



UNIVERSITY OF NAIROBI
HOUSING RESEARCH AND DEVELOPMENT UNIT

P. O. BOX 30197 NAIROBI KENYA TELEPHONE 27441 EXT. 212 TELEGRAMS VARSITY

APPROPRIATE BUILDING TECHNOLOGY:

The Katangi Agricultural Project

of the

Undugu Society of Kenya

UNIVERSITY OF NAIROBI
ADD LIBRARY

Author: Hans Teerlink (Undugu Society of Kenya)
in collaboration with
P.A. Erkelens (H.R.D.U.)

November 1980

University of NAIROBI Library



0356456 4

Housing Research and Development Unit

Director: T.S. Chana

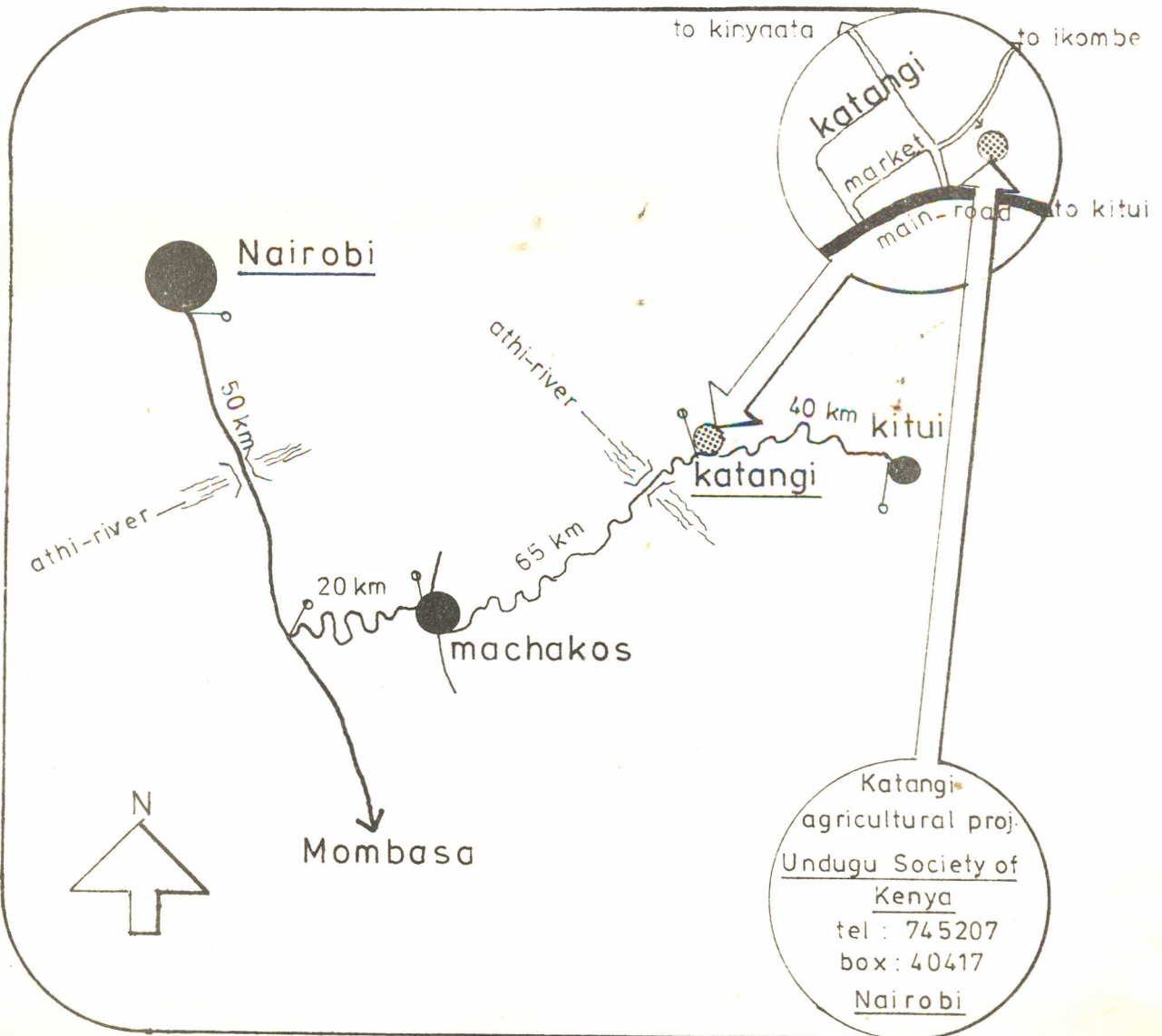
P.O. Box 30197, Nairobi, Kenya. Tel. ²⁷⁴⁴¹~~27441~~ ext. 212.

UNIVERSITY OF NAIROBI
LIBRARY

PREFACE

The Agricultural Project in Katangi, Machakos District, is one of the projects undertaken by the Undugu Society of Kenya. (See also appendix E). Besides the agricultural aspects of this project also some buildings had to be constructed. This report discusses the buildings: staff houses, a house for the ex-parking boys community and classrooms. Chapter One gives the background of the building project while the other chapters deal with the construction of the buildings. Basic appropriate building techniques and construction methods were applied in this project. The H.R.D.U. is therefore pleased to publish this report to highlight the application of its research findings by non governmental organisations such as the Undugu Society. It is hoped that the publication of this report will encourage other institutes to undertake these kind of demonstration projects, where research findings can be effectively applied.

T.S. Chana
DIRECTOR



Contents	Page
<hr/>	
<u>PREFACE</u>	
1. <u>BASIC INFORMATION</u>	1
1.1 Introduction	1
1.2 Objectives for the building design	1
1.3 Concept, experiment and goal of the buildings	2
2. <u>LAYOUT AND DESIGN</u>	3
2.1 Description	3
2.2 Drawings	4
3. <u>BUILDING SYSTEM</u>	7
3.1 Description	7
3.2 Evaluation	8
3.3 Pictures	9
4. <u>ROOF</u>	11
4.1.1 Description of roof/structure	11
4.1.2 Evaluation	11
4.2.1 Description of roof covering	12
4.2.2 Production	12
4.2.3 Evaluation	12
4.3 All-in costs of the roof	14
4.4 Pictures	16
5. <u>WALLING</u>	31
5.1 Description	31
5.2 Evaluation	31
5.3 Pictures	34
6. <u>RAINWATER STORAGE AND SUPPLY</u>	39
6.1 Description of the system	39
6.2.1 The above ground ferrocement watertank	39
6.2.2 The underground ferrocement watertank	39
6.3 Pictures	42
7. <u>FINANCIAL EVALUATION AND RECOMMENDATIONS</u>	45
7.1 Cost breakdown of the Katangi experimental house per square meter plinth area	45
7.2 Recommendations for future adjustment of this house in relation to rural or urban areas	45
7.3 Price comparison of the house in relation to other construction methods of housing	48

8.	<u>APPENDICES</u>	<u>Page</u>
A.	The costing of sisal-cement roofsheets compared to other types	49
B.	The costing of sisal-mud block wall compared to other types	51
C.	The costing of ferro-cement water tanks, compared to other types	53
D.	Cost breakdown of different construction methods of housing per square meter plinth area	57
E.	The Undugu Society of Kenya, its philosophy and programme	59
9.	<u>REFERENCES</u>	63

1. BASIC INFORMATION

1.1 Introduction

The Undugu Society of Kenya is probably one of the few institutions to adopt new building methods in one of their projects. New projects, during preparation, often tend to be based on the conventional building methods once they have obtained the finances, which is money and skilled-labour absorbing process.

This is of course acceptable when there is sufficient money and skilled labour. But in many rural areas or market-centres, skilled labour is either scarce or unavailable, and thus the conventional building materials and skilled labour have to be imported from urban centres. In this way "beautiful buildings" are set up for the local community to admire, but never within the financial reach of an individual. Besides, the community will not grow up into an improved low-cost-housing system.

1.2 Objectives for the building design

The Undugu Society of Kenya expressed two basic objectives to be achieved in the building process. These were related to the society's interest in community development and involvement:

1. To make use of the available local labour (which was mainly unskilled), not only for reasons of local employment (temporary) but mainly to involve the whole locality in a building experiment, from which they will benefit even after completion of the buildings. This would involve the following objectives in the building design:
 - (i) simple construction details would be chosen
 - (ii) avoid the usage of many different details and keep the options limited.

2. The location should benefit as much as possible from the capital investments. This would involve the usage of:
 - (i) natural-local-available materials
 - (ii) materials available from the local suppliers
 - (iii) local available transport (lorry, tractor, ox, donkey)
 - (iv) local fundis, workgroups and institutions (e.g. a Village Polytechnic) for sub-contracts.

1.3 The concept, experiment and goal of the building

The basic concept in the construction of the houses is to create a long-lasting-low-cost house, by combining a conventionally built central core, - which acts as a central stabilizing unit and is built with permanent materials by skilled labour (kitchen, fireplace, washing place, shower, - and the (main) additional part of the house, built with improved local building materials, built (partly) by self-help (unskilled) construction.

The basic experiment in these buildings is to realize the above described concept, by making use of existing knowledge from different institutions in Kenya which do research or experiments in the field of low-cost constructions.

(References 1,2,3,4,5.).

The goal is to combine the otherwise fragmented research knowledge in one house, and uplift their results to a practical realization. In this way (although Undugu is a charitable organisation) it can still contribute in finding a practical solution for the existing housing problem in Kenya.

2. LAYOUT AND DESIGN

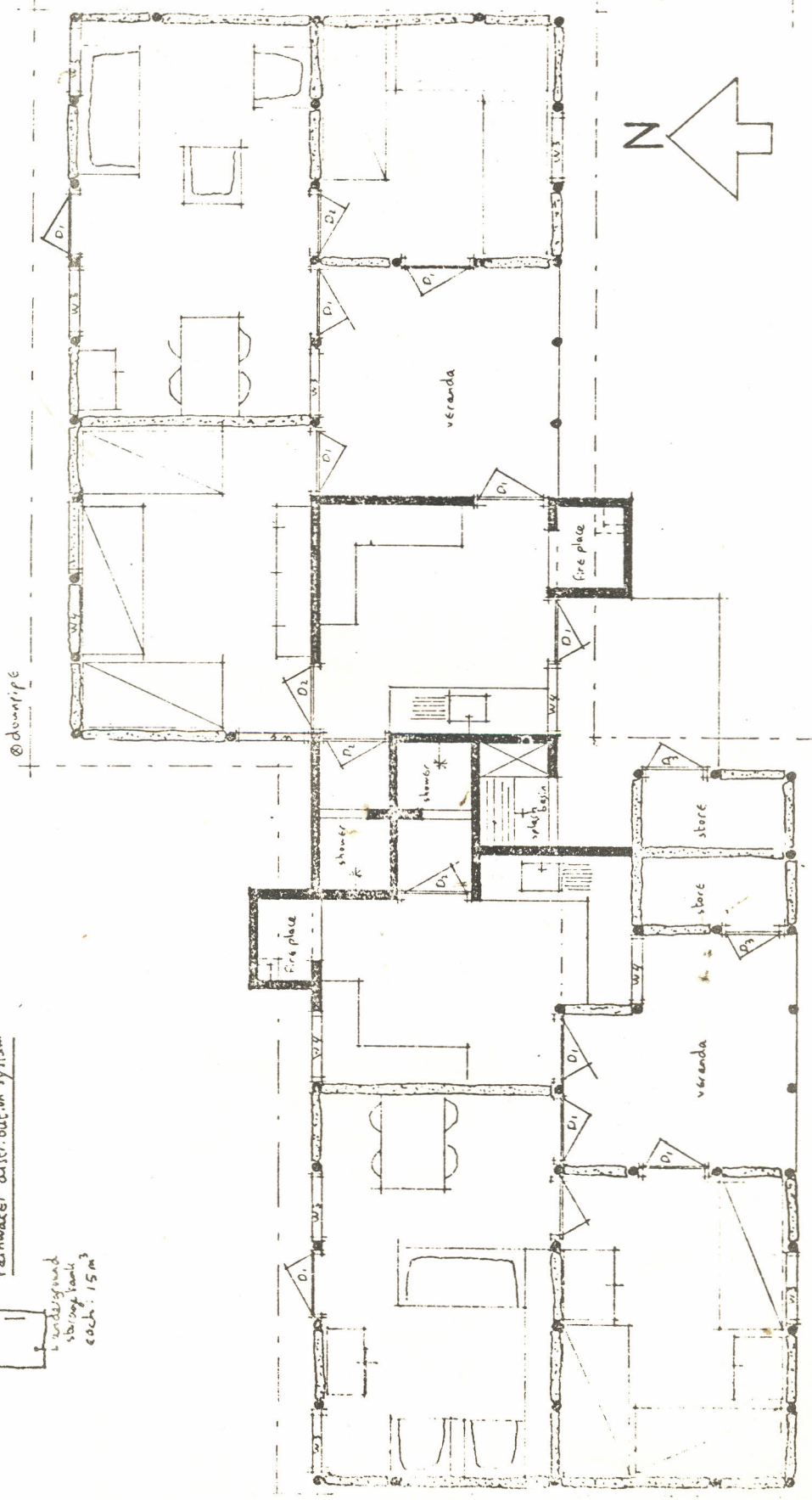
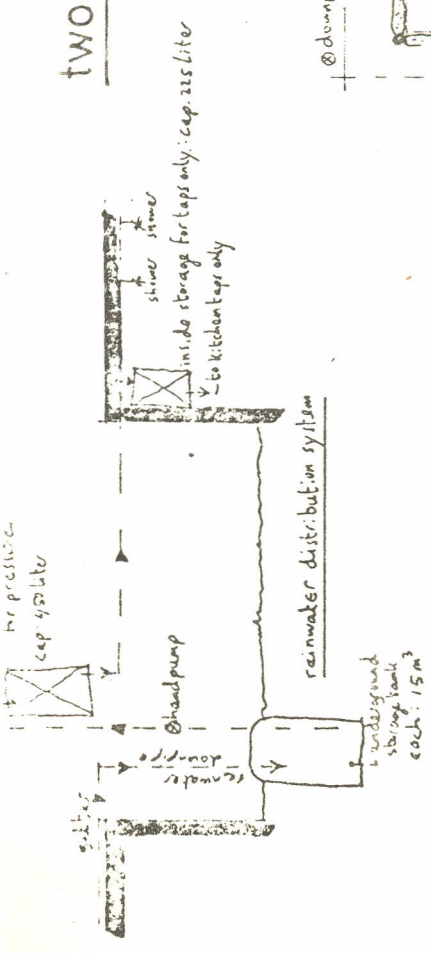
2.1 Description (see also drawings E₁, S₁ and C₁ on the next pages)

- The central core (the dark lines in the drawing) and especially the washing places and shower, need such a position and accessibility that both an integrated (community) or separated use of a house (bachelors or subtenancy) is possible. In the existing designs the same central core serves in three different house-types:
 - integrated use of core in community house (drawing C₁);
 - separated use of core in house with sub-tenant rooms;
 - separated use of core by two households (drawing E₁)
- The family houses to have an outside area (verandah) near the kitchen. The accessibility to the other rooms through this verandah so as to allow a separate use of the different rooms (i.e. the boys, wives, children).
- All rooms are designed according to the space standards as set in the Grade II-Bylaws of the Kenya Building Code.
- The dimensions of the rooms are related to a bedspace of 1 x 2 meter, to allow for an optimum number of beds.
- Window openings are mostly placed in North and South elevation. The roof overhang is 50 cm.
- The livingroom is facing North, since the sun in the the northern hemisphere during the cold season.
- Since Katangi has no piped watersupply scheme, the whole roof area is used for rainwater collection; thus sufficient water storage facilities have to be created. (See Chapter 6.).
- The positions of the gutter and the watertap points are designed to reduce the length of gutters and waterpipe to a minimum.

