UNIVERSITY OF NAIROBI
HOUSING RESEARCH AND DEVELOPMENT UNIT

CONSTRUCTION OF FARM BUILDINGS

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P R E F A C E

Building is a large industry and very important for the progress of farming, and for the health and comfort of the people.

Much is to be done in the field of building in rural areas of Kenya. Up to now mainly local building materials and traditional constructions have been used, but as farming is progressing and new enterprises are introduced there is a need for more and improved buildings. Hence there is a great need for study of new materials, besides the local ones, and the new building techniques.

This paper deals with the planning of buildings, building materials, various structures, and plans for various buildings on a farm. Of course, there are many different ways to construct a building and many different materials to use, so it is hard to say which type is the very best, but it is hoped that the facts given here and the various plans and suggestions will be of value for the study of buildings, for teaching staff and for the students who will become advisers on buildings in the field.

Kristoffer Haugum
Embu Institute of Agriculture
March, 1973

C O N T E N T S

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Buildings in rural areas of Kenya

The standard of housing in the rural areas is not very good. The same type of houses which have been used for centuries are still being used today without much improvement.

The main buildings are dwelling houses made of mud walls with a wooden frame and roof thatched with grass or palm leaves. Traditionally they had only one room, soil floor and no windows (or one small window with a wooden shutter). On the floor there was a fireplace which simply consisted of three or four stones where the cooking was done and people used to sit when it was cold. There was no outlet for the smoke except from a gap between the wall and the roof. This was also the only ventilation.

Sometimes a sort of ceiling was put across on the top of the walls and the space above, under the roof, used as a store for food stuff and other things.

In some areas there was a simple grain store, not far from the dwelling house, which looked like a big basket with a hat on top. The wall was made of weaved twigs and the "hat" of thatch.

Nowadays the same traditional building materials are used but the dwelling houses are rectangular with two to four rooms and often one or more windows in each room. The windows normally have wooden shutters. The rooms are used as bedrooms and sittingroom but often they use the old, small living house as a kitchen.

Thatch is still very common but as soon as they can afford it they buy corrugated iron sheets for the roof. They try to avoid having a fire in the house with iron sheets, because the soot from the smoke reacts with moisture and corrodes the zinc coating on the iron sheets, making them rust.

Traditionally there were no buildings other than the dwelling houses and stores. There were no houses for the livestock. The cattle were kept on free range or in a "boma" (fenced in) during the night.

Where farming is becoming more intensive, new enterprises are introduced and the people require better living houses. In these areas a wider range of buildings and an improved standard of housing is found.

Good management of pigs, poultry and dairy cattle requires at least some kind of housing. The advantages of having buildings on a farm are:

1. It makes work and life more comfortable. More and better work can be done when you have protection against rain, wind and hot sun. It is easier to keep tools and other things in order and find them when they are needed.

2. It protects the animals and helps to get a higher output because the animals feel comfortable and the hazard of disease is reduced. It also prevents the animals from damaging the crops.

3. It protects machinery and tools from rain and sun, hence making them last longer and reducing the cost of maintenance.

4. It protects the stored crops, reducing loss and damage caused by rot and pests. The crops can be stored for long periods and used when needed or sold when the prices are high.

5. It protects fertilizer and chemicals used for spraying crops and animals. A dry and safe place will reduce damage and loss, and keep children and animals away from fertilizers and chemicals which are often poisonous. There is also a danger of fire with some of these products.

Advice to the farmer about building

As new types of buildings are introduced there is a great need of advice on how to plan and construct the new buildings. Most buildings are constructed to last for many years, perhaps a generation or more so a bad layout and construction may cause inconvenience and extra work to the owner all his life. It is therefore very important to spend some time and thought in planning a building before it is erected.

Untraditional building materials may also be beneficial in making a rational building and getting the best economic results from the enterprise. Local materials should be used as much as possible. They are normally the cheapest because there is not much transport cost, and people often have some experience in using them.

However, sometimes it pays to import materials from other areas and it may be necessary to give some advice on how to use the new materials in the best way. It could also be necessary to encourage the use of some local materials which are available but not commonly used, and to give advice on their best uses.

Planning of Buildings

Points to consider before deciding to build a new building:

1. Is the building really needed?
   Don't erect a building because of personal prestige, thinking of the neighbours, it will look nice, etc.

2. Is the money required to build the house, and finish it within a short time, available?
   It is a loss to have a half finished house standing not being used. The house may also decay very quickly standing like this. Planning and calculations will show what

money and materials are required. What is required should be available within a few months. Also make sure that carpenters and labourers are available when you want them.

3. Can the farmer use the building profitably or make life considerably more comfortable for himself and his family? The enterprise concerned should pay for the building cost and maintenance of the house before it is written off. Estimate the building cost, the annual maintenance cost and the life of the building.

Example: A house estimated to last 15 years

	Per Year
Building cost Sh.1500	Sh.100.00
Maintenance cost	" 50.00
Annual cost for 15 years	Sh.150.00

In this case no capital is saved up, which is desirable, to build another house when this one is to be written off in 15 years' time.

