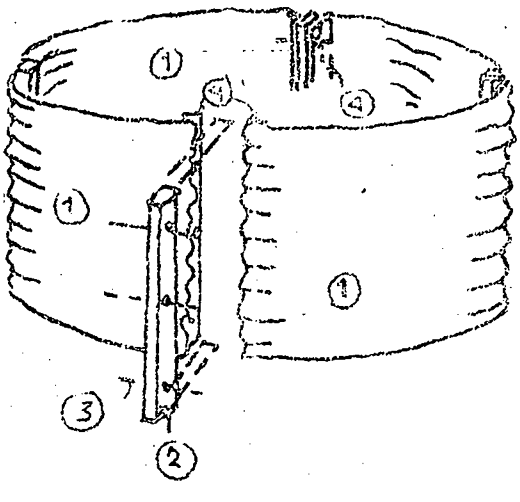
construction stade

1- form
2- hoop reinforcement
3- chicken wire
4- concrete
5- gravel and stones
6- cleaning out pipe
7- supply pipe



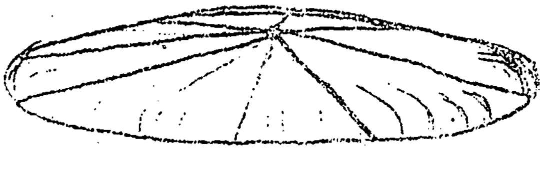
final stade

1- ferrocement roof
2- manhole
3- inlet pipe
4- overflow



form for tank wall

1- corrugated galvanised iron form
2- wedge, to be able to dismantle
3- bolthole
4- angle iron



form for roof

- bent GI sheets

The overflow and inlet pipe are built in.
The inside of the tank is plastered with mortar to fill up the corrugations, when this has hardened sufficiently a second final coat is trowolled onto the inside of the tank wall, and finished with a wooden float.
A 5 cm thick layer of mortar is next laid onto the floor of the tank and the function with the floor and the wall rounded. The floor can be constructed without reinforcement, but some is recommended. The inside of the tank is painted with a thick cement slurry to seal the tank.
The roof can be made in the same way using formwork. In the roof a manhole is constructed. See the tests proposal.

7.2. <u>Rice husk lime cement.</u>

RECAST- center (Research Centre for Applied Science and Technology in Kirtipur) is doing research into low-cost "cement" materials. Here follows a chapter out of RECAST's Annual Report 1977-1978:
"Low-cost cementious materials; As being one of the main construction materials the demand for cement is very high, and the existing factory in the country can meet only about 20 % of the current demand.
At present, except the portland cement there is no alternative cement available in the local market. The use of high strength portland cement even for ordinary masonry and plastering work is in fact misuse. Moreover, beside the high cost, the transportation problem is acute in remote areas. Thus the work in the development of cementious materials in the RECAST is directed towards making low-cost alternate cement available not only for cheap construction, but also at the spot where it is needed.
In the development of cementious materials are rice husk (agricultural by-products) and lime sludge (wastages of sugar factory). The rice husk cement based on these raw materials has the physical properties as follows:

Comparative tudies of Physical Properties of Ric Husk Cement and Portland Cem nt.

Porpertie	Portland Cement	Rice Husk Cement	Indian standard 66/67 masonry cem.
Fineness Spe ific sur ace cm^2/gm	2300 3000	5000	minimum 5000
Soundness: Lechatelier expansion Autoclave expansion		3 mm 1mm	maximum 10mm maximum 1mm
Setting time Initial sett ng Autoclave se ting	45 minutes 12 hours	45 mins. 150 mins.	min. 90 mins max. 14 hours
Compressive trength: in 7 days (g/cm^2) in 28 days kg/cm^2)	min. 280 normally 300-400 33 -40%	90 max. 200 average 178 50%	min. 25 min.25

Water requir ment.