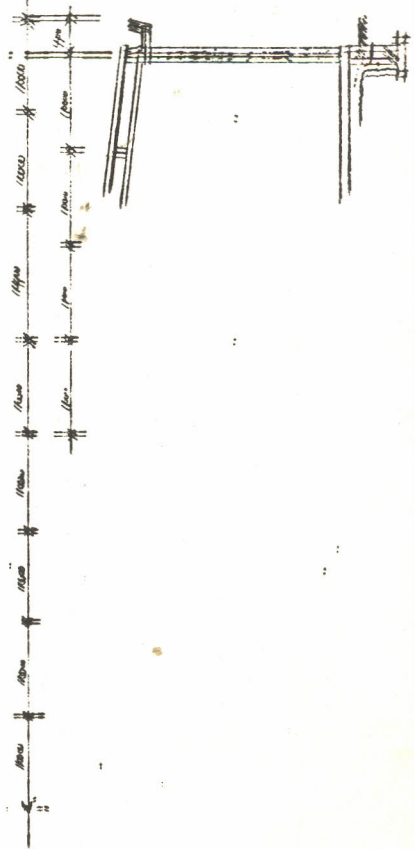
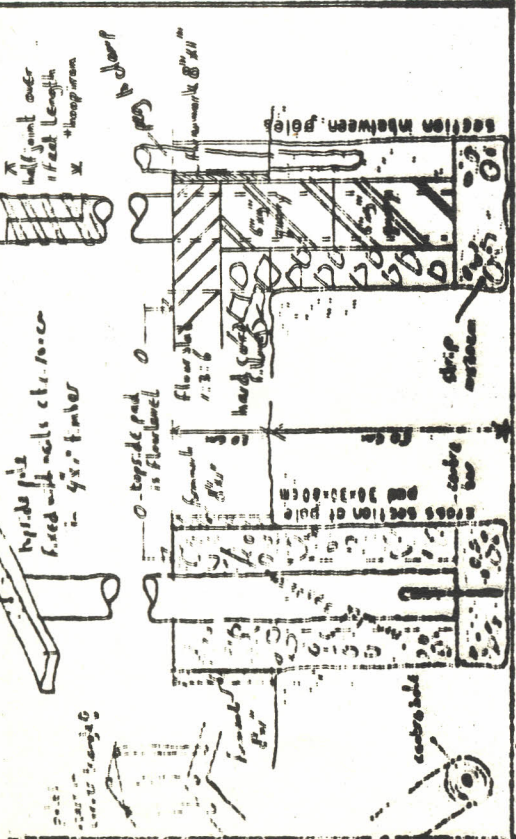
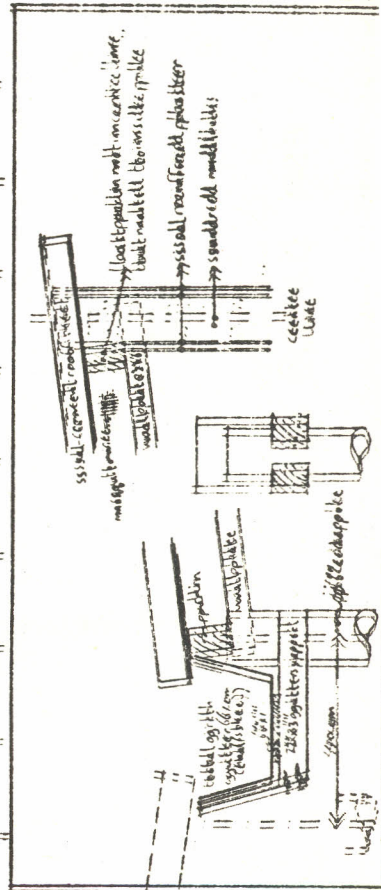
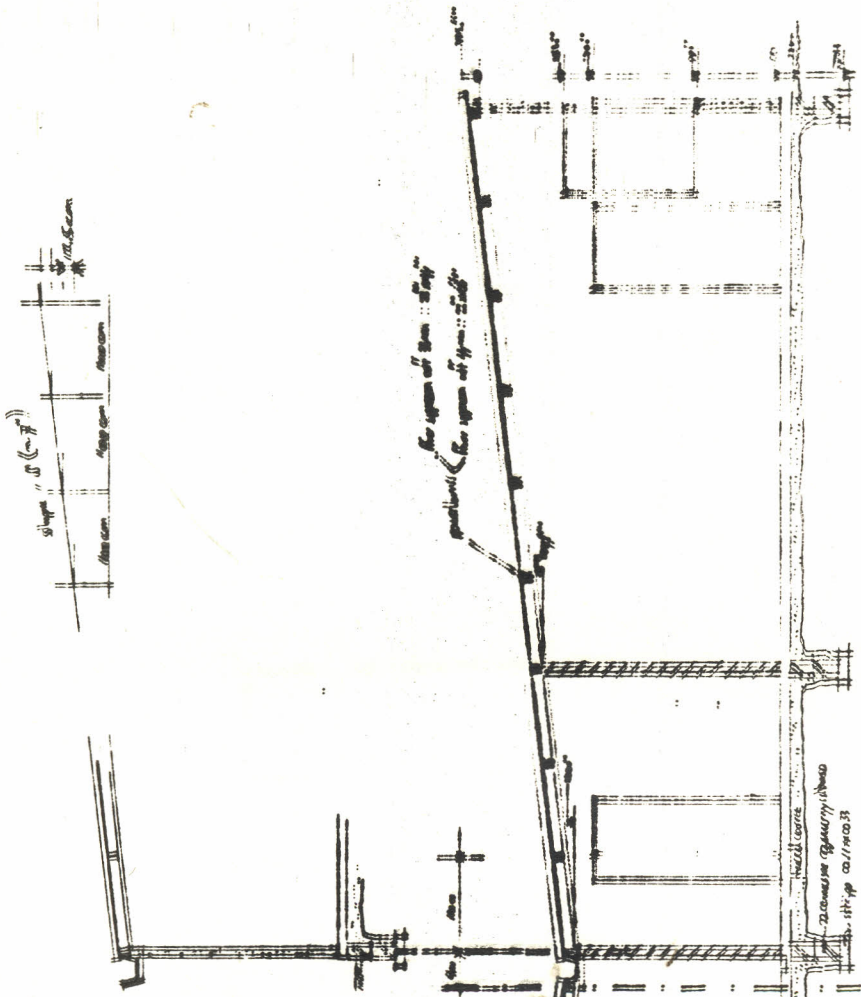
2.2 Drawings, see pages 4, 5 and 6.

two families separate use

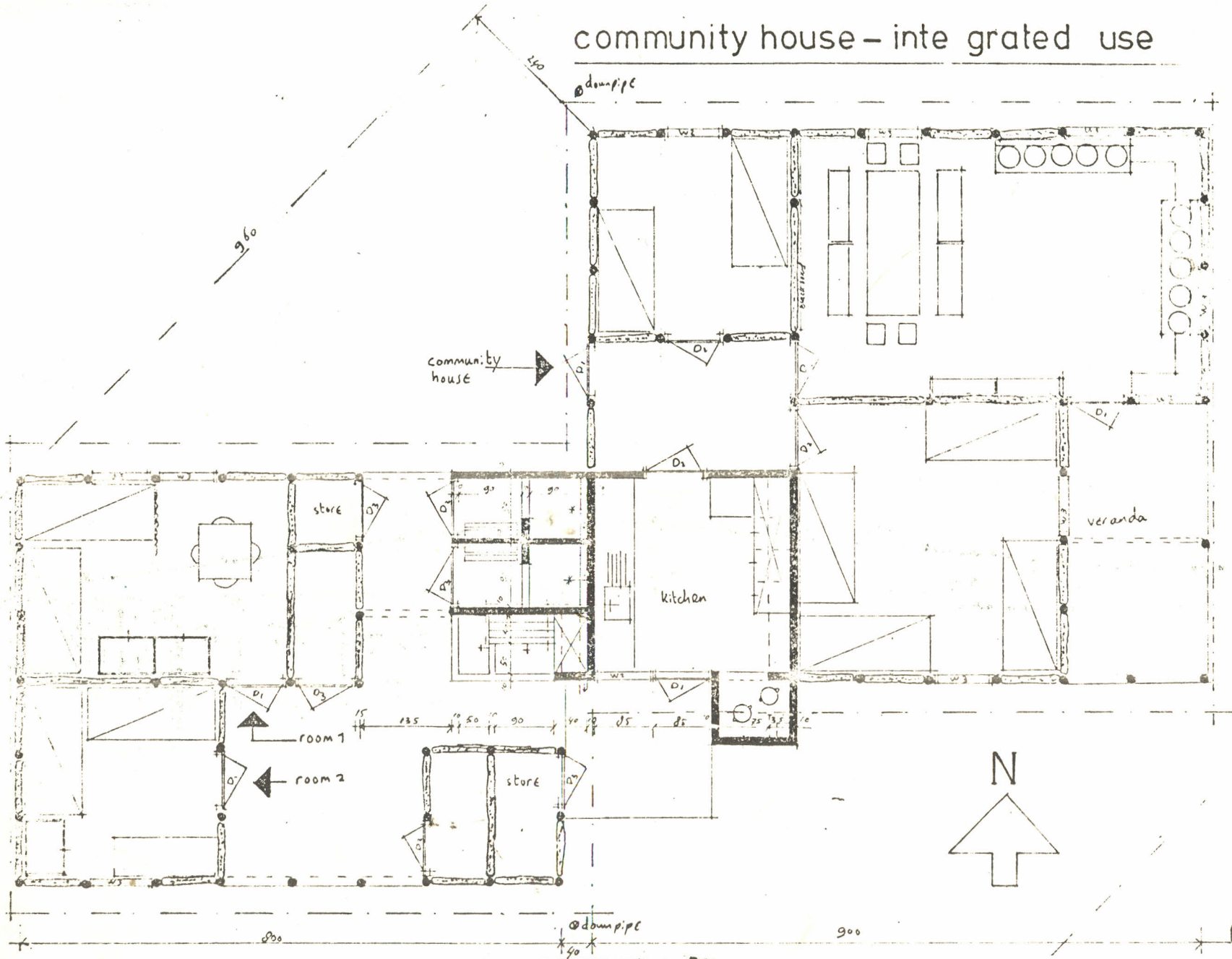
undugu 'cultural project' (M.A. (Arch)) Katanji, 2001, 1998



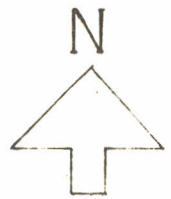
3x100
 9x100
 9x100
 @down pipe
 @down pipe



community house - integrated use



undugu' agricultural project - integrated use - katangi



3. THE BUILDING SYSTEM

3.1 Description

- The shower and kitchen (the central core) is built in quarry stone and acts as a central stabilizing unit for the whole house. (see ref. 1.)
All the other rooms can be built in locally available materials. For this, a construction of cedar poles was chosen (nearest to the traditional building-method), clamped in concrete pads, spaced at 1 meter from each other. (see picture 1.).
In between the poles there is a wallfilling constructed of sundried mud-blocks, reinforced with sisalfibre in the joints. (see ref.5 and Chapter 5 and picture 2).
A single pitched roof (easiest in details) with only straight purlins and wallplates is fixed on top of the poles.
- The advantages of using the cedarpoles for structural purpose, and the mudblocks for wallfilling are:
 1. Reduction of total building time, as after setting the poles, both wallfilling and roof-construction can be done at the same time (see picture 3); and
 2. In case of regular rainfall (which could destroy the sundried mudblocks, depending on the sand/clay ratio of the soil), it is possible to allow first the completion of the whole roof, after which the wallfilling procedure can start (see picture 4).
- A module of one meter (see 2.1) is used in the design. However, one deviation of 40 cm is introduced in the system at the partywall: to allow the external rainwater collection gutter to run unobstructed in between the butterfly roof, without changing the details of the gutter or roof at this particular section.
- A separate pad foundation for each single pole should have been sufficient (the traditional method). However to make the work of lining and spacing of the poles easier and still accurate (all door and window frames have to fit in between two poles) a trench of 30 cm wide and 50 cm deep was first excavated.

Then a concrete strip of 10 x 30 cm was made, in which iron bars were fixed at 1 meter centre to centre for the cedar poles. After erection of the cedar poles, the base of each pole was surrounded with concrete (30 x 30 x 60 cm).

- Setting and leveling during the building construction is reduced to the minimum; only once in the beginning: the 10 x 30 cm concrete strip is leveled accurately. The floorlevel is now fixed by the topside of the concrete pads; and the roof level is fixed by the length of each cedar pole.