4. Is this the best use for the money available, or are there other more profitable ways of spending it?

e.g.
   a. Buying fertilizer
   b. Cultivating or buying more land
   c. Buying more and better cattle
   d. Buying tools and machinery
   e. Building other more necessary buildings.

After it is found necessary and beneficial to build a new house the actual planning can start. There are very many things to take into account when planning a new house.

Some points to consider when planning a house for animals:

1. Comfort for the animals.
   a. Suitable space for the animals. There should be sufficient floor space for resting and movement. There must also be enough space for all animals at one time at the feeding and watering places. Too much space is, of course, a waste.
   b. Ample light will ease cleaning and work and increase the output.
   c. Dry and clean house. Elevate the floor from the ground if necessary, or fill up with soil or stones to make the floor higher than the surrounding ground. A water proof roof should be provided to keep the rain out.
   d. Good ventilation. There should be a slight movement of air through the house to ensure there is always enough fresh air.
   e. Draught proof, especially in cold areas. Pigs and young animals are most sensitive to draught.

f. Not too hot. Provide good ventilation in hot areas. In some places it may be beneficial to insulate the roof to prevent the heat from the sun reaching inside the house.

g. Not too cold. In cold areas it may be necessary to insulate the roof, walls and even the floor. The house should be draught proof but well ventilated.

2. Convenient for labour.
   a. Easy to feed the animals. The troughs should be low to avoid lifting of heavy food stuffs. There should be a short way between feed store and feeding place. Avoid steps. They are awkward when carrying a big load, walking in dark, using a wheel barrow, for old and handicapped people and dangerous to children. It is better to make the floor slope if possible. Make corridors, doors and gates wide enough for easy transport.

   b. Easy to take out the produce; milk, eggs, etc.

   c. Easy to clean, change litter and get out dung.

   d. Easy movement of animals in and out of the house, and internally.

   e. Place the house conveniently near farm road, yard, water for easy access and transport. It should also be possible to watch the house from the dwelling house.

3. Good site and layout. Place the house so that it does not disturb your neighbours and yourself with noise or odour. Think of possible extensions to the house later. The extensions should fit in with the old building and the site should be big enough for later extensions. Make a good looking elevation if it does not cost too much extra.

4. Cheap and longlasting. We are interested in the building cost and the annual cost of a building. A long lasting building will often give a low annual cost but high building cost. Shortage of capital is one of the main problems for Kenya farmers who want to erect a new building so we often have to make a compromise to get a low annual cost. We are not interested in very long lasting buildings (100 years). After 20 - 25 years things may have changed so much that we would like to build a new and different house, and get rid of the old one.

Many of these points to consider when planning a house for animals are also applicable when planning a dwelling house or store.

Drawing of Buildings

It is very important to make a detailed plan and proper drawings of the building before the actual work is to begin. That saves a lot of work and trouble during the busy building period.

The contractor and craftsmen, of course, have to understand the plan and drawings and carry them out as they are supposed to do.

The drawings of a building should give us a good idea of the layout and construction without much description. The drawings should be to scale so the measurements can be found even when they are not given on the drawing.

Many things, like doors and windows, are shown on the drawing with certain signs so they don't need any explanation, but the main things, like the purpose of each room, are written on the drawing. It should also be written on the drawing that "All measurements are in cm".

A complete drawing of a building should contain:

a. Ground plan
b. Cross section (1 or 2)
c. End elevation
d. Side elevation (front).

It may also be necessary to include:

e. Perspective view
f. Foundation plan
g. Details.

Scales used are normally 1:10, 1:20, 1:50, or 1:100.

Most of the measurements are given on lines above and to the left of the drawing, but sometimes they are written on the other side or inside the actual drawing.

Building Materials

CONCRETE

Concrete is artificial stone; a mixture of sand, cement, coarse and fine aggregates and stones mixed with water.

It is used for:

a. Foundations - for heavy buildings, dry and rat-proof houses.

b. Floors - in cowsheds, pig pens, dairies, dwelling houses, workshops and machinery sheds.

c. Walls - for buildings where strong and weather-proof walls are required.

d. Yards, roads - in wet and dusty places.

e. Cattledips

f. Water tanks

g. Bridges and drifts

h. Fence posts

i. Dams

j. Silos

Advantages of concrete

It is long lasting and not damaged by weather, rot, pests.
It is strong for wear and pressure and can take a lot of heavy traffic.
It is fire proof.
It is rat and mice proof.
It is cold in hot climates.
It is wind and water proof.

Disadvantages of concrete

Expensive material, transport and labour.
Not changeable (permanent).
Needs firm ground and foundations.
Cold in cold climates - a poor insulator.

The Ingredients

1. Ordinary Portland Cement is manufactured from clay and limestone, ground together with water and burnt to a high temperature and then ground to powder. It is sold in 50 kg (39 cubic dm) bags or in bulk. Store the cement in a dry place and not too long. Even damp air can spoil the cement. The cement should be like powder when used, not lumpy or hard. It can still be used if you are able to crush lumps between your fingers.