On the compa ative study of the prperties it can be concluded that though somew at inferior in quality to ordinary portland cement the rice hus cement can be used as masonry, plastering, light foundation e en to meet the ISI specification for masonry cement. In addition, this cement can also be used as a raw material for the production o cementious pipes and corrugated roofing sheets.
At present, ork is in progress for (1) testing the developed technology a pilot scale of 1 ton per day, (2) replacement of rice husk by ashes for the places where the rice husk is either scare or not available, and (3) quality improvement, with special reference to the strength.
The technolo y so far developed can be used either for small or large scale roduction. Moreover, as there is no need for foreign component an extra fuel energy and also that there is every pos- sibility of voiding imported machineries this technology car be

useful even for remote areas.

Seeing the results at the RECAST- centre in Kirtipur, like masonry walls and plasters, it will be interesting to test the waterproof qualities of wall and the standard of joint between wall and GI- pipe.
Also it must be decided, how to control the rice husk cement quality for each batch.
See the tests proposal.

7.3. Bricks.

Bricks are usually not available in hilly areas due to lack of adequate mud. If bricks are available, like in Parbat and Baglung districts, they are more expensive than stones, because in order to produce the bricks you need much labour and fuel energy, for stones this is not necessary.

7.4. Chalk.

Chalk instead of of cement is possible. But chalk costs about 10 Rs/pathi (10Rs/± 4kg) and nepalese cement 76Rs per bag (50kg).
Chalk is usually produced on a small scale only.

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8. Comparison of labour requirement and cost of different types of tanks.

To get an idea of labour requirement and costs for HMG a comparison of 9, 10 or 12 m^3 tank has been made. It is hard to make an exact comparison, but that is not necessary to give an approximate idea.
The labour requirement is expressed in relation to the weight of a tank. The cost for HMG is in Nepalese Rupee. Some approximatins have been made, and these could be debatable.

8.1. COMPARISON of QUANTITIES

material	unit	valve box 2 times	cem. masonry tank 12 m^3	stone arch tank 9 m^3	plastic sh. tank 9 m^3	mud masonry tank 9m^3	ferro cement tank 10m^3	rice husk tank 9 m^3 (5)
uncut stones	m^3	5 (4)	18 (3)	33	30 (1)	25 (3)	? (2)	18 (4)
gravel	m^3	0.4	4	1.7	-	2	3	4
sand	m^3	0.8	8.8	10.2	-	5	2.25	8.8
cement	bag/50kg	5.6	38	81	-	20	15	38
wood	m^3/m^2	2.4 m^2	0.73 m^3	4.2 m^2	0.73 m^3	0.73m^3	-	0.73 m^3
steel bar 4 mm	m'	-	-	-	-	-	480	-
steel bar 6 mm	m'	18	-	30	-	-	-	-
chicken wiremesh	m^2	-	-	-	-	-	36	-
plastic sheet	m^2	-	-	-	25	-	-	-
glue	tin	-	-	-	2	-	-	-
GI sheet	m^2	-	17		17	17	-	17
frame/ form	pc.	-	-	16	-	-	12	-
mason	MD	15	52	55	52	52	20	52
carpenter	MD	4.8	18	2	18	18	4	18
stone cutter	MD	9.6	-	35	-	-	-	-
labourer	MD	32	154	130	154	154	30	154

8.2. COMPARISON of WEIGHT (in kg)

MATERIAL	rate	cem. masonry tank, 2 valve boxes	stone arch tank	plastic sh. tank, 2 valve boxes	mud.masonry tank, 2 valve boxes	ferro cem. tank, 2 valve boxes	rice husk tank, 2 valve boxes
uncut stones	2600 kg/m^3	59 800	85 800	91 000	78 000	18 200	59 800
gravel	2600 kg/m^3	11 440	4 420	1 040	6 240	8 840	11 440
sand	1700 kg/m^3	16 320	17 320	1 360	9 860	5 156	16 320
cement	50 kg/bag	2 180	4 050	280	1 280	1 030	2 180
wood	900 kg/m^3	700	300	780	700	50	700
steel bar 4 mm	7800 kg/m^3	-	-	-	-	190	-
steel bar 6 mm	7800 kg/m^3	14	26	11	11	11	11
chicken wiremesh	0.5 kg/m^2	-	-	-	-	18	-
plastic sheet	4 kg/m^2	-	-	100	-	-	-
glue	10 kg/tin	-	-	20	-	-	-
GI sheet	10 kg/m^2	170	-	170	170	-	170
frame/ form	25 kg/pc.	-	400	-	-	300	-
	total	90 621	112 316	94 031	96261	33 795	90 621