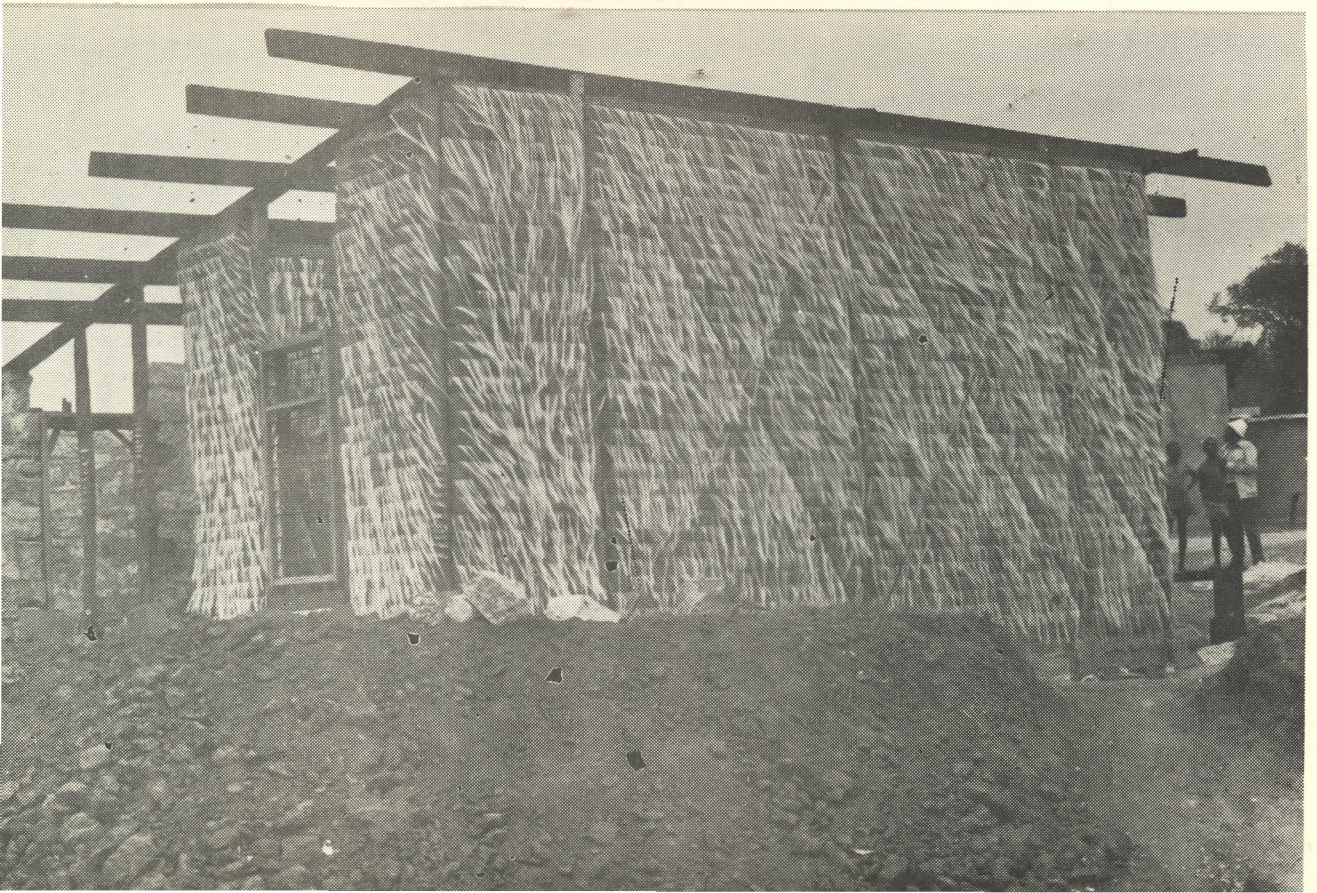
3.2 Evaluation of the building system

- The construction of the cedar poles clamped in the concrete pads, provides sufficient stability so that there is no need for the central core as stabilizing unit. Therefore the party wall only could be made of stone: not for stability purposes, but because the stone wall allows an easier installation of water-supply pipes.
- Also the opposite solution is possible: maintaining the central core out of stone, gives the opportunity to omit the cedar poles (supposing the advantage of finishing the roof before starting with the wall is not needed).
Considering the wood-conservation programme, the second solution is recommendable.

3.3 Pictures, see pages 9 and 10.



1. Foundation: Cedar poles, clamped in concrete pads spaced at 1 meter centre to centre.
2. The wallfilling inbetween the poles of sundried mudblocks; in the joints reinforced with sisal fibres.





3. After the foundation, the walling and the roof can be built simultaneously.

4. In case of regular rainfall, the roof can be finished first.

Note: the floorlevel is fixed by the topline of the concrete pads; the rooflevel by the length of each cedar pole.



4.2.1 Description of the roof covering

A solid smooth material is needed for rainwater collection. Corrugated iron sheeting is about the only possibility in rural areas (transport). However, research (see ref. 4 6) done on this, has led to a suitable alternative: locally made sisal cement roof sheets. These have the following advantages:

- They can be produced on the building site;
- They have a better thermal insulation; and
- Their total costs reach only 2/5 of the asbestos cement sheets and 1/2 of a corrugated iron sheet, gauge 26.

4.2.2 The production of the sisal cement roof sheet

For detailed information see, Swift, Mr. D.G. and Smith, Mr. R.B.L, The Construction of Corrugated Roofing Sheets Using Sisal Cement; (ref. 4).

The roof sheets are shaped similar to Asbestos 'Super-Seven' sheets. A sheet is 1.25 meter long and 0.95 meter wide, and takes:

- 14.5 kg. cement, in weight ratio (3); in volume ratio (2).
- 9.5 kg. sand, in weight ratio (2); in volume ratio (1).
- 5 liter water;
- 500 gram sisal: 160 gram 1" chopped, added to mortar
340 gram as long fibres in the sheet.

The total weight of one sheet is approx. 30 kg.

The series of pictures of the production (see 4.4) will provide more information on the production process of the sheets.

4.2.3 Evaluation of the sheets

The next summary of prices as per Jan. 1980 include materials, waste, transport to Katangi and production-labour for a roofsheet of 1 meter length:

- | | |
|---|------------|
| - sisal cement roof sheet (87 cm cover width) | KShs.20/- |
| - asbestos cement sheet (87 cm cover width) | KShs.49/- |
| - c.i. sheet gauge 26* (cover width 53 cm) | |
| calculated to a cover width of 87 cm | KShs.37/50 |

For more detailed costing see Appendix A.

* In many low-cost structures extremely thin sheeting is used. However a sheeting of lesser thickness than 0.5 mm (gauge 26) is not recommended for permanent structures.

The production of the roof sheets needed some experience. The quality of the first week's production was poor; sisal fibres came out to the surface of the sheet, and the last coat of the sheet (the compressive zone in the construction) was made too thin and caused hair-cracks during fixing. Almost each hair crack is a source of leakage. Some of these poor sheets could be repaired by applying a coat of cement-water, which penetrates properly in the hair cracks. Since the sheets have to be cured for seven days under water, the final result of a sheet is known after a week.

Therefore it is recommended to make a production only one or two sheets a day, for the first few weeks, in order to test the results before starting a full production.

The top side of the sheet is the first (bottom) layer in the mould: it is recommended to use at least 40% of the total mortar for this first layer. The third (top) layer on the mould is the bottom layer (or inside) of the final sheet. It is not very harmful when the mortar cover on the sisal is not 100% at this side of the sheet: the in-side and tensile zone.

Fixing of the sheets. It is rather common in building practice to make the holes (for fixing) in an asbestos cement sheet by carefully nailing and turning the roofing nail through the sheet at the same time. However when this procedure is applied on a sisal cement sheet it will cause hair cracks in the sheet. So it is better to drill holes in the sheet, or to prefabricate them. Each sheet is only fixed with two 4" nails at the topside, which can be covered by the next row of sheets on top. Only the top row of sheets on the roof, is fixed with the special roofing screws plus rubber cap.

The final strength of the sheets depends on the composition and mixture of the components, a proper curing, but also a proper quality of the sisal, cement, sand and water. Some information about the materials:

- Sisal, grade 3L (longest length), perfectly clean, washed and dried;
- Cement, from factory, to be dry stored;
- Sand, to be clean (no dust, silt or vegetable matter) and passing a 15 mm sand sieve; and
- Water, to be clean (without salt, silt or vegetable matter). Drinkability cannot be a measurement of cleanliness!

When starting a production in the rural area, it is recommended to have samples of the available sand and water tested in a laboratory (e.g. Ministry of Transport and Communication).

Note: A considerable decrease in strength of the sheets (even to the point of failure) was experienced when using water from a reservoir which was slowly by slowly more polluted: especially by silt, due to the drying-up of the water, and people walking in the water loosening the bottom silt. Especially the decrease of the initial strength after one day is rather dangerous, since, at that time the sheets are lifted and placed in the water basins. This movement could cause hair cracks.

Furthermore it is recommended to allow the sheets to harden in the envelope for 30 hours (in the shadow); after this period the plastic envelope can be removed, and the sheet cured under water for another 7 days.

4.3 All-in costs of the roof

The prices, as shown in Chapter 4.2.3., refer to the cost per running meter of sheeting, and 87 cm cover width. Alike the actual width and the cover width are different, the same counts for the sheet length and the cover length. The used roof pitch of 7° needs an end overlap of the sheets of min, 20 cm.

An asbestos cement sheet is manufactured in length upto 3 meter. Corrugated iron sheets are manufactured in length upto 3.5 meter. The length of a Sisal Cement Sheet however is limited by the longest length of a sisal fibre, and by the weight of the sheet; although the sheets of 1.25 meter are not defined as the 'limit of length!' it cannot be recommended to increase their weight much more.

Based on the above data, the next prices per square meter effective roof covering are as follows:

- Sisal Cement Sheet	KShs.28/75
- Asbestos Cement Sheet	KShs.62/75
- C.I. sheet, gauge 26	KShs.46/30

Note: A more complicated roof design, than the used single pitched roof, will affect, proportionally a sisal cement and an asbestos cement roof more, than a c.i. roof: ridge, eave and valley pieces are more expensive, and the cutting of the sheets is more labour intensive; the chance of damaging is higher.

The extra weight of the sisal cement sheets affects the size and the spacing of the supporting roofstructure, and will also affect the prices.

Table 1: Size and spacing of purlins in relation to the type of roofcovering.

type of roof material	purlin spacing (maximum)	purlin size	purlin meter price	price per square metre roof area
sisal cement	1.0 m.	6"x2"	7/65 KShs	8/50 KShs
asbestos cement	1.5 m.	5"x2"	6/35 "	5/00 "
c.i. sheets, gauge 26	1.5 m.	4"x2"	5/05 "	4/00 "

the span of the purlin is 4 meter from wall to wall.

Note: The price per square meter roof area only includes the timber-material. A more complicated roof design than the single pitched roof and an increment of the roof span (e.g. the use of trusses) will still increase the difference in price per square meter roof area. However a smaller span of the purlin than the used 4 meter will reduce the difference.

The extra weight of the sisal cement sheets does not affect the thickness of the commonly used walls in single-storey houses in the low cost sector (e.g. a 6" stone wall). Even the load-bearing capacity of a 4" stone wall will be sufficient.

The extra weight of the sisal cement sheets will only affect the size of a strip foundation, as commonly used in single-storey houses in the low cost sector (15 x 45 cm), in soils with a low bearing capacity (e.g. made up ground, alluvial, loose or wet clay and red soil; bearing capacity under 35 kN/m²). In all other common soils in Kenya even a concrete strip of 10 x 30 cm will be sufficient. (see ref. 3).

4.4 Pictures, see pages 16 upto 29.



5. The production place for the roof sheets

6. Volume batching of the sand. (box size: 180 x 180 x 200mm)





7. Volume batching of cement. (box size: 220 x 220 x 250 mm)

8. Chopping the sisal fibres of 1 inch length. 185 gram to be added to the mortar.





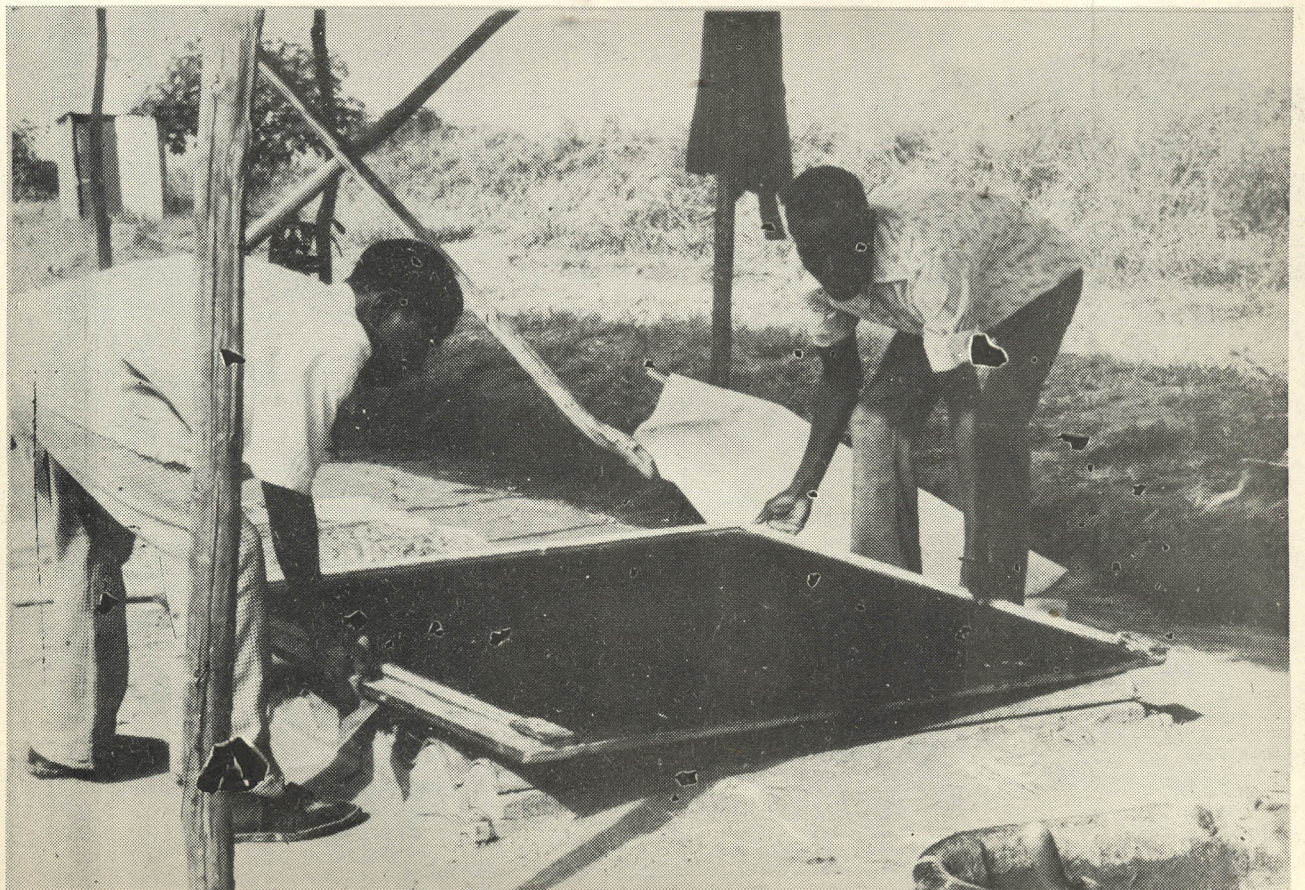
9. Dry mixing of the ingredients: sand, cement, chopped sisal.

10. Adding water to the mixing: 4 - 5 one litre tins.





11. Preparation: placing an Asbest Super Seven sheet of 1.25 cm length on top of a concrete mould.
12. Preparation: placing a plywood board on top of the asbestos sheet.