2. Aggregates are either gravel or crushed stone. The aggregates should be hard and clean. Particles with sharp corners (edges) are better than round ones. It should not contain organic matter or dirt. If it is very dirty it should be sieved and washed. Coarse aggregates are mainly those which are retained on a 5 mm sieve. Fine aggregates are those which pass through; that means sand. To test the sand mix some sand and water in a bottle and shake. The water should not get a dark colour. Sand from the sea can be used if it is the only sand available.

3. Stones can be added if there is space for them. They must be coated all around with sand and cement.

4. The water must be clean, without colour. Sea water can be used if fresh water is not available, but not in reinforced concrete.

Making Cement

Correct amount of ingredients. There should be enough sand to fill all the holes between the coarse aggregates, enough cement to make a complete film and enough water to mix it properly and to complete the cement film to cover all particles and complete the chemical reactions.

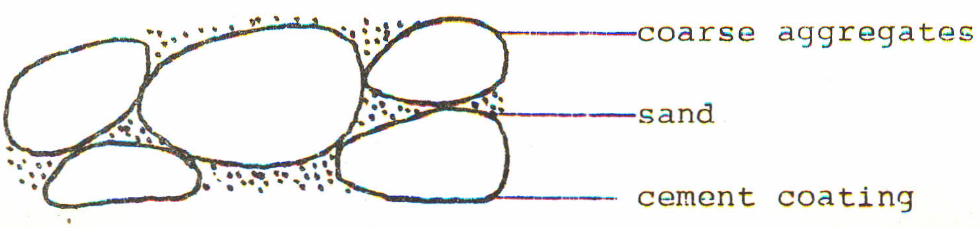


Figure 1.

Too little sand leaves holes between the coarse aggregates and makes a poor contact between the particles. Too much sand increases the surface area. The surface area of sand is larger compared to the same volume of coarse aggregate. More cement is then needed.

Too much water makes the concrete weak. The water will collect and when it later evaporates, holes will be left in the concrete. Some water and cement may also leak out through the workform. Too little water makes it difficult to compact the concrete to get good contact between the particles. Lack of water will also stop the hardening process.

For big and important concrete work a certain ratio between cement and water is given, but for small scale work it is good enough to add water until you get a mixture like thick porridge.

Mixing Table - Kenya Standard

Cement/Wet Sand/Coarse Aggregate (Ratio by Volume)	Use
1 : 4 : 8	Foundations for light buildings.
1 : 3 : 6	Foundations for normal buildings.
1 : 3 : 5	Floors.
1 : 2.5 : 5	Walls.
1 : 2 : 4	Reinforced floors and overhead floors.
1 : 1.5 : 3	Dams, bridges, tanks.

Calculations for a concrete floor

Rectangular floor 750 cm x 400 cm. 5 cm thickness
Total volume of concrete required:

$$750 \times 400 \times 5 = 1{,}500{,}000 \text{ cu.cm} = 1{,}500 \text{ cu.dm} = 1.5 \text{ cu.m.}$$

If we mix 1 cu.m sand with 1 cm.m ballast (coarse aggregates) we do not get 2 cu.m mixture, but less because some of the sand will fill the holes between the coarse aggregates. We therefore have to order more sand and ballast than is required according to the volume of concrete. Add 20% for this and 10% for waste and spill.

Mixing ratio for floors 1:3:5
The cement added does not affect the volume so we divide by 8 instead of 9.

Total volume of ingredients $\frac{1.5 \times 130}{100}$ = 1.95 cu.m

Ballast $\frac{1.95 \times 5}{8}$ = 1.22 cu.m

Sand $\frac{1.95 \times 3}{8}$ = 0.73 cu.m

Cement $\frac{1.95 \times 1}{8}$ = 0.24 cu.m

Specific weight of concrete		approximately	2.2
" " "	sand, ballast	"	1.7

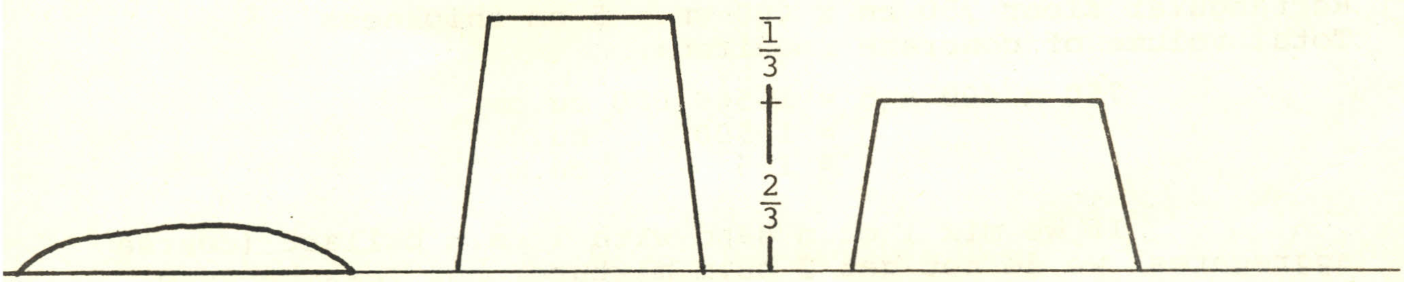
Weight of required sand	1.7 tons x 0.73	=	1.2 tons
" " " ballast	1.7 " x 1.22	=	2.1 tons
Number of bags cement	240 cu.dm. : 39	=	6.2 (i.e. 7 bags)