8.3. COMPARISON of COST for HMG. (in Rs)

aterial and abour	rate	cem. masonry tank, 2 vb.	stone arch tank	plastic sh. tank, 2 vb.	mud masonry tank, 2 vb.	ferrocem. tank, 2 vb	rice husk tank, 2 vb.
ment stones	- (13)	-	-	-	-	-	-
ravel	- (13)	-	-	-	-	-	-
and	- (13)	-	-	-	-	-	-
epalese cement	76 Rs/bag (6)	3 314	6 156	426	1 946	1 566	-
japanese cement	85 Rs/bag	3 706	6 886	476	2 176	1 751	-
ice husk cement	25 Rs/bag (7)	-	-	-	-	-	950
ood	- (13)	-	-	-	-	-	-
teel bar 4mm	3 Rs/m'	-	-	-	-	1 440	-54
teel bar 6mm	3 Rs/m' (8)	54	90	54	54	54	54
chicken wire mesh	10 Rs/m² (9)	-	-	-	-	180	-
lastic sheet	41 Rs/m² (13)	-	-	1 025	-	-	-
lue	50 Rs/tin (11)	-	-	100	-	-	-
I sheet	75 Rs/m² (13)	1 275	-	1 275	1 275	-	1 275
rame /form	-	-	-	-	-	-	-
ason	20 Rs/MD (6)	1 340	1 100	1 340	1 340	700	1 340
carpenter	20 Rs/MD (6)	456	40	456	456	176	456
tone cutter	15 Rs/MD (6)	115	525	115	115	115	115
abourer	- (13)	-	-	-	-	-	-
total with nepalese cem.		6 554	7 911	4 791	5 186	4 231	
total with japanese cem.		6 946	8 641	4 841	5 416	4 416	
total with rice husk cem.							4 190

Rem. vb.= valve box; MD= man day

Explanation of the written numbers in the tables:

1= thicker walls use more uncut stones

2= these amounts based on information of the manual: 'Ferrocement Watertank' by S.B.Watt

3= the mud masonry, plastic sheet tank and rice husk cement tank amounts are based on the UNICEF manual: 'Village Water System in Nepal and Bhutan' by R.Johnson, mainly

4= vave box of Pokhara standardization, but two times sand and cement rates for pointing the inside of the walls.

5= assuming you need the same amount of rice husk cement as portland cement

6= based on a Rising Nepal article (16 April 1979)

7= according to Mr.R.D.Shrestra of RECAST

8= according to Pokhara Standardization cost estimate

9= average price in the bazar in Nepalganj, Kathmandu and Pokhara

10=according to a calculation of Mr. Leo Goulet of UNICEF, that financed the plastic sheets.

11= assumed by the author

12= the bazar price in Pokhara

13= HMG hasn't to pay, village contribution by free labouring

8.4. Remarks on the weight comparison.

It is assumed of the tank construction is proportional to the labour from the villagers. Stones are not usually a problem, but fetching sand means a lot of work.
The weight of the stone arch tank is about three times the weight of a ferrocement tank.

8.5. Remarks on the cost comparison.

The price of a tank is not the total price, because no minor items have been listed: like tools, fittings, etc.
The lowest price doesn't tell us anything about the quality of construction; a cheap tank can function well and an expensive tank badly.
Use of less cement means to HMG not only less material cost, but also less transport cost.
The rice husk cement, mud masonry tank, plastic sheet and ferrocement tank are clearly cheaper than the other tanks.