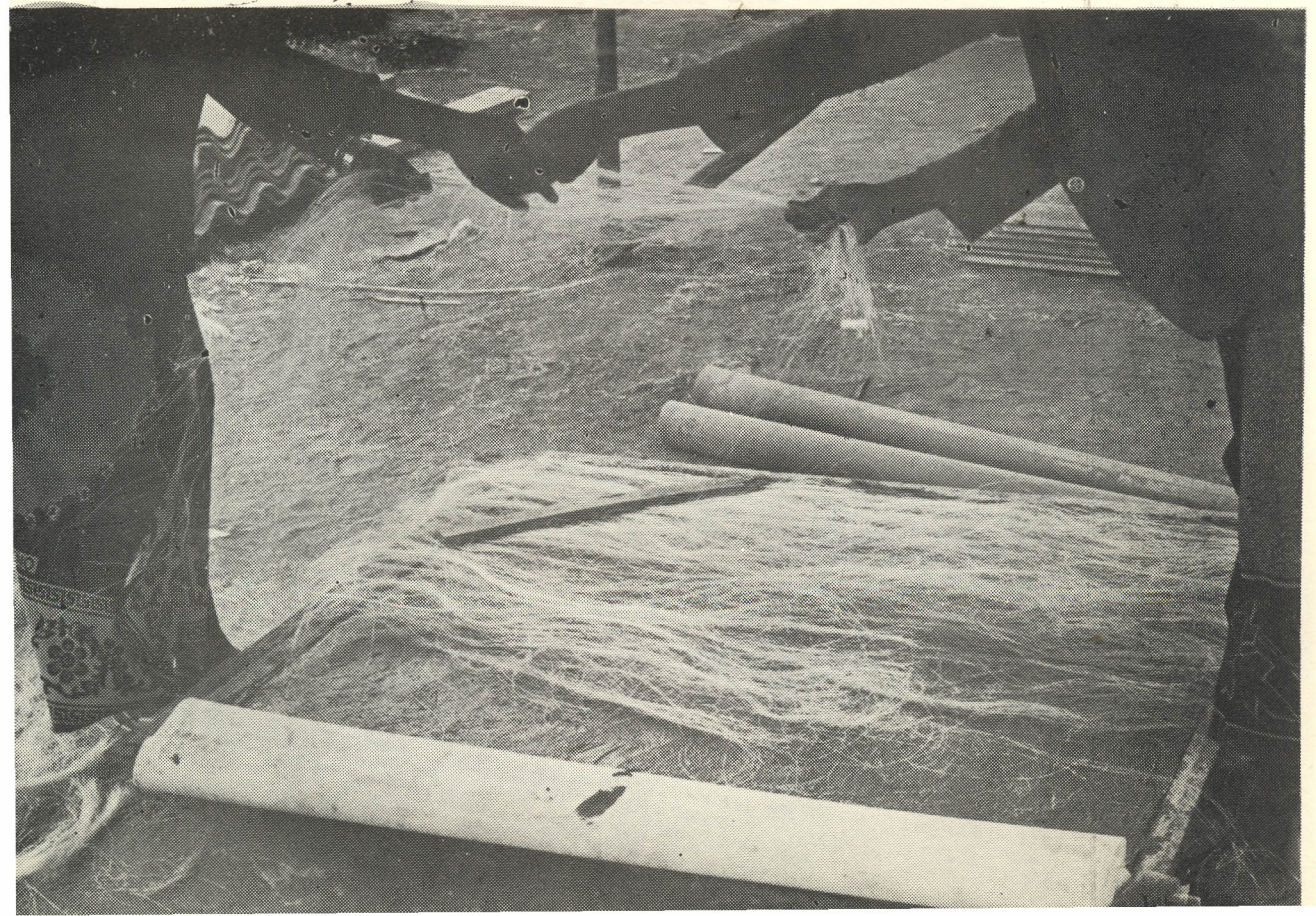
13. Preparation: placing a double plastic sheet (the envelope) on top of the board.
14. After unfolding the envelope, the first layer of the mortar can be spread. (40% of the total volume of mortar).

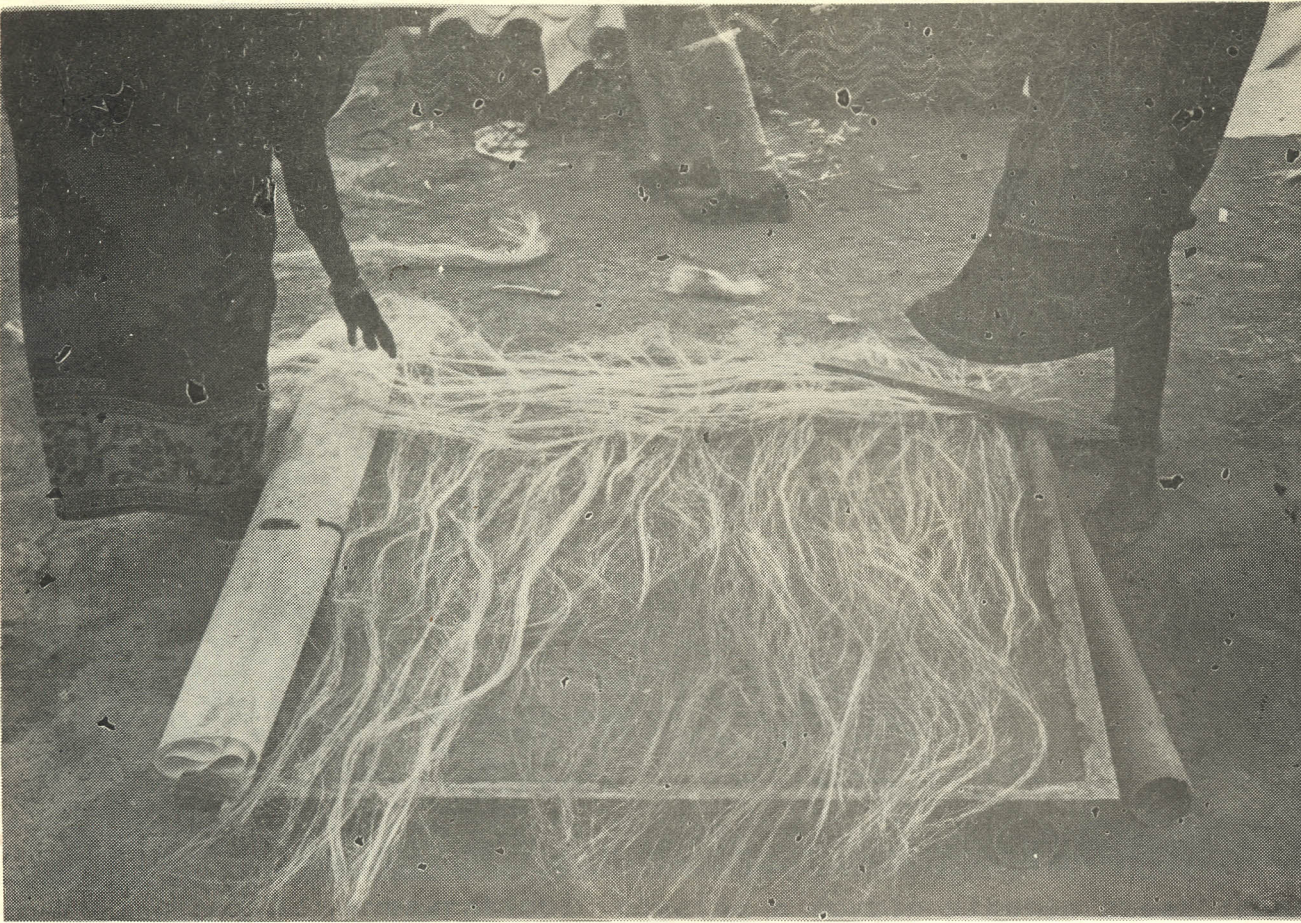




15. Weighing the long sisal fibres: 315 gram, to be divided in 4 bundles.

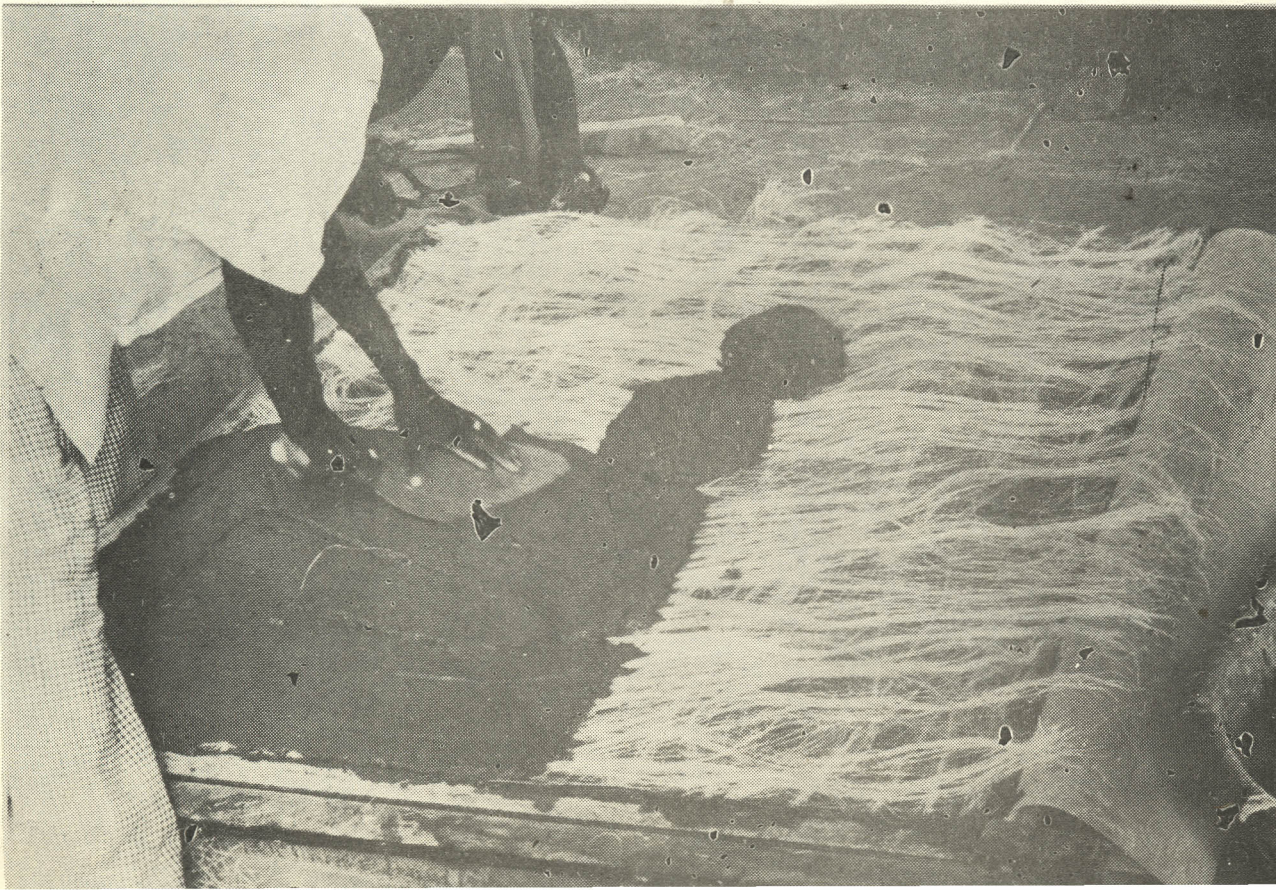
16. Placing the first sisal layer in one direction.





17. Placing the second sisal layer in the orthogonal direction.

18. Spreading of the second mortar layer. (30% of total volume) of the mortar.





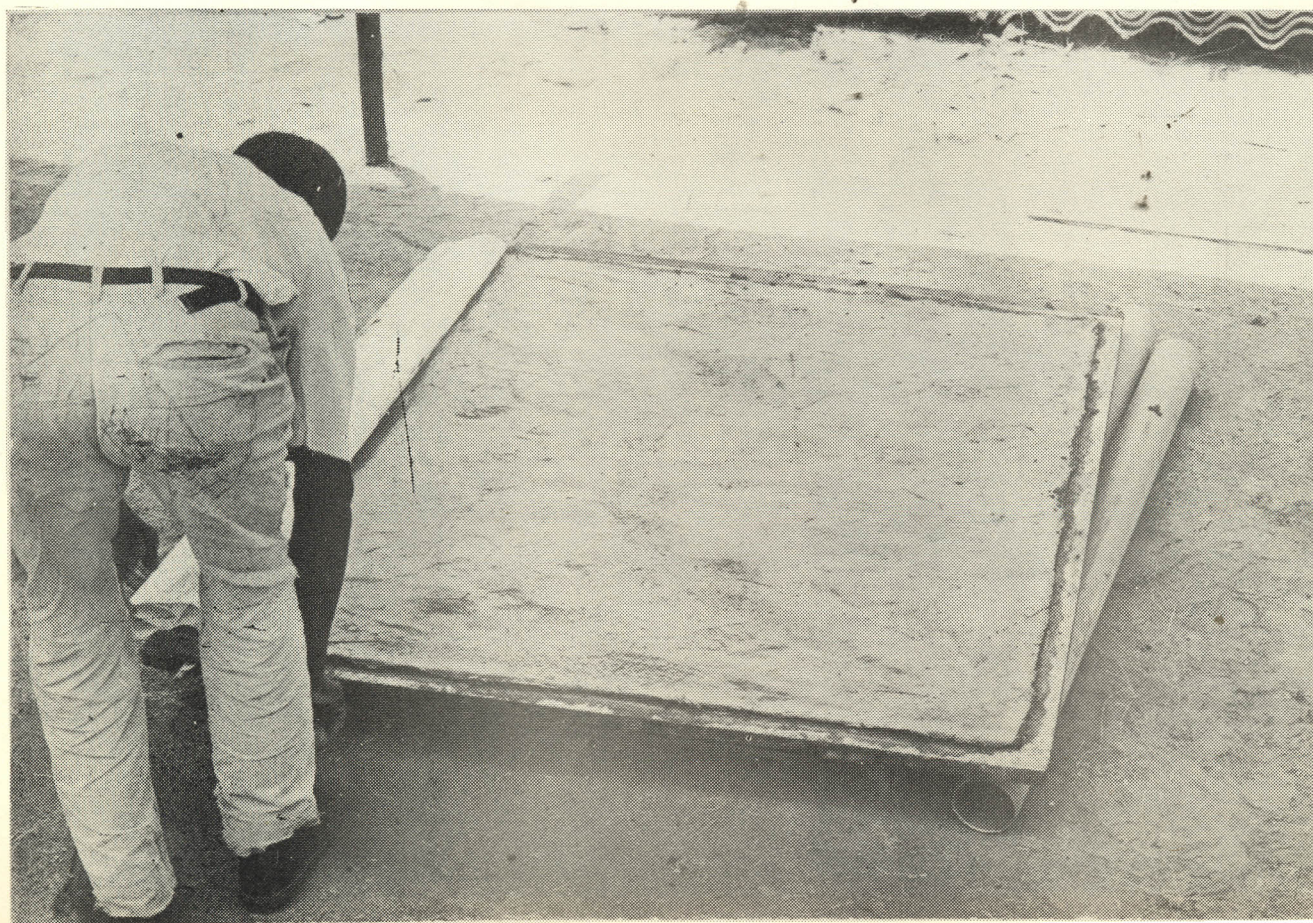
19. Placing of third sisal layer in one direction.