Proper mixing.

a. Machine mixing is the best way of mixing concrete but for small scale work it might be difficult to get a machine and it will be rather expensive.

b. Hand mixing is normally adopted on small jobs. The mixing should never be carried out on the bare ground, as this results in the materials being contaminated by earth which is scraped up. It should be done on a close boarded platform or a concrete floor. It should be near to the place where the concrete is to be deposited.

After proportioning the materials are mixed at least twice dry and twice wet. Usually two men, one on each side, taking from the bottom, shovel the heap to one side. This operation is repeated, the heap being thrown back to its original position. If necessary the materials are again turned over until the colour is uniform, free from streaks of brown and grey. Water is then added in a hole dug in the top of the heap. Turn the heap over at least twice or until a uniform consistency is obtained. It should be like a thick porridge. A simple test is to fill a bucket with ready mixed concrete, turn it upside down on the platform and lift up the bucket. The concrete should not flow nor should it keep the same shape as the bucket but should slump about one third of the height of the bucket.



too wet too dry suitable

Placing and compacting concrete.

Concrete should be placed in position as soon as possible and before setting has commenced. Avoid carrying the concrete, use a wheel barrow if possible. Do not transport the mixed concrete a long distance, the ingredients will then separate and the mixing is spoiled.

Concrete after being placed in position should be well rammed or tamped to consolidate it. It is done by using a shovel or a stick in the concrete or knocking on the work form. For bigger jobs mechanical vibrators are used.

Curing Concrete.

Hardening of concrete is a chemical process between cement and water. Concrete will set in three days but it will take seven days for the chemical reaction to complete. If it dries out before this chemical reaction has completed the process will stip. Therefore, keep the concrete wet (damp) for seven days. Cover it with sacks, grass, polythene, etc. and spray with water.

Wooden workforms should be wet before filling in the concrete.

When concrete work is started it should be finished without stopping. If the work is stopped for some days there may be a weak zone where the new concrete is joined to the old.

Workforms.

These are normally made of wood, with a smooth wall to the concrete and posts and rails outside to strengthen the wall and keep it in position. It must be strong enough so that it does not move when concrete is filled in. It should be smooth and fairly waterproof. Empty cement bags can be used to cover the walls inside. The form work must be removeable.

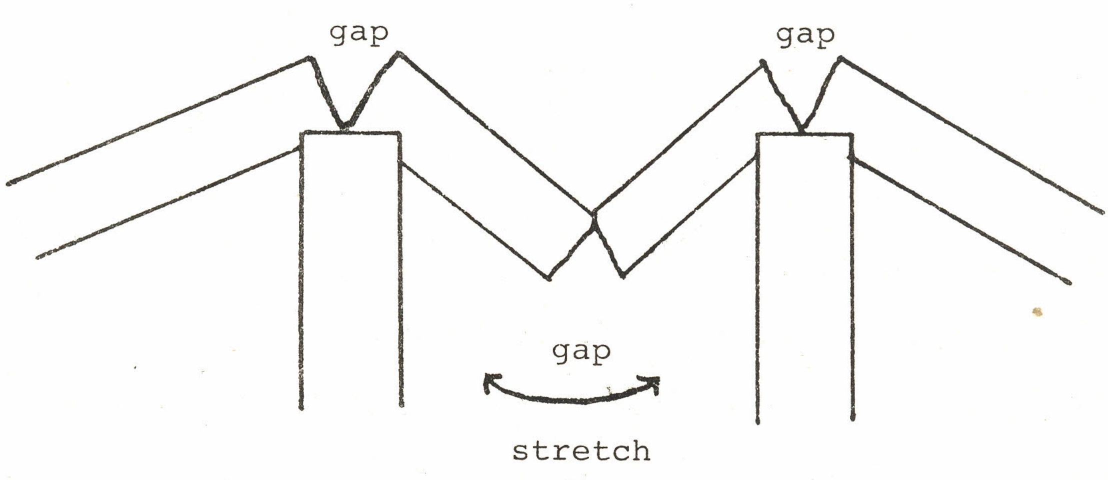
The form work can be taken away after 3 days, but it is better to leave it for 7 days, because it makes it easier to keep the concrete wet.

Reinforcement of concrete.