9. Water quality.

Up to now not much research into water quality has been done. In Dumre (Gorkha district) along Pokhara to Kathmandu raod a sedimentation tank has been built. But no sand filtration or other methods of disinfection are used in the rural areas.
Most water sources are springs supplying water of adequate quality. Tests have been done and showed that the main water pollution is caused in the households and not in the water tank or system.
Using small streams requires a filtration or a disinfection method for the water. LDD - Pokhara will try a factory made sand filter for this purpose.
UNICEF ordered 10 numbers of them

10. Trials, demonstration and tests.

10.1. What is the point of doing tests and trials?

As discussed in the remarks on the tanks roofing and valve boxes they aren't often constructed in the best way. Ferrocement slabs or arches can be improvements, but the exact reinforcement required is not known. And it is impossible to calculate this due to the chicken wire. Many people are not aware of the possibilities with ferrocement.

By constructing a ferrocement tank, plastic sheet tank or rice husk cement tank you collect experience and knowledge of these methods. By seeing the models people will be able to construct in a village in the same way. It is a good thing to promote cheaper models.

Tests can be done by loading a slab with an empty petrol drum and slowly filling it with water or by filling a built tank with water to see that the tankwall is waterproof or not. It is better to construct a model tank on the ground instead of in the earth to show the construction and this is also the worst situation for the stability and waterproofness of the walls.

The recommended place for demonstration is the Panchayat Training Centre in Pokhara for the following reasons: Pokhara is in the centre of Nepal and easy to reach; in Pokhara it is possible to get the construction materrials through LDD and in the bazar; the financer is able to control the money flow, which would be difficult in a village location.

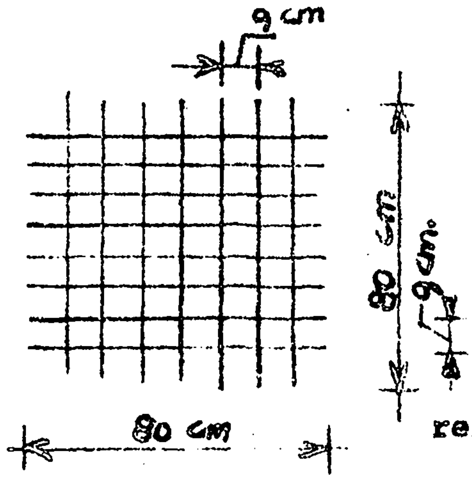
The best solution will be, if LDD undertakes the tests itself to provide experience which remains in NEpal. Interested engineers, overseeers or foremen can carry out the work. Some skilled masons will be needed to construct the models. To produce rice husk cement Mr. R.D.Shrestra of RECAST was willing to give help and advice. He supposed the production cost and overhead cost will take about 25 000 NRs.

Mr. N.B.Pradhan of theGobar Gas Factory in Butwal was willing to advice on the ferrocement tank design.

The following test proposals are a brief idea on how to carry out the work, the time and cost table is an estimate only.

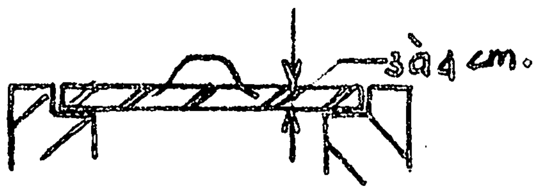
After the tests an end report has to be written describing the results and used constructing methods. Exact information about used tools, materials and labour has to be added. It is useful to draw standard designs for ferrocement constructions with its reinforcement and formwork.
Photos have to record the tests for the visual lay-out.