20. Placing of last sisal layer in the orthogonal direction.





21. Cutting of the overhanging ends of the sisal.
22. Application of the third (final) mortar layer.
(30% of the total mortar volume)

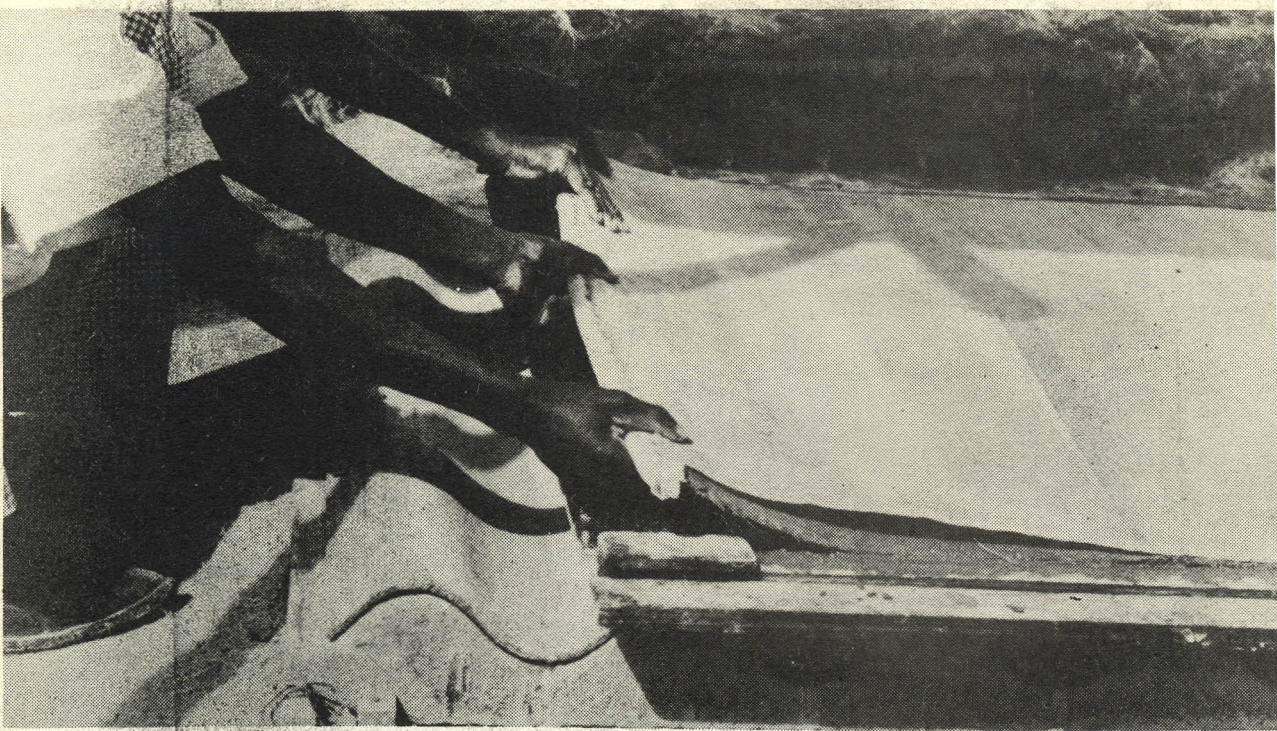




23. Closing the envelope by covering with the top layer of the plastic sheet.

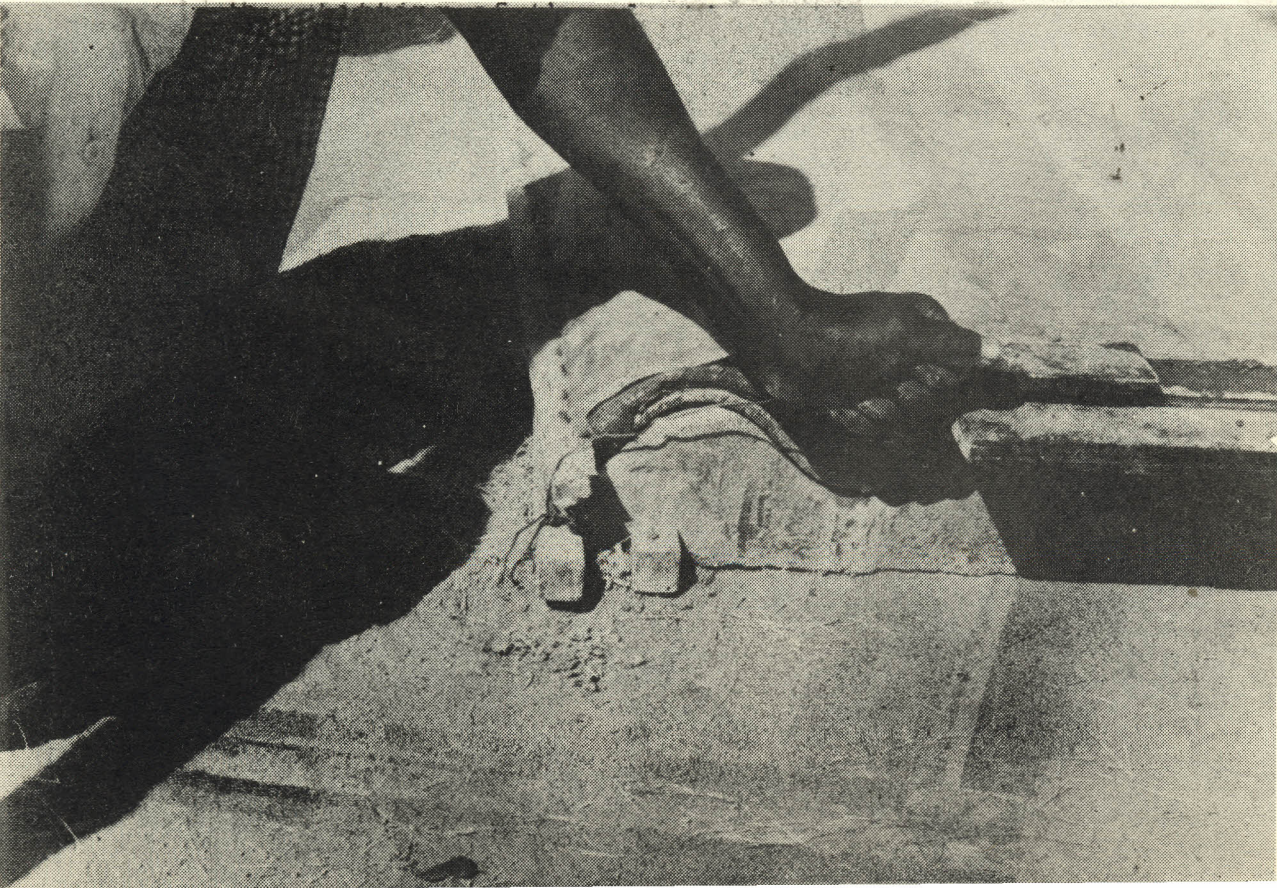
24. Smoothing and removing of air bubbles by a lino paint roller.





25. Lifting of the plastic envelope (with inbetween the plastic the layers of cement sand and sisal) from the board.

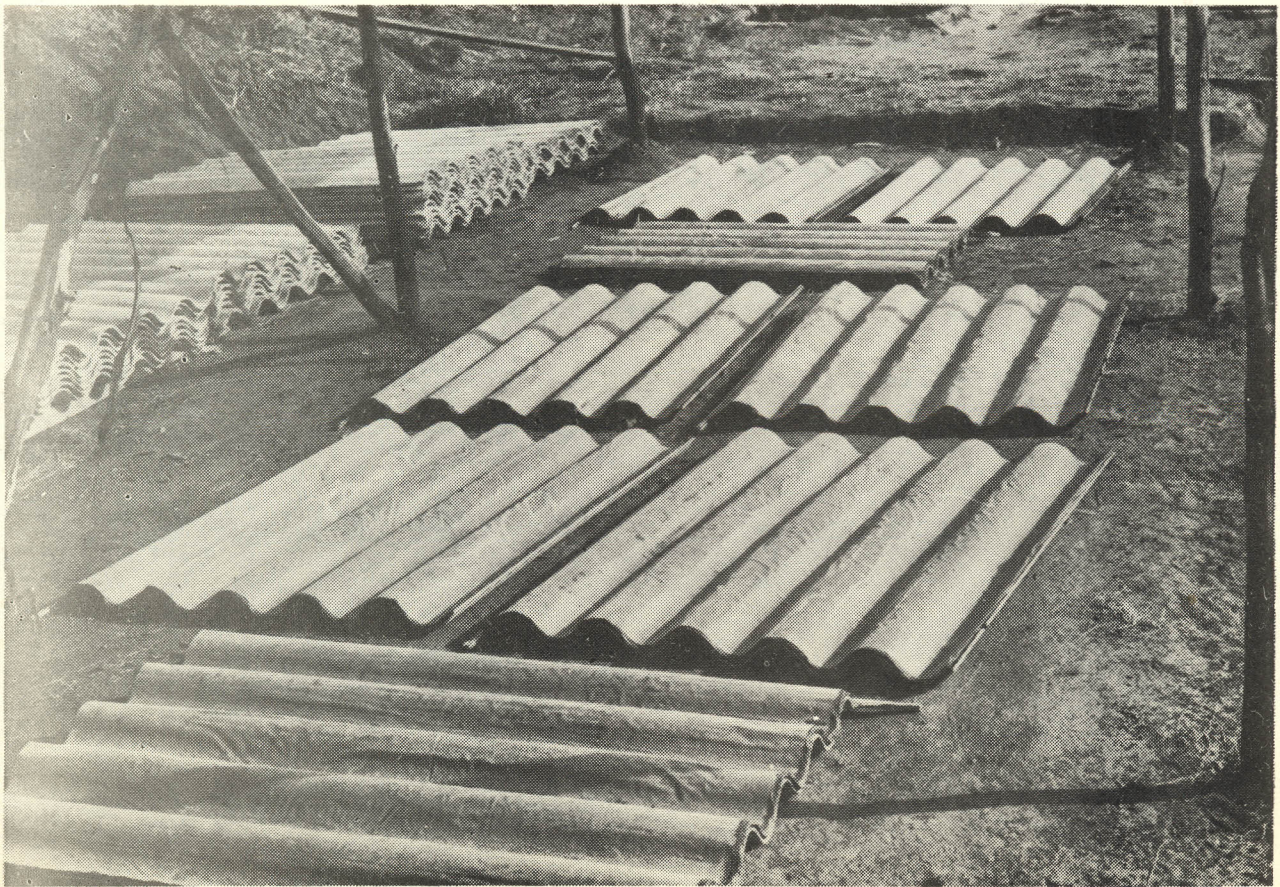
26. Fixing the envelope to the concrete mould.





29. The asbestos sheet which holds the new made sisal cement sheet is removed from the concrete mould.

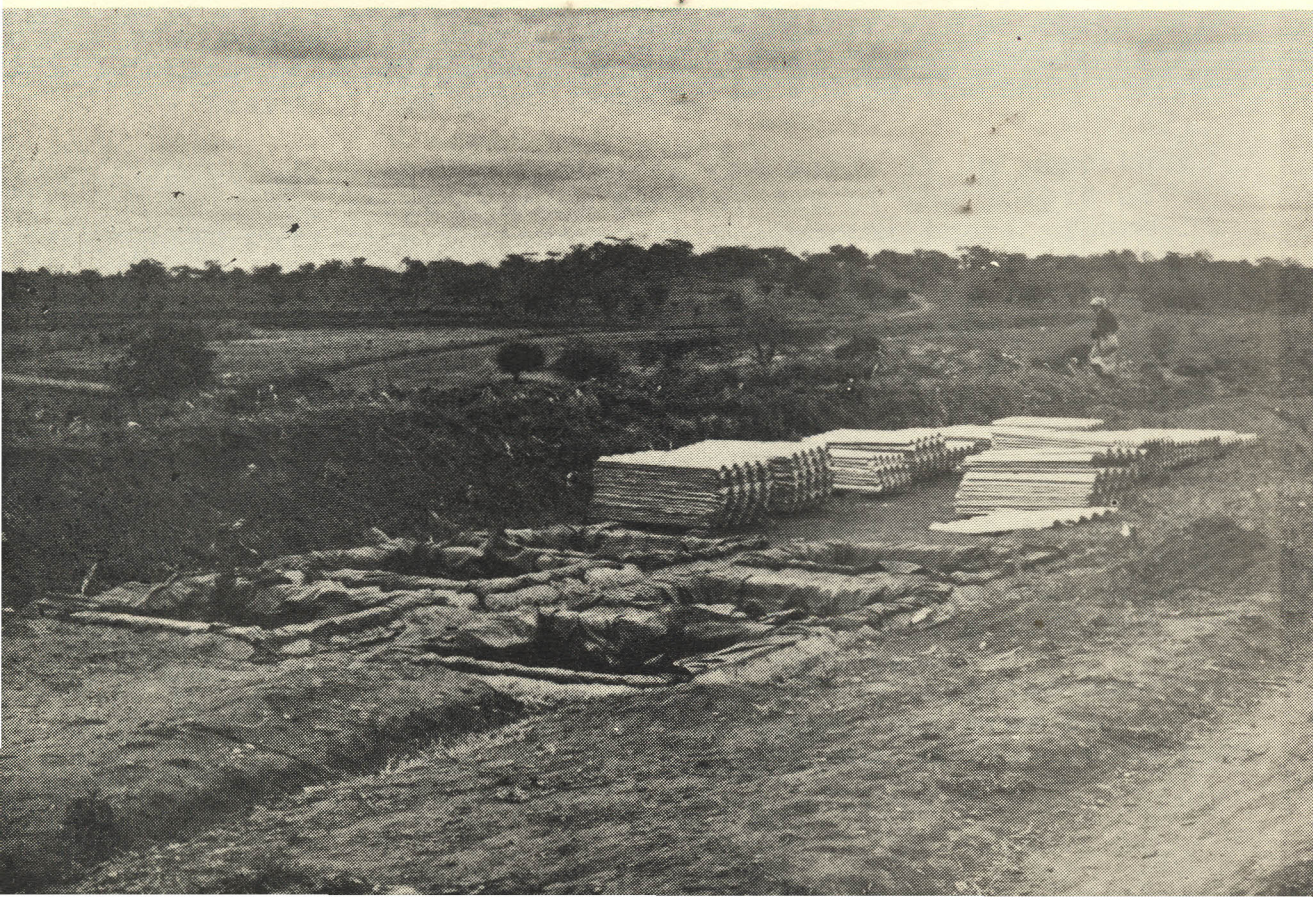
30. One day's production. Allow 30 hours for initial curing (harding).





31. After 30 hours hardening the sisal cement sheet can be removed from the asbestos sheet, then the plastic envelope is moved, and the sheet is then placed underneath water to allow curing for another seven days.

32. Overview of the curing and storage of the sheets.



5. THE WALLING

5.1 Description

Walling system: Cedar poles, clamped in concrete pads at 1 meter spacing from each other, and a wall filling (in between the poles) of sundried mud-blocks stapled without mortar in the joints; but with sisal fibres, (500 gram sisal fibres of 1.5 - 2 feet length, per one square meter of wall), distributed over the horizontal joints and hanging down at the inside and outside of the wall, after which the inside and outside of the wall have to be plastered. (see picture 37. a.o.)

The mud-blocks: in size 10 x 14 x 28 cm., are made with a mud-block (compression) machine (alike CINVAPAM), obtained through the Karen Centre for Research and Training (see picture 33. a.o.).

A mixture of red soil (with a little additional water) gets, after compression, its own shape and is then firm enough to be transported carefully to the drying place. Here the blocks are sundried for three weeks.

The plaster: The wall gains its strength through the inside and outside skin of the wall (2.5 cm. thick plaster coat together with the sisal fibres).

Tests done by the Physics Department of Kenyatta University College show a higher resistance against earthquakes than e.g. an ordinary concrete blockwall with hoopiron at each alternate course.