Concrete can resist very much pressure but very little stretching. When concrete is bent pressure will occur in it on the side where the force is. On the other side it will stretch. To avoid cracking of the concrete that side is reinforced with iron bars. Iron can take very much stretching. There are two types of iron bars:

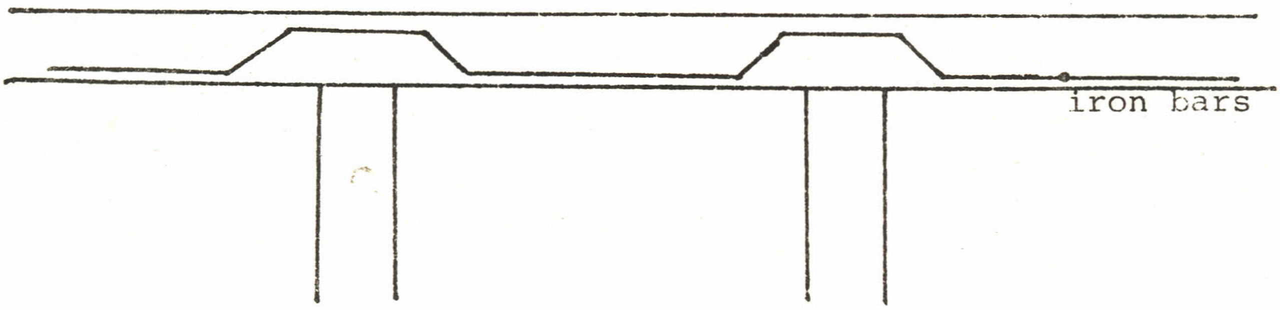
1. Plain bars take a stretch of 1200 kg/sq.cm.
2. Rough bars take a stretch of 2000 kg/sq.cm.

Principle reinforcement of a overhead floor or a bridge:



Side view - without reinforcements gaps occur on the stretching side.

Figure 3a.



Side view - with reinforcement. The iron bars are bent so they lay in the stretching zone of the concrete.

Figure 3b.

Principle reinforcement of a house:

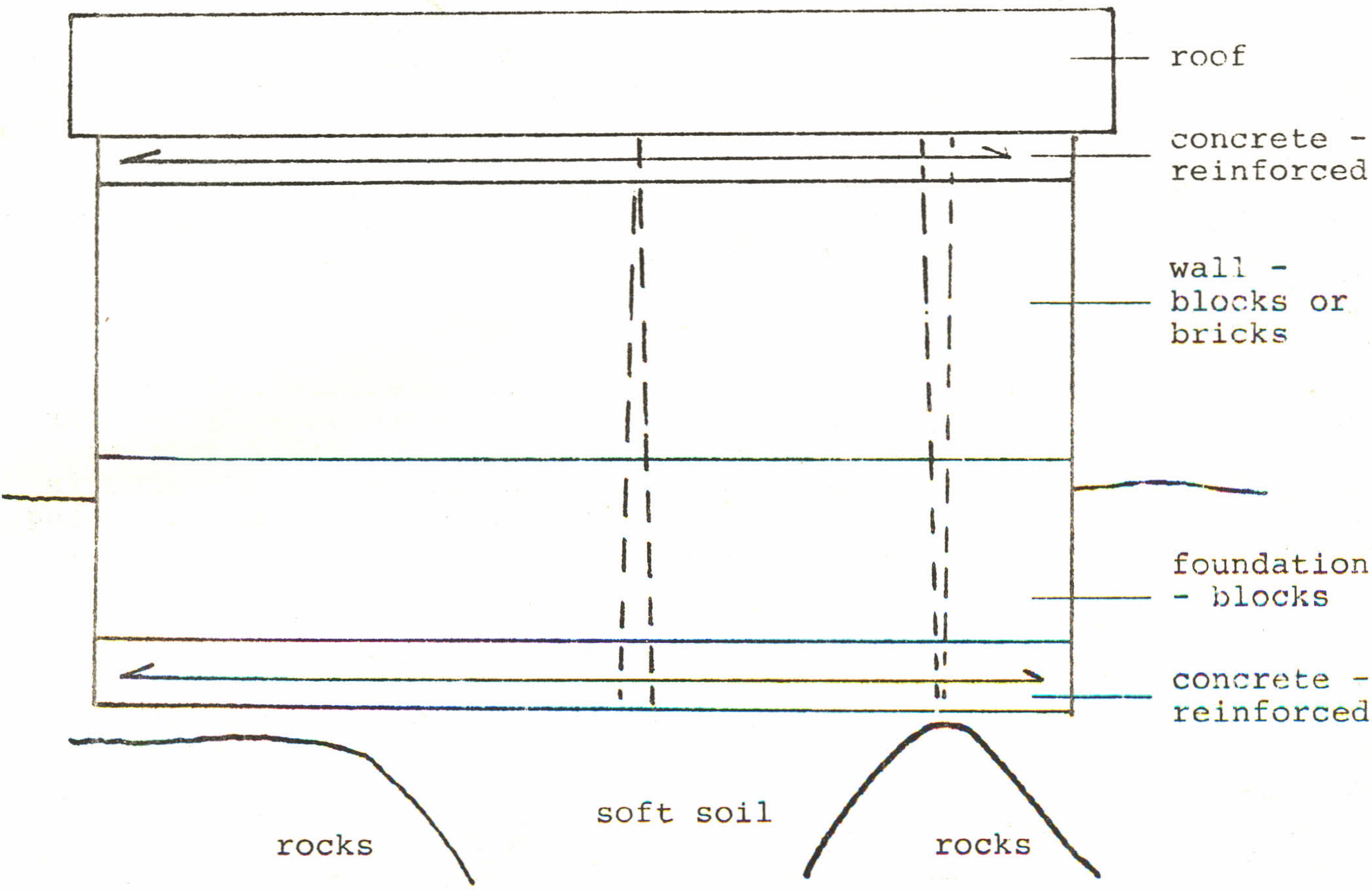


Figure 4.

The dotted lines indicate how the wall would crack if there was no reinforcement.

Things to look for when reinforcing concrete:

1. Make sure the concrete is well compacted around the iron bars.
2. The iron bars must be at least 2.5 cm inside the concrete below the surface, to protect them from water and air (rust).
3. Make sure the iron bars are in the stretching zone. That means where the gap would be widest if the concrete cracked.

4. Have the right amount of iron bars. Specialists must calculate for a big and important construction.

5. Bend the ends of plain bars. Rough bars do not need bending, but overlapping 50 cm.

Concrete blocks.

Concrete blocks are often made of cement and sand at a ratio of 1:7. Ballast or cracked pumice stone can also be added.

Common sizes and uses of concrete blocks:

1. 10 x 23 x 46 cm - dividing and external walls of small buildings.

2. 15 x 23 x 46 cm - external walls and foundations for light buildings.

3. 23 x 23 x 46 cm - foundations for heavy buildings.

They can be made by using a simple block-making machine operated by an engine or by hand. They can also be made by using simple wooden workforms on a platform or floor. Make the required size and fill the forms with concrete. Compact it by ramming it and knocking on the workform. If the blocks are left in the forms for some days it is easier to keep them wet.

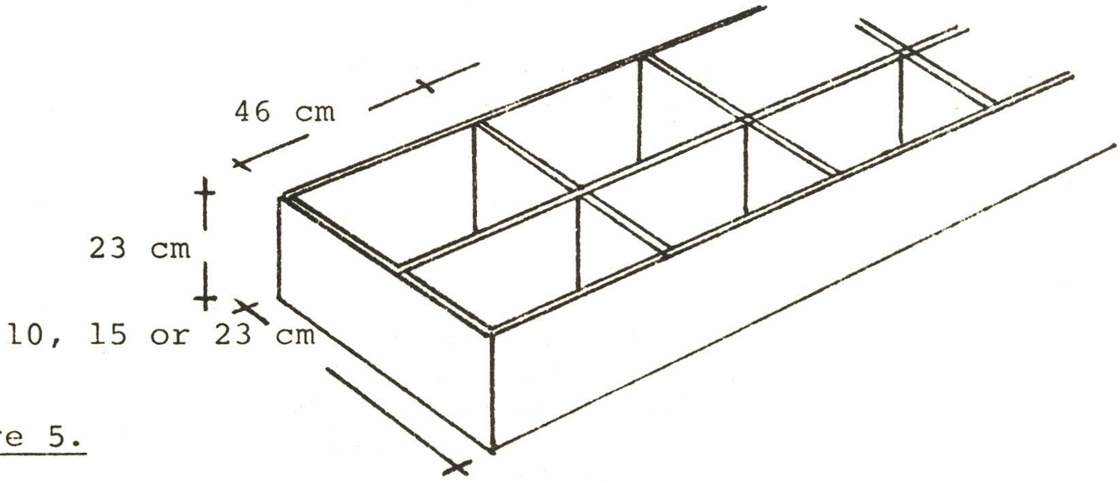


Figure 5.

It is easier to make the blocks solid, but they can also be made with holes in. This makes a lighther block to handle, less concrete is required and they are better insulators because of the air spaces.

Concrete blocks may vary very much in quality. It depends on the same factors as mentioned for making concrete.

MORTAR

Mortar is a mixture of cement and sand and sometimes lime. A thin layer of mortar is used to join blocks or bricks. The sand used should be fine, but not dusty.

Cement Mortar.

The mortar does not need to be stronger than the blocks used, 1 part cement to 7 parts of sand. It is often made stronger than is necessary. The mortar has to be a bit wetter than concrete to make it easier to work with and because the blocks "suck" the water out of it.

Cement - Lime Mortar.

Hydrated lime is added to make the ratio 1:1:7 - cement : lime : sand. The lime makes the mortar more buttery and easier to work with. This is economical and strong enough for most structures.

Finishing Mortar (Coat Topping).