10.2. TEST 1: Ferrocement slab for valve boxes.



reinforcement

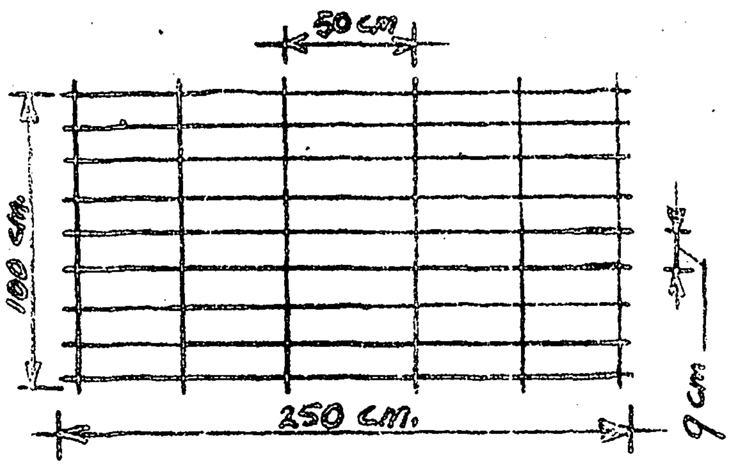
- 6 mm steelbar is used
- square netting
- both sides of the reinforcement chicken wire
- cement mortar has to be trowelled in the reinforcement



slab on valve box

- proper slab construction

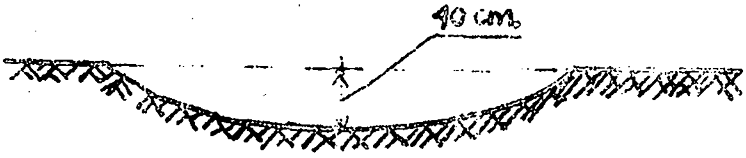
Ferrocement slab for tank roof.



reinforcement

- 6 mm steel bar is used
- two layers of chicken wire mesh
- By varying the amouth of reinforcement it is possible to find the economic ratio

Ferrocement arch.



the form in the ground

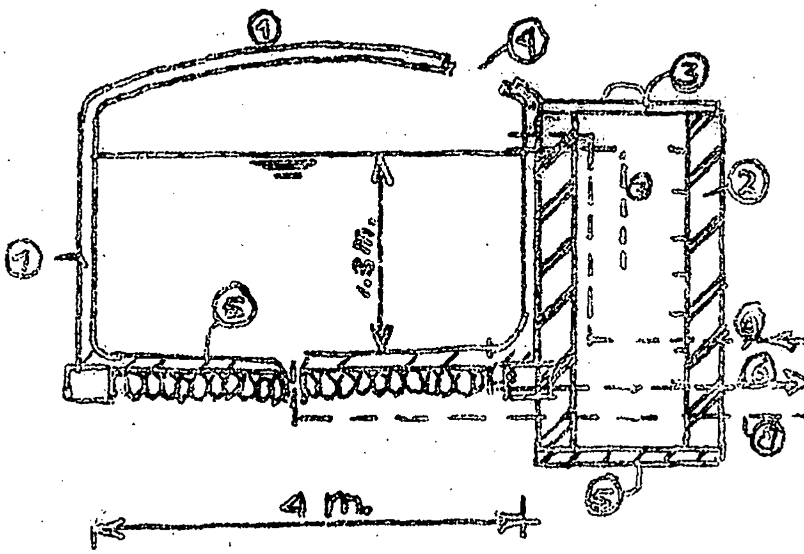
A ferrocement arch is easy to be construct.
- make a form in the ground properly
- lay a piece of plastic on the earth
- place the chicken wire in the form
- on the chicken wire the reinforcement
- lay the second chicken wire and fix it to the others.
- trowel cement mortar in the reinforcement
- after 1 or 2 days lift the arch and trowel it smoothly
- place it on the walls of the tank.

A arch is stronger than a slab.
One slab or arch of ferrocement will be weight about 75 kg.