The mixture of the Plaster:

- Cement: 14 litre, weight ratio (1) volume ratio (1)
- Sand: 52 litre, weight ratio (4.5), volume ratio (3.5)
- Sisal: 250 gram, chopped in 2.5 cm length.

When applying the mortar on the wall, it is important that the sisal fibres, hanging out of the joints of the wall, are integrated in the mortar coat. Therefore the hanging sisal fibres have to be lifted with one hand when applying the first mortar on the mud-blocks; then the fibres can be pressed down in the mortar, after which additional mortar can be applied on top.

5.2 Evaluation

Walling system: Proved to be efficient. Although the poles were not necessary for the stability of the whole house, the main advantage of the system is that after the completion of the foundation, both the roof and the wall can be constructed at the same time.

In case of rain (which can damage the sundried mud-blocks) the completion of the whole roof area is recommended, before starting with the walling (used roof overhang: 50 centimeter).

The stability of the wall during building process: Although the blocks are stapled on each other without mortar in the joints, it is possible to finish first the stapling of the blocks over the full height of the wall (sometimes being 3.20 meter height) and then plaster the whole wall in one time. To give a little horizontal support to the top courses during the plastering of the wall, one inch hoopiron is fixed over the outside and inside surface of the wall: inbetween each two poles, in both vertical diagonals of a wall segment. (see picture 39).

As an experiment the cedar poles were omitted in a wall of 4 meter long and 3 meter high. Here the wall had to be plastered in several stages: after each eight courses of mud-blocks, it needed plastering first to obtain enough stability of the wall for the next eight courses.

The mud-blocks: After some days of experience, a group of 5 labourers was able to produce 500 blocks a day (a group of 3 people made about 300 blocks a day). The strength of the sun-dried blocks is sufficient for its purpose, although 4 hours of rain exposed on the blocks, spoiled the blocks on the edges. However, other experiments (e.g. done at the Karen Village Technology Unit) show that the sun-dried mud-blocks are able to resist rainfall for quite some time. (at time of this report the wall is already 1½ years old).

The durability of the blocks seems to depend a lot on the composition of the soil (and especially the ratios of sand and clay in it). Further research and especially the development of a simple soil test, together with recommendations for an 'ideal' composition would be of great value. At the time of this report, the Housing Research and Development Unit of the University of Nairobi was carrying out further research in soil stabilised blocks.

The plaster: The quantity of plaster used on the walls in these buildings, was approximately twice as much as the quantity recommended. The reason for this being that the 'fundis' (craftsmen) wanted to eliminate each unevenness of the mud-block wall, in order to get the straight appearance of a concrete block walling. This caused the plaster coat to be 5 centimeter at some places. However, by instructing the fundis that a slightly uneven wall was accepted, it was possible to reduce the amount of mortar used.

For estimate purposes it is suggested to quote 2 cm. plaster at each side of the wall. The finished wall is approximately 20 cm thick and is strong, firm, earthquake resistant, rainwater and insect proof, and has a high degree of heat insulation.

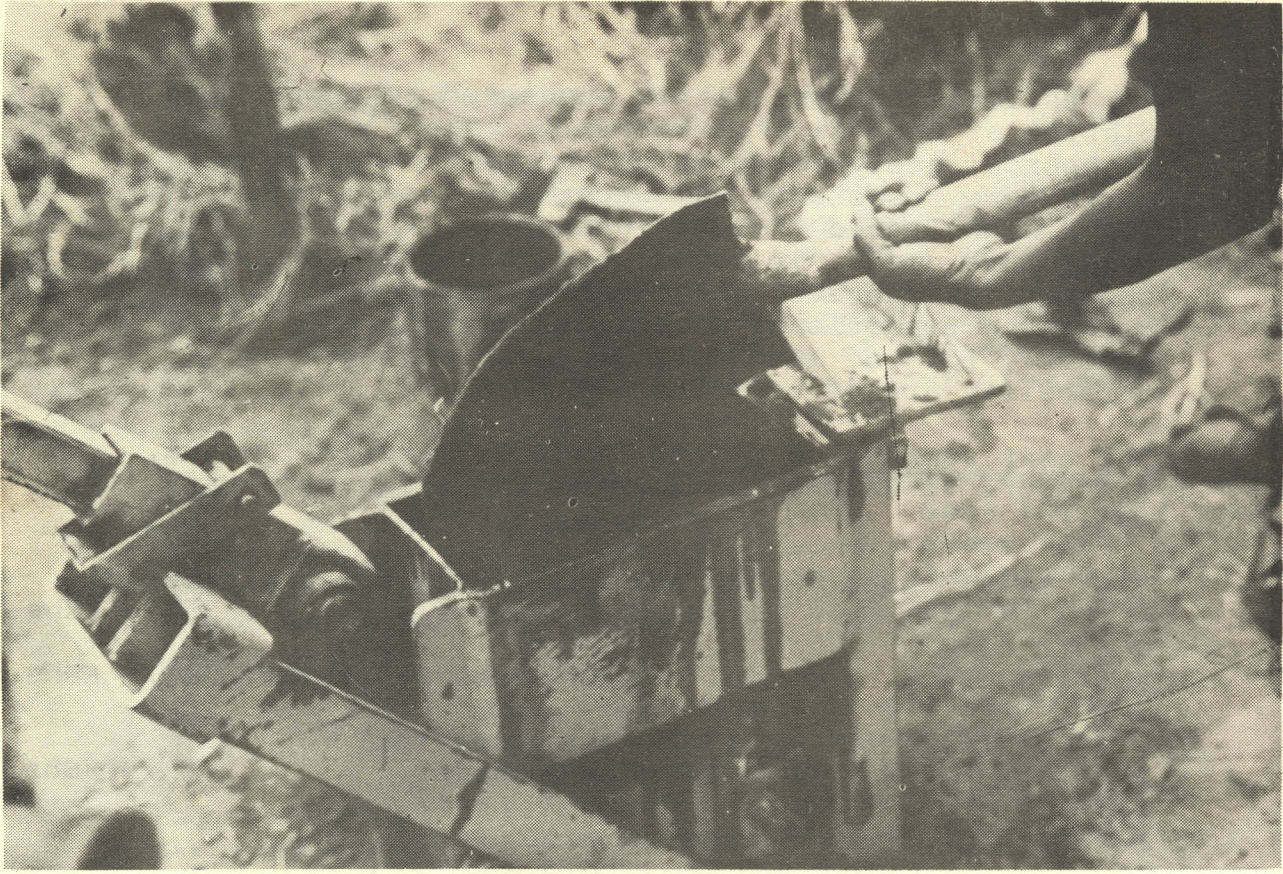
For future needs, it would be of great value to find cheaper alternatives for the cement plaster; e.g. using the traditional mixture of cowdung and ashes. However, for the last one, tests on strength and durability are of importance.

The next summary of prices include material, waste, transport to Katangi and labour for 1 square meter wall:

- 6" sisal cement mud-block wall (both sides plastered)
20 cm thickness 52/- KShs.
- 6" concrete block wall (both sides plastered) 110/- KShs.
- 6" quarry stone wall (inside plastered)
17 cm thickness 81/- KShs.

For detailed costing see Appendix B.

5.3 Pictures see pages 34 upto 38.



33. Filling of the mud-block press

34. The mud-block press, in compression position





35. Immediately after compression the mud-block has its own shape and can be handled carefully as a solid.

36. Three weeks of sun-drying.





37. The sun-dried mud-blocks without mortar in the joints; instead 500 gram sisal fibres of 1.5 - 2 feet length is distributed over the joints, per one square meter of wall area.



40. Application of the plaster. (mix: 1 bag cement, 3.5 cement bags filled with sand and 700 gram of 1" length chopped sisal).

6. Rainwater storage and supply

6.1. Description of the system (see picture 41)

The rainwater is collected by a single gutter in between the butterfly roof. At both ends of the gutter a ferrocement watertank was erected above the ground (see 6.2.1.). An overflow from this tank is stored in two underground ferrocement watertanks (6.2.2.).

To obtain pressure for the watersupply in the house, a hand operated pump gets the water from the underground tanks into a small galvanized iron watertank of 450 litres at 3 meter height.

To avoid the showers to empty the watertank completely, a separate small watertank of 225 litres is placed inside the house to supply the taps in the kitchen only.

All wastewater (from shower, kitchen and splash basin) is collected in a wastewater ferrocement storage tank and can be used in the 'shamba' (farm).

Note: The aboveground watertanks were built before the erection of the house and were used as waterstorage for construction purposes.

6.2.1. The aboveground ferrocement watertank (see picture 45)

This tank was made by the Katangi Village Polytechnic. On a circular foundation a timber mould is placed. Three layers of chicken-wire are fixed to the outside of the timber mould, over which a thick plaster layer (Volume ratio Cement: Sand = 1 : 2) is applied against the mould. After the plaster has hardened, the timber mould can be removed and then the inside of the tank can also be plastered. Finally a coat of waterproof cement is applied on the inside.

Specifications:

Capacity	: 3 m ³
Height	: 1.8 m.
Inside-diameter	: 1.5 m.
Thickness	: 6 cm.
Price (1980)	: 842/= KShs. (incl. foundation + rent mould)
Price per m ³ storage	: 280/= KShs.

Note: -The use of the mould means some investment, but it can be used for about 14 tanks.

-For costing see Appendix C.

6.2.2. The underground ferrocement watertank (see pictures 42, 43, 44)

See reference (7).

The volume of an underground ferrocement tank can be increased (compared to the aboveground tank) without

causing a direct proportional increase in price. The surrounding soil acts as support and formwork. The tank consists of a roof (the dome) and the tank as such.

The dome

- a circular trench of 30 cm depth and 20 cm width is dug (diameter 1.7 meter);
- the soil is thrown into the centre and put into a suitable domed shape;
- 4 x 3/8" steelbars (2 bottom and 2 top) with 3/8" (10 mm) rings spaced at intervals of 45 cm c.t.c. are placed in this trench to form the ringbeam;
- 8 bars are bent in a radial direction over the dome;
- 2 layers of 2.5 cm chickenwire are laid on top of the bars;
- a 4 cm plaster layer (cement: sand = 1:2) is applied over the dome and the ringbeam is concreted;
(C:S:A = 1:3:6); and
- 2 port holes are spaced in the dome, to be the future access for digging the tank.

The tank

- After a week the ground underneath the dome can be dug out as far as the inner edge of the ring beam. The tank is shaped like a bucket, thus decreasing in radius from the rim to the bottom;
- a first layer of about 1.0 cm plaster (cement:sand = 1:2) is thrown against the smooth earth wall;
- 2 layers of 2.5 cm chickenwire are fastened, integrated to both the wall and floor by using U-nails of 2" length;
- several layers of mortar mix (C:S = 1:2) are applied, till a total thickness of about 4 cm is reached; and
- Finally a coat of waterproof cement is applied on the inside.

Specifications:

Capacity	: 19.0 m ³
Depth	: 1.8 m. underneath ringbeam total depth 2.1 m.
Inside diameter	: 3.4 m.
Thickness	: 4 cm.
Price (1980)	: KShs.3,267/-
Price per m ³ storage	: KShs.172/-

Note: - See drawing: section of underground water-tank, on page 41.
- For costing see Appendix C.