1 - 2 cm thick, used on floors and other places exposed to very hard wear. Ratio 1:2 - cement : sand. A steel trowel is used to make a smooth, hard surface.

Grout.

Water is added to a normal mortar and used to fill cracks or joints in masonry.

Lime Mortar.

Lime mortar is made of 1 part hydrated lime to 3 parts of sand. This is used in brickwork and plastering of brick walls.

VOLCANIC STONE

This is quarried in many parts of Kenya. It is used in improved dwelling houses for walls and foundations. It is also used as foundation for other houses like poultry houses, pig houses, dairies and stores. Of course, it can be used for walls for these houses, but a cheaper material will normally be satisfactory.

After the stones are quarried by use of explosives they are chiselled by hand to make blocks like the concrete blocks, 23 cm high and 10, 15 or 23 cm wide. The length is uneven, from 30 cm to 1 metre.

The volcanic blocks are used in the same way as concrete blocks. Which one to use, concrete blocks or volcanic stone, depends on the price on the spot where it is going to be used. Volcanic blocks are more decorative than concrete blocks. They are usually not plastered but concrete blocks ought to be plastered. Volcanic blocks are of a more even quality than concrete blocks. The weight of the two types of blocks is not very different.

Volcanic stone can also be cracked with a machine and used as ballast in concrete.

Pumice.

Pumice is a light material of volcanic origin. It is not very strong, but can be crushed and used as aggregate in concrete floors and blocks for walls in one storey houses.

CORAL STONE

This is found as rocks in the coastal areas. Chips or small stones are used in the mud walls, mainly for decoration, because they are whitish. They can also be used as ballast when making concrete.

Coral stone is also cut into blocks, size 15 x 15 x 30 cm. They are not very strong, but can be used for foundations and walls in one storey houses. They make the houses decorative.

MURRAM BLOCKS

These are made of cement, sand and murram. Ratio 1:3:5. They can be made in the same way as concrete blocks using a machine or by hand. The strength of these blocks depends mostly on the cleanness of the murram - often it is mixed with earth. Murram blocks can be used for walls in one storey houses, and foundations for light houses. They are not used in many districts.

NATURAL SOIL

Natural soil, mud, is widely used as building material in Kenya. Almost every type of soil can be used, but some are better than others. Pure clay and black cotton are not so good.

The most common use of soil is to make a double frame of wooden sticks and fill mud in between to make a solid mud wall. The topsoil normally is not good so it is removed and the subsoil is dug up with a hoe. Water is added to the loose soil which is kneaded by treading. The mud is then filled in and rammed between the sticks of the wall, the outside of the wall is scraped smooth.

Sundried blocks.

The soil mixed with water is thrown into wooden moulds of the same type as used for making concrete blocks. The size of the mud blocks varies but often they are about 10 x 20 x 30 cm to make the wall 20 cm thick. The mould is removed as soon as the block is made. It is stiff enough to retain its shape and is left undisturbed until firm enough to handle. The blocks are then turned up after a day or two to assist in drying.

The main weakness of mudwalls and sundried blocks lies in the low resistance to water. Water from the ground and heavy driving rain may spoil the walls quickly if they are not protected. Over-hanging eaves help to protect them, and the site must be dry.

Soil mixed with cement.

Soil mixed with cement greatly increases the properties of strength and weatherproofing. This mixture can be used for solid walls, but normally they are cast in wooden moulds or made by the use of a machine. Clay and silt are not good for this type of block. They show marked changes when the moisture content is varied. A mixture of soil and sand or murram is best.

The soil must be dry before mixing with cement and water. If it is wet it has to be left in shallow layers to dry.

Sandy soil needs the least cement 5 - 10%, silty and clay soil 10 - 15%.

Water should be added so the mixture is wet through but not so much that water can be squeezed out of it in your hand. The blocks should be kept wet for 1 week. They should not be used before three weeks. The mortar used should be of the same mixture as the blocks.

BRICKS

Bricks are small blocks made of clay. These are used in many parts of Kenya where the right type of clay is available. Where bricks are produced on a large scale rather expensive machinery is used for excavating the clay, moulding, drying and burning the bricks. However, often the bricks are made locally on a small scale and very little equipment is needed.

When the bricks are to be shaped the clay has to be a bit wet so it is plastic. It is either cut from the ground with a big knife or kneaded into wooden workforms to get the shape and size wanted. The size is normally 23 x 11 x 6.5 cm (approximately). The workform is removed immediately and the bricks left to dry. When they are dry and strong enough to be handled, they are piled up in a big stack, 3 m high and 4 - 5 m square (depending on the amount of bricks). The stack is plastered with mud all over. At the bottom 2 - 3 holes are made through the stack in which wood is burnt. The heat from the burning rises up between the bricks and burns them so they become hard and get a red colour. This way of making bricks does not cost anything. It is just a question of labour, and most people can make their own.

In areas where there is suitable clay and supply of cheap or free fire wood for burning, people should be encouraged to make bricks for their own houses. They are simple to use and make good walls for all kinds of houses. Bricks absorb water easily so if the walls are not plastered, the eaves should be overhanging to protect the walls from driving rain.