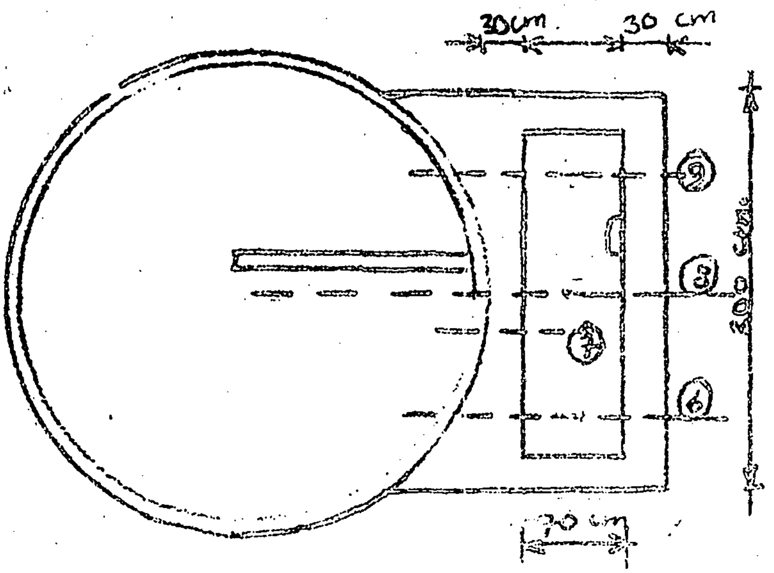
10.3. TEST 2: Ferrocement tank (15 m^3).

To show the possibilities with ferrocement for tanks a demonstration model is needed.
The form for the wall can be constructed in the bazar in Pokhara probab ly, otherwise in BTI in Butwal.
The réof forms can be cut on the project side. The sheets can be bought in the bazar, as well as the piling.

the demonstration model



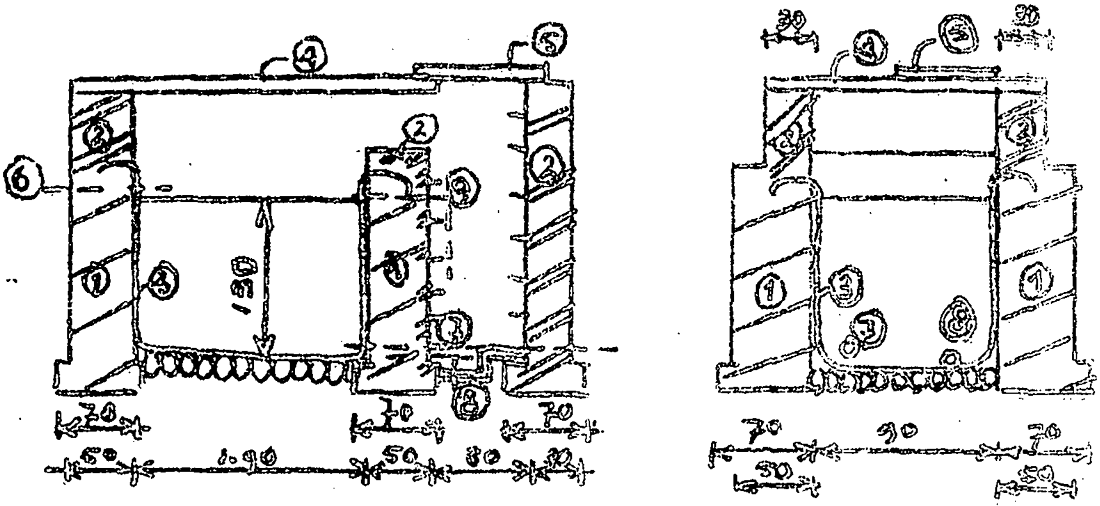
1 ferrocement roof and wall.
2 cement mortar masonry
3 ferrocement slab
4 manhole
5 concrete
6 supply pipe
7 overflow pipe
8 cleanig out pipe
9 inlet pipe



10.4. Test 3: Plastic sheet tank (2.5 m^3).

Seeing the results in Syang of the use of plastic in the tank, it is recommended to construct a demonstration model.

the demonstration model



1 mad masonry
2 cemnet mortar masonry
3 plastic sheet
4 ferrocement slab or arch
5 " slab
6 inlet pipe
7 supply pipe
8 cleaning out pipe
9 overflow pipe

TEST 4: Rice husk lime cement.