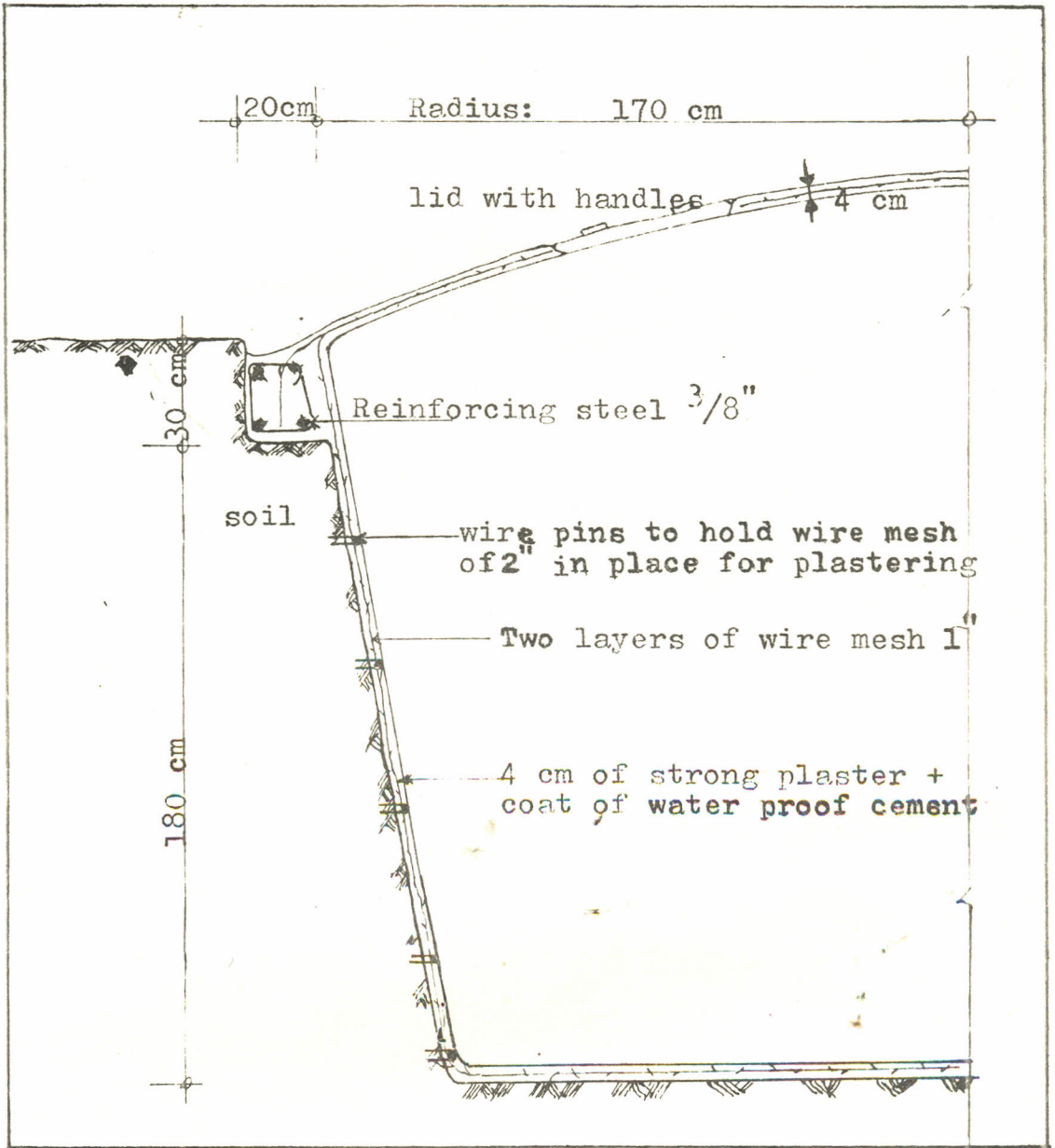


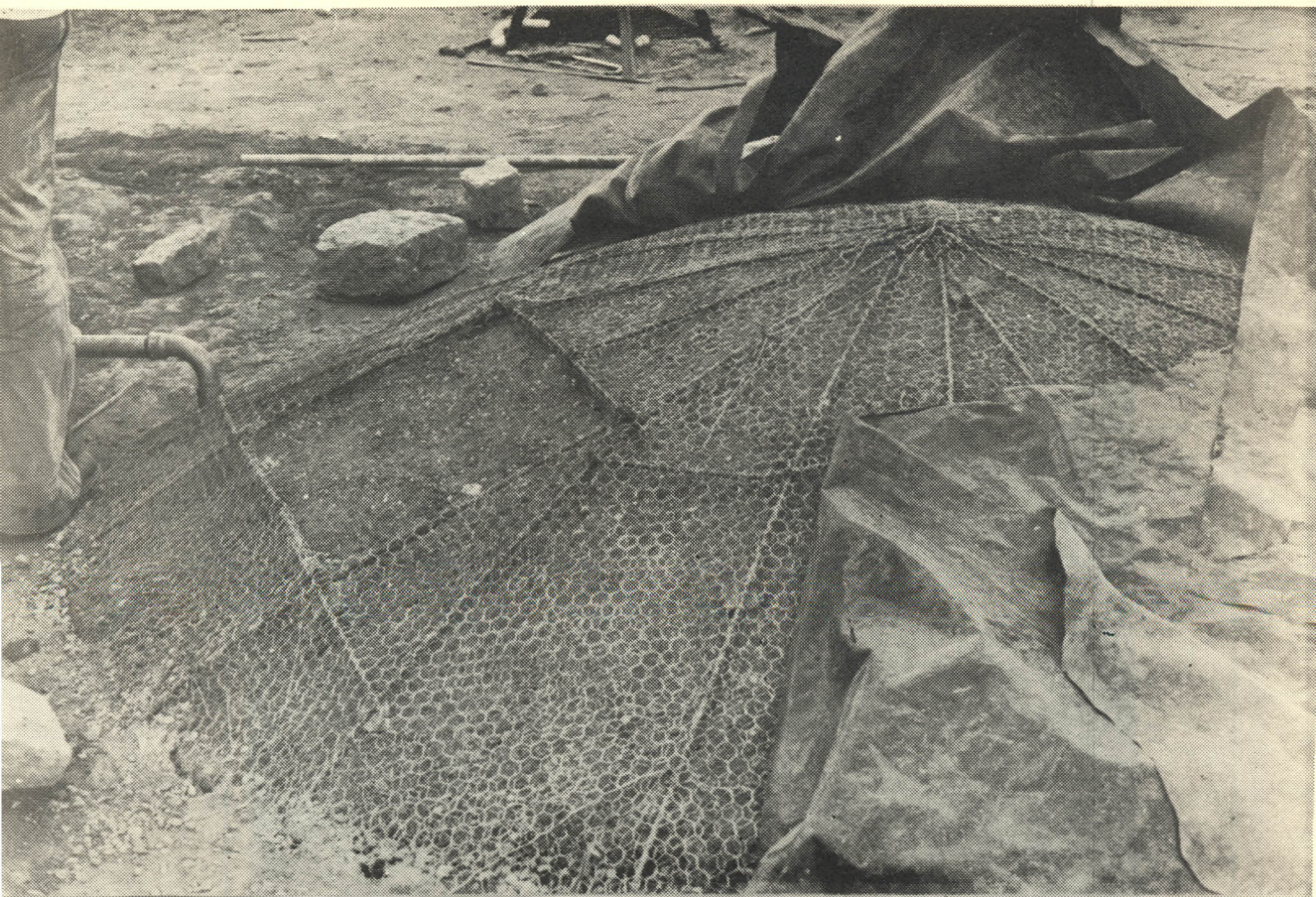
Fig. Section of underground water tank.



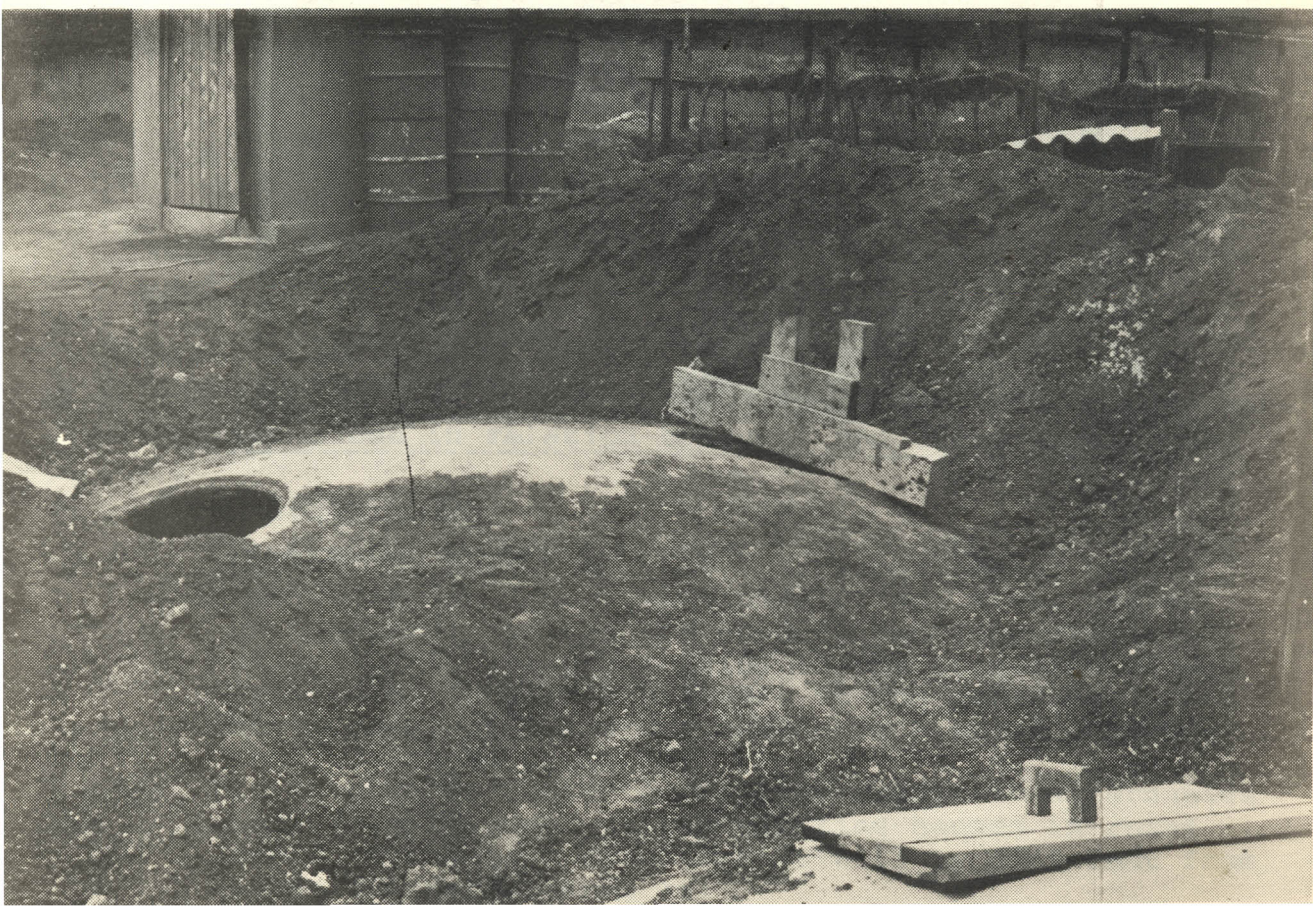
41. Overview of the water storage system.

42. The underground ferrocement watertank: digging a trench, shaping the dome and placing the reinforcement.





43. The underground tank: applying two layers of 2.5 cm. chickenwire, concreting the trench and finally plastering the dome.
44. The underground tank: after hardening of the dome (one week), the tank can be dug through the port holes.





45. The above ground ferrocement watertank.

- no water tap at all, versus kitchen and shower;
- an earth floor, versus concrete floor and cement screed;
- a cypress batten door with doorbolt only, versus cedar framed braced and ledged doors with mortise lock and night-rush;
- a cypress window frame of 50 x 50 cm, versus cedar window frames of 85 x 140 cm with burglarbars, weldmesh, aluminium adjustable louvre and glass louvre blades.

To give a better impression of the real position of this building type, it will be better to differentiate between an urban and rural type, thus suggesting the following adjustments:

- adjustments for the urban type:

- design
 - adjustments of the plan in relation to terraced or grouped site-plans;
 - private outdoor space which can be securely enclosed, has to be added;
- labour
 - adjustment to higher labour prices;
- construction
 - the central core of stone walls; and the other part of the house in sisal mudblock wall without cedar poles.

- adjustment for the rural type:

- design
 - only one door for each room. The door facing towards the verandah;
 - no kitchen, but only a tap and splash basin in the verandah;
- construction
 - no central core of stone walls, but only the sisal mud-block wall with the cedar poles;
 - Instead of a concrete floor a rammed earth floor plus 5 cm. murrum and a 2.5 cm. cement screed;
 - cedar batten doors with doorbolt and padlock;
 - cedar window frames with weldmesh and cedar shutters.

Table 3:-

Cost breakdown of the adjusted types, per square meter plinth area, in KShs., - January 1980.

	URBAN TYPE 1)	RURAL TYPE 2)	
	fully paid labour	fully paid labour	selfhelp + paid labour
Foundation/floor	130/-	80/-	65/-
Walling	110/-	85/-	55/-
Roof (incl.gutter)	90/-	85/-	75/-
Doors + Windows + Mongery	140/-	45/-	45/-
Miscellaneous	15/-	5/-	5/-
TOTAL	485/-	300/-	245/-

1) Contractor's profit is not included.

2) Contractor's overhead and profit is not included.

7.3 Table 4:

Price comparison of the experimental house in relation to other construction methods of housing per square meter plinth area.

(see also Appendix D, for a cost breakdown)

	Price per square m. plinth area
1. <u>Traditional mudhouse</u> ; grass thatched roof: gum-poles + cypress door are bought. No paid labour	35/-
2. <u>Traditional, improved mudhouse (A)</u> ; mbati roof gauge 37; roofstructure of gum-poles, by local fundi; cedarpoles in wall; cypress door	75/-
3. <u>Traditional, improved mudhouse (B)</u> ; mbati roof gauge 30, roofstructure of sawn cypress preserved, by local fundi; cedarpoles in concrete pads; outside wall plastered; floor 1" screed on murram layer; cedar battendoor + cedarframes; local fundi + selfhelp	245/-
4. <u>Rural experimental type, described in 7.2</u> : sisal-cement roofsheets; roofstructure of sawn-cypress-preserved; sisal mudwall; floor 2.5 cm. screed on murram layer; cedar battendoor + cedarframes; local fundi + selfhelp.	245/-
5. <u>Katangi experimental house</u> : see report Paid labour + building site overheads	465/-
6. <u>Urban experimental type, described in 7.2</u> : Central core of stone; sisal cement roofsheets; sisal-mudwall; 10 cm concrete floor; cedar framed doors + cedar windowframe; paid labour + building site overheads.	485/-
7. <u>Stone house in rural area</u> : mbati, gauge 26; sawn cypress roofstructure; 23 cm concrete block-walling; 10 cm concrete floor; cedar framed doors; local fundi + selfhelp.	660/-
8. <u>Stone house; following grade II Bylaws</u> , contractor built; asbestos sheets roof; including site overheads + contractor's profits. (this figure is not rigid; tenders often show differences upto 200%!)	1200/-

Note: - All prices as per January 1980, in KShs. including materials, waste, transport to Katangi. Labour, building site overheads and contractor's profit are included as indicated.

- Water installation, sanitation and electricity are not included

8. Appendix A. THE COSTING OF ROOF SHEETS

All prices as per January 1980, in KShs.
Including materials, waste, transport to
Katangi and labour. (no contractor's
profit and overhead)

1. Sisal cement roof sheets; 95 cm width; effective
roof-coverage 87 cm.- Materials:

Cement:	2 bags (45/- Shs.) make 7 sheets (of 125 cm length)	
	$2 \times 45/- =$	12/85 KShs. per sheet
	$\frac{7}{7}$	
Sand :	10 kg =	-/30 KShs. per sheet
Sisal :	500 gram =	<u>3/00 KShs. per sheet</u>
	Total material	<u>16/15 KShs. per sheet</u>

- Labour:

- 1 person for cutting sisal, weighing and
mixing (1 person is enough to supply two
production streams!)

- 2 labourers for actual sheetmaking.
They produce 8 sheets of 1.25 m. length
in a day.

Total labour $\frac{21}{80} \times 3 = 8/17$ Kshs. per sheet
8 sheets

- Summary, one sheet of 1.25 meter:

Material	16/15 KShs.
Labour	8/17 KShs.
Plastic in mould	<u>0/65 KShs.</u>
	24/97 KShs. per 1.25 m.
	- 19/97 KShs. per 1 m. sheet sisal cement
	- 28/70 KShs. per square meter effective roof covering.

2. Asbestos Cement 'Super Seven' sheets; width 95 cm;
effective roof
coverage 87 cm.

49/- KShs. per 1 meter length of sheet
62/75 KShs. per square meter effective
roof covering.

3. Corrugated Iron sheeting (galvanized); width 67 cm;
effective
roof coverage
53 cm.

The following prices are Nairobi prices and do not
include the transport to Katangi.

	price in KShs. per 1 meter length	price per square meter effective roof covering
Gauge 37	10/35 KShs.	21/- KShs.
Gauge 32	12/75 KShs.	25/90 KShs.
Gauge 30	15/80 KShs.	32/10 KShs.
Gauge 26	22/80 KShs.	46/30 KShs.
Gauge 24	29/40 KShs.	59/40 KShs.

8. Appendix B. THE COSTING OF SISAL MUD-BLOCK WALL
 COMPARED TO OTHER TYPES, PER SQUARE METER
 WALL

All prices as per January 1980, in KShs.
 Including materials, waste, transport to
 Katangi, and labour. (no contractor's
 profit and overheads).

1. Sisal-mudblock wall

- Mudblocks: 5 labourers produce about 500 blocks
 a day (3 labourers about 300 blocks).
 Approximate waste during handling 10%.

$$\text{Labour: } \frac{5 \times 21/80}{450 \text{ blocks}} = \frac{109/-}{450} = 24 \text{ cents a block}$$

A wall of one square meter contains 30 blocks,
 each one being 10 x 14 x 28 cm.