TIMBER

In Kenya there are large forests, both natural and planted, which are not utilized. Some species are good for building, other for making furniture, while some are most useful as fire wood. It is one of Kenya's most valuable natural resources and greater utilization should be encouraged and promoted.

As mud houses with a wooden framework are the most common type of construction in Kenya, there is a great demand for posts and sticks for the walls and poles for the roofs. The wall posts should be of good quality, but the rest does not need to be of the very best. In some areas there is enough timber grown for that use on the farms or in local forests, but in many areas they have to buy it rather expensively from other districts.

Mangrove Poles. In the coastal areas mangrove grows and the poles are widely used in that area as posts in the walls and trusses in the roofs. They grow near and in the sea and are cut when they have got a diameter between 6 and 12 cm. They are strong and long lasting.

Sisal Poles. In areas where sisal is grown the sisal poles are used for building, mainly as trusses in the roofs but also split and used for walls in poultry houses and stores and sometimes as support and protection of mud walls. They are not very strong, but are quite resistant to termites. Only the inner soft part is eaten by them.

Cypress, pine, podo, camphor and cedar are the most readily available timbers in Kenya.

Cypress is grown in highland plantations and sawn for use in construction, plywood and joinery. It is a soft wood which is easy to work.

Pine is similar to cypress. It is sawn and used in construction, boxes and plywood. It is a soft wood with easy workability.

Podo is also sawn and used in joinery, construction and plywood. It is also soft and easily workable.

Camphor is also sawn but not used in construction, but more for furniture and joinery. It is a soft wood with moderately easy workability.

Cedar is used very much for poles and fence posts because of its durability. It is very resistant to rot and is very little attacked by termites. It is a soft and easily worked wood. It is also sawn and used in joinery, floors and boats.

The Table.

The following table shows the most common kinds of timber used in Kenya and some facts about them.

Naming. The first column shows the standard names, and where applicable the most common Kenya name, depending on the area where the timber is produced.

Hardness is closely related to density and is a measure of the resistance of a timber to indentation. Timbers have been rated in three classes: soft, moderately hard and hard. This rating is based on side grain hardness.

Strength ratings are for green timber. It should be noted that most seasoned or dry timber has increased strength properties of the order of 25%. Podo and cedar have exceptional increases of nearly double their green strength.

Seasoning or drying of timber has been described as to both rate of drying and the amount of degrade or seasoning defect that occur during drying. The rate of seasoning is described as rapid, moderate or slow, whereas the amount of degrade is described as little, moderate or severe.

Timber availability. Both the availability and the occurrence of each species is given. Availability has been classified as very abundant, readily available, moderately available, moderately scarce and scarce.

Market availability. This refers to the availability of each species directly from the sawmill or from timber merchants. The three classes are readily available, available and scarce.

Workability. This is closely associated with density and based on the ease of working dry timber with normal hand or machine tools. The classes are easy, moderately easy, moderately difficult and difficult.

Durability. The rating is based on resistence to termite and fungal attack in timber buildings under damp conditions. Four classes are recorded: very durable, durable, moderately durable and perishable. Timber in the class "perishable" should be impregnated with preservative before use, while moderately durable timber should be given a superficial treatment before use.

Treatability. Resistance to impregnation by pressure treatment to a large extent determines the usefulness of non-durable timber species. The timbers described have been classified as permeable, moderately resistant, resistant and very resistant.

COMMON TIMBERS IN KENYA

	Standard/Common Name	Spec. Gravity (at 12% m.c.)	Side Hardness	Green Strength	Seasoning Rate	Seasoning Degrade	Timber Availability (in the forest) Rating	Timber Availability (in the forest) Location
1.	Australian Blackwood	.66	mod.hard	fairly strong	rapid.	mod.	mod. scarce	Highland plantations
2.	Afzelia/Mbambakofi	.83	very hard	strong	nod.	little	mod. scarce	Coastal forests
3.	Muna	.50	soft	fairly strong			mod.available	Mt. Elgon, Mt. Kenya.
4.	Muhuhu	.93	very hard	strong	mod.	mod.	scarce	Coastal forests, highlands
5.	Pillarwood/Musaisi	.75	mod.hard	strong	mod.	severe	mod. available	Mt. Kenya, Tinderet, Nandi
6.	Iroko/Mvule	.75	mod.hard	mod.strong	rapid	little	scarce	Coastal forests, N.E.Mt. Kenya
7.	Musine	.72	mod.hard	mod.strong	mod.	mod.	readily available	Kakamega, Nandi forests
8.	E.A. Cypress	.46	soft	mod.strong	rapid	little	very abundant	Highland plantations
9.	Mukeo	.66	mod.hard	mod.strong	mod.	mod.	mod.available	Mt. Elgon, Elgeyo, Mau, Aberdares, Mt. Kenya.
10.	Saligna gum	.77	very hard	