The accent of this cement test will be laid on the aspects of production of the rice husk lime cement,
the quality of the cement.
workpossibilities with rice husk lime cement.
water sealing with th e cement.
By building a small tank these aspects will be cleared.
The small tank can be built exactly according to the Pokhara standardization ($2.5\ m^3$).

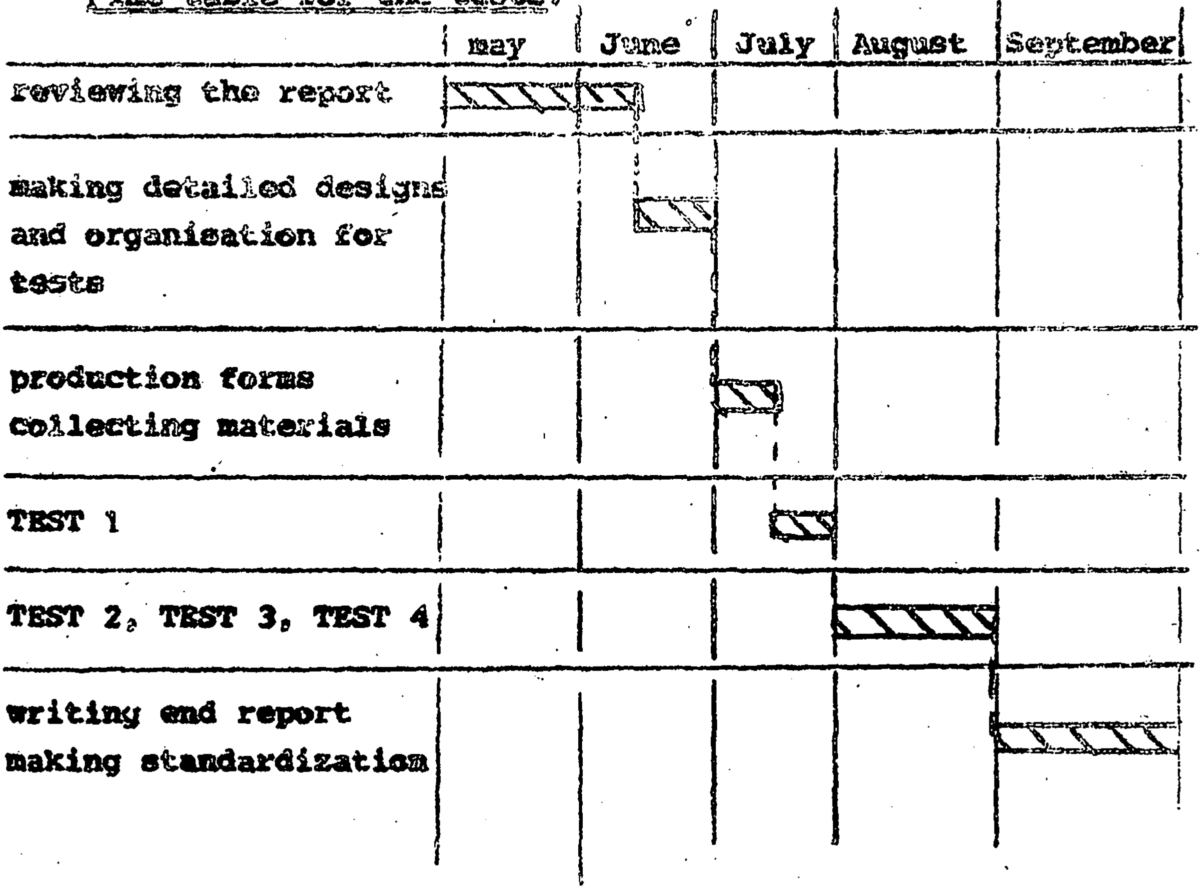
10.5. QUANTITIES for tests.

material and labour	unit	TEST 1 ferrocement slab and arch	TEST 2 ferrocement tank 16 m^3	TEST 3 plastic sheet tank 2.5 m^3	TEST 4 rice husk lime cement tank 2.5 m^3
stones	m^3	1	10	20	13
sand	m^3	1	4.3	0.8	4.4
gravel	m^3	-	6.4	0.4	1.1
cement	bag of	10	29	6	-
rice husk lime cem	50 kg.	-	-	-	25
steel bar 4mm.	m	-	535	-	-
steel bar 6mm.	m	300	-	for fc. slab	for fc. slab
chicken wire mesh	m^3	40	50	-	-
plastic sheet	m^2	-	-	12	-
glue	tin	-	-	1	-
forms	-	-	needed	-	-
mason	MD.	8	33	32	22
stone cutter	MD.	-	10	12	12
carpenter	MD.	-	10	-	-
labourer	MD.	10	62	61	51
supervision	WEEK	2	4	4	4
minor items	-		fittings wire mesh 10 mm steel rod	fittings wire mesh 10 mm steel rod	fittings wire mesh 10 mm steel rod

Cost for HMG.

material and labour	rate Rs/unit	TEST 1 ferrocement slab and arch	TEST 2 ferrocement tank 16 m^3	TEST 3 plastic sheet tank 2.5 m^3	TEST 4 rice husk lime cement tank 2.5 m^3
stones	150	150	1500	3000	1950
sand	60	60	258	48	264
gravel	150	-	960	60	165
Nepal Portland cem.	76	760	1748	456	-
rice husk lime cem.	?	-	-	-	25000
steel bar 4 mm	0.3	-	1605	-	-
steel bar 6 mm	0.3	900	-	-	-
chicken wire mesh	10	400	500	-	-
plastic sheet	41	-	-	492	-
glue	50	-	-	50	-
forms	2000	-	2000	-	-
mason	30	240	990	660	660
stone cutter	25	-	250	300	300
carpenter	30		300		
labourer	20	200	1240	1220	1220
supervision	-	LDD staff	LDD staff	LDD staff	LDD staff
minor items		200	500	500	500
	total	2910	11851	6786	30059

Time table for the tests:



11. Summary.

This report deals with several tank constructions in Nepal.
Sometimes the tank functions are unsatisfactory, espially the sedimentation function.
The valve boxes attached to the tank are overall bad constructed, the maintenance of the tank and operating of the valves are difficult.
The GI-sheet roofs can maybe improved to avoid oxidization and insects of entering.
Ferrocement slabs for valve boxes and ferrocement slabs or arches for tank roofing are proposed alternatives.
Circular tank walls, the use of plastic lining for sealing tank walls and ferrocement tank are possibilities to construct a reservoir water tank with as result less use of material, labour and cost for CWS.
Instead of Portland cement rice husk lime cement can be introduced for masonry and plaster work.
By constructing better valve boxes the maintenance of a tank will be easier.
Tests have to prove and to show the possibilities of the alternatives.
Also the test constructions wil have a demonstrative function for people concerned with the Community Water Supply- program.

12. Main sources of information.

1. Local Development Department in
   Pulchok, Pokhara, Nepalganj and Biratnagar.
2. UNICEF Kathmandu
3. SATA Kathmandu
4. American PEACE Corps Kathmandu
5. German Volunteer Service Kathmandu
6. RECAST, Kirtipur *
7. Gobar Gas Butwal
8. " Ferrocement watertank and their construction" by
   S.B.Watt of Intermediate Technology Publications
   9 King Street
   LONDON WC2E 8HN, UK.
9. " Ferrocement appications in developing countries"
   National Academy of SCiences
   2101 Constitution Avenue
   Washington DC 20418, USA.
10. " Village water systems, a technical manual for Nepal
   and Bhutan" by UNICEF, Box 1187, Kathmandu, Nepal.
11. Rural water supply; Standardization
   LOcal Development Department, Pokhara.
12. "Technical Training Manual" no 1,2,3,4 and 5 by LDD,
   SATA and UNICEF.
13. Journal of ferrocement (vol.8) no 1 January 1978.

* also Building Research Station. Lahore