Plaster: Mix - cement:sand = 1:3.5

Summary of 1 m² sisal-mudblock wall

blocks: 30 x -/24	=	7/20 KShs.
cedar poles 4/50 KShs. per meter	=	4/50 KShs.
500 gram 1 ⁵ -2 feet sisal fibres	=	3/00 KShs.
Labour for stapling blocks: 2 man hour (unskilled) at 2/50 KShs.	=	5/00 KShs.
*plaster both sides 1/25 m ³ x 443/-	=	17/70 KShs.
Labour for plastering both sides: 3 man hour unskilled @ 2/50 2 man hour skilled @ 3/50	=	<u>14/50 KShs.</u>
Total	=	<u>51/90 KShs.</u> =====

3. 6" quarry stonewall, plastered on one side

blocks

(6"x 9"x 18") off quarry	2/00	
transport	<u>1/80</u>	
total		3/80

9.5 blocks per m ²	x 3/80	=	36/10 KShs.
* joining mortar 35 liter	@ 0/41	=	14/35 KShs.
labour: skilled 3 man hour	@ 3/50		
: unskilled 1 man hour	@		
	2/50	=	13/00 KShs.
*plaster one side 1/50 m ³	x 410/-	=	8/20 KShs.
labour: skilled 2 man hour	@ 3/50		
unskilled 1 man hour	@		
	2/50	=	<u>9/50 KShs.</u>
			81/15 KShs.
			=====

2. 6" con crete blockwall, plastered on both sides

blocks

(15 x 23 x 46 cm) off factory	4/20	
sales tax	0/63	
transport	<u>1/80</u>	
		6/63

9.5 blocks per m ²	x 6/63	=	63/00 KShs.
*joining mortar 22 liter	x -/41	=	9/00 "
labour: skilled 2 man hour	@ 3/50		
unskilled 1 man hour	@		
	2/50	=	9/50 "
*plaster both sides 1/30 m ³	x 410/-	=	13/65 "
labour plaster:			
skilled 3 man hour	@ 3/50		
unskilled 2 man hour	@		
	2/50	=	<u>14/50 "</u>
			109/65 KShs.
			=====

* Plaster:	1 m ³ plaster (C:S = 1:3)	
	- 8 bags cement x 45/-	= 350/- KShs.
	- 1.1 m ³ sand	= 50/- "
	- 1"chopped sisal	
	5.5 kg x 6/- KShs.	= 33/- "
		<u>443/- KShs.</u>
		per m ³
	without sisal	410/- KShs.
		per m ³

8. Appendix C. THE COSTING OF FERROCEMENT WATER TANKS,
COMPARED TO OTHER TYPES

All prices as per January 1980, in KShs.
Including material, waste, transport to
Katangi, and labour. (no contractor's
profit and overheads).

1) The aboveground ferrocement watertank

Capacity	3 m ³ (666 gallon)
Height	1.8 m.
Radius	0.75 m.
Thickness wall	6 cm.

Plaster mix - cement:sand = 1:2.

The foundation

- 1 m ³ hardcore	= 45/- KShs.
- 0.2 m ³ concrete ²⁾ @ 317/-	= 64/- KShs.
- labour: skilled 1 man day @ 30/- unskilled 2 man days @ 22/-	= 74/- KShs.
	<u>183/- KShs.</u>
	=====

The Tank

- 0.5 m ³ plaster ¹⁾ x 565/-	= 283/- KShs.
- chickenwire (3 layers of 6' wide) 15 meter	= 120/- KShs.
- rent mould + transport ⁵⁾	= 70/- KShs.
- waterproof mixture 1 kg.	= 60/- KShs.
- labour: skilled 2 man days @ 30/- unskilled 3 man days @ 22/-	= 126/- KShs.
	<u>659/- KShs.</u>
	=====

Total price 842/- KShs.
(280/- KShs. per m³ storage)

-
- 1) Plaster:Cement:Sand = 1:2
 1 m³ - 12 bags cement x 45/- KShs. = 540/-
 - 0.5 m³ sand = 25/-
565/- KShs.
- 2) Concrete: C:S:A = 1:3:6
 1 m³ = 4 bags cement @ 45/- KShs. = 180/- KShs.
 - 0.5 m³ sand = 25/- KShs.
 - 1 m³ aggregate = 112/- KShs.
317/- KShs.

2. The underground ferrocement watertank

Capacity 19.0 m³ (4200 gallon)
 Depth 2.1 m.
 Radius 1.7 m.
 Thickness wall 4 cm.

Plaster:Cement:Sand 1:2
 Concrete: C:S:A: 1:3:6
 Reinforcement: 3/8" bars

The dome

- Labour excavating ringbeam + shaping dome
 skilled 1 man day @ 30/-
 unskilled 2 man days @ 22/- = 75/- KShs.

- Reinforcement ringbeam + dome
 9 length of 3/8" bars (length
 20 ft) = 495/- KShs.

 labour:
 skilled 4 man days @ 30/- = 120/- KShs.

- Concrete²⁾ ringbeam: 0.65 m³ x 317/- = 206/- KShs.

 labour:
 skilled 1 man day @ 30/-
 unskilled 1 man day @ 22/- = 37/- KShs.

- Plaster¹⁾ dome: 0.45 m³ x 565/- KShs. = 255/- KShs.

 Labour:
 skilled 1 man day @ 30/-
 unskilled 1 man day @ 22/- = 52/- KShs.

1,239/- KShs.
 =====

The Tank

- Excavation of tanks: 2.1 m deep, 19 m³ soil
 labour:
 unskilled 18 man days @ 22/- = 396/- KShs.

- Chickenwire: 2 layers: 51 m = 1.7 roll
 @ 240/- = 408/- KShs.

- Plaster¹⁾ Tank: 1.1 m³ @ 565/- = 622/- KShs.

 Labour:
 Skilled: 9 man day @ 30/-
 unskilled: 6 man day @ 22/- = 402/- KShs.

- Waterproof mix: 5 bags of 1 kg. @ 40/- = 200/- KShs.

2,028/- KShs.
 =====

Total Price: 3,267/- KShs.

(172/- KShs. per m³ storage)

3. Galvanized Iron storage tanks

(gauge 24) prices in KShs., as per Jan. 1980

capacity	price off-factory	transport to Katangi	founda-tion	Total price	price ₃ per m ³ storage
4.5 m ³ (1000 gall)	1500/-	350/-	220/-	2070/-	460/-
9.0 m ³ (2000 gall)	2700/-	450/-	434/-	3584/-	398/-
11.25m ³ (2500 gall)	3200/-	450/-	521/-	4171/-	370/-
13.5 m ³ (3000 gall)	3600/-	450/-	606/-	4656/-	345/-

8. Appendix D. TABLE 6: COST BREAKDOWN OF DIFFERENT CONSTRUCTION METHODS OF HOUSING PER SQUARE METER PRINTH AREA

For description of types refer to Chapter 7.3, page...	Found- ation +floor	Wall	Roof+ gutter	Door+ Windows	Misc.	TOTAL
1. Traditional mudhouse no labour	0	8/-	7/-	15/-	5/-	35/-
2. Traditional improved mudhouse (A) local fundi + selfhelp	0	20/-	35/-	15/-	5/-	75/-
3. Traditional improved mudhouse (B) local fundi + selfhelp	45/-	45/-	105/-	45/-	5/-	245/-
4. Rural exp. type see 7.2 local fundi+selfhelp	65/-	55/-	75/-	45/-	5/-	245/-
5. Katangi exp. type paid labour+buiding site overheads	125/-	105/-	85/-	135/-	15/-	465/-
6. Urban exp. type see 7.2. paid labour+building site overheads	130/-	110/-	90/-	140/-	20/-	490/-
7. Stone house:rural area local fundi+ selfhelp	125/-	220/-	145/-	155/-	15/-	660/-
8. Stone house: Grade II Bylaws contractor built paid labour;building site overheads+ contractor's profit	Total price is not rigid - - - - - Tenders show differences up to 200%!					1200/-

Note: All prices as per January 1980, in KShs. Including materials, waste, transport to Katangi; Labour, building site overheads and contractor's profit are included as indicated.

8. Appendix E. UNDUGU PHILOSOPHY AND PROGRAM

preface out of "The Road to Undugu",
see ref. 10.

Undugu is the Ki-Swahili word for "brotherhood" or "solidarity". The Undugu philosophy is based on three principles: respect, concern and service.

The aim of Undugu is to establish a human, brotherly relationship amongst the people living in the slums of Nairobi. The existing law amongst them is the law of survival; they must have their daily food legally or illegally.

Undugu looked into these slum areas and tried to place itself behind the eyes of the people living there. This reflected on us two major worries people are dealing with:

(i) insecurity and (ii) poverty.

(i) Insecurity for the day of tomorrow, whether they are able to satisfy the fundamental needs of human kind: food and a safe shelter to sleep. Both so much related to money and work in an overpopulated slum. Shelter and work are often means of exploitation: if you do not like it you go, there are other people waiting. Needs of unity, love, selfrespect and esteem by others are often overshadowed by this insecurity. It deprives the people living in a slum of any incentive to do something to improve the social conditions from within.

(ii) Poverty with all its attributes: a high rate of unemployment and many incomplete families, single women with children or single man keeping their wives in the reserves. Most people try to earn something in the informal sector, either legal or illegal: by brewing and selling of chang'aa (liquor) or prostitution. No facilities for proper healthcare and family planning. Overcrowdedness, with lack of electricity, water, sanitation and privacy: 6 to 8 people could share one small room to save on rent.

Insecurity and poverty create dependency. If help is offered, the people grasp at it and try to get as much as possible. They tend to throw their problems to the agency offering the help and let the solving of the problems to the agency.

The Undugu programme is based on these two major worries of the people; the attention is focused on two points:

1. Lack of hope, distrust in themselves
2. Dependency.

In order to build up a trust in their potentialities, seminars are organized with the Undugu staff and the people to whom the service is offered. During these seminars it is also encouraged to start village committees, where problems can be discussed and where the people concerned are involved in solving these problems.

Working with people and not for the people is the aim of the Undugu Society. They feel that a good society is made of responsible people and not of beggars and the experience is that people respond very well with a sense of responsibility if communication is done in a respectful way. The solution to squatters has to be taken on a political level, but any policy would fail if the people are not educated to take up their responsibilities. The people feel that being poor, they are cheated and exploited by the society, but cheating and exploiting must not be their answer. If they are united in a responsible brotherly (Undugu) way, they cannot only solve some of their own problems, but they might be able to modify the attitude the society has towards them and start looking at real brothers and sisters who without any fault of their own are deprived of their rights to live as human beings.

UNDUGU PROGRAMME

The present Undugu programme is born out of an initiative of missionary, Fr. Arnold Grol who noticed that a considerable number of youth was roaming along the streets or staying idly at home. They were unable to attend school or to get any professional training and could not find employment. This motivated him to start several youth clubs to give something for these young people to do. The youth centres offer recreational facilities to the youth, arts, drama, discussion groups. The most famous representative is the Undugu Beat 75, a popular band.

The first such club was started in April 1973 and Undugu was born. So many activities were initiated after this one in different slum areas of Nairobi, that the structure of a youth club was not sufficient anymore to carry its own load.

In May 1975 the Undugu Youth Centres was registered under the Societies Act under the name of Undugu Society of Kenya.

At this time the following activities and projects exist:

- O.1 Undugu Youth Centres: In Makadara, Kariobangi, Mathare Valley, Ngei, Dandora, Kitui, Ngomongo, Kinyago, with a variety of clubs in sports, drama, debating, music, dances.
- O.2 Undugu Vocational Training Centre in Mathare Valley, with the following sections: car-mechanics, carpentry, masonry, tailoring, home-economics, batic/handicraft (future: leatherwork, photography).
- O.3 Small scale business loan scheme: A revolving fund for loans to an individual or group to enable them to start a small scale business.
- O.4 Sponsorship programme: Through financial-adoption-programmes of different organizations and individual donors, sponsoring youth into Primary and Secondary Schools and Training Courses.
- O.5 Women Groups: In order to develop the community spirit the women in Mathare Valley are organized in sewing groups: earning a little money and learning through adult education: reading, writing, household economy, nutrition, health care. The newest group is the U-Dada Club, a service to town prostitutes.
- O.6 Undugu Basic Education Schools: In Mathare Valley, Majengo-Pumwani and Ngomongo (New Grogan). The programme started as Undugu Informal Schools to give ex-parking boys and school drop-outs a basic primary education, not leading to the Certificate of Primary Education, but geared at the development of the individual.
Recently recognized by the Government as "Basic Education", with an approved syllabus jointly made by the Kenya Institute of Education and Undugu, in order of priority: Swahili, arts and crafts, music, social studies, religious education, physical education, mathematics, business education, science and English.
- O.7 Adult Education through evening classes for the people of Mathare Valley.
- O.8 The Parking Boys Project: Not only for the boys in the streets but also for the children of the slums, from poor families, children with inadequate parental care, or with no parents at all. The aim of the project is to improve the conditions and prospects of these children by:

- A reception centre where newcomers can be provided with food, shelter, medical care and education, while their cases are investigated by a social worker. Those who have homes are returned home.
- For the homeless there is a set up of community homes (around 20 boys each) with a 'housefather'.
- Providing education through the vocational training centre and the basic education schools; to the more bright children by sponsorships to further education.

The whole parking boys programme is based on a free decision of the boys to stay or leave. We cannot rehabilitate those who enjoy their actual situation, but we can try to assist in rehabilitating those who find themselves beyond their own control in a certain position.

0.9 Undugu Agricultural Project: In Katangi (Machakos District) and born out of the parking boys project. The more our Society can offer to the boys, the more boys can be rehabilitated; some boys in our communities feel the attraction to town less than others, moreover what we can offer in the communities is limited to town surroundings (schooling, sports). In an agricultural surrounding many other activities can keep the boys occupied.

In phase 1 of the project we accommodate a community of about 20 boys. They will have academic courses like in the Basic Education Schools, and will be initiated into agricultural knowledge, animal husbandry, etc.

In phase 2 the project will be developed into an agricultural training centre and will also have an intake from the youth of the area.

Besides this there will be an agricultural production unit, geared towards cash crop cultivation and dairy products so that it should give an income to the "Nairobi Parking Boys Project".

0.10 A Community Health Programme for the slum population is the newest adventure, still at the development stage.

UNIVERSITY OF NAIROBI
ADD LIBRARY

9.

REFERENCES

- (1) Mein P.J., An autonomous housing prototype for low-income families; H.R.D.U. Nairobi, May 1977.
- (2) Kaszner O., Guidelines for room types in low cost housing; H.R.D.U. Nairobi, 1977.
- (3) Eygelaar, J., Foundations for low cost houses; H.R.D.U., Nairobi, 1979.
- (4) Swift D.G., and Smith R.B.L., The construction of corrugated roofing sheets using sisal cement; Kenyatta University College, Physical Dept. and University of Nairobi, Department of Civil Engineering, September 1979.
- (5) Swift D.G. and Smith R.B.L.; (article on sisal cement mudblocks).
- (6) Appropriate Technology, vol.5, No. 4, 1978 Fibre reinforcement roofing project of the Intermediate Technology Development Group.
- (7) Appropriate Technology, vol.4, No.3, 1977 Low cost watertanks in the Pacific Islands, K.C. Calvert and R.J. Binning.
- (8) Kaj Blegvad Andersen, African Traditional Architecture, a study of housing and settlements patterns of rural Kenya; Nairobi, Oxford University Press 1977.
- (9) Teerlink J. 1) Information on design and construction of buildings built for the Undugu Agricultural Projects, Katangi, January 1980.
 2) Information on progress of the buildings and financial evaluation of the building costs of the Undugu Agricultural Project, Katangi Location, May 1980.
- (10) The Road to Undugu, Undugu Society of Kenya, Nairobi, revised edition 1980.
- (11) Andrew Hake, African Metropolis, Nairobi Self Help City, Sussex University Press, 1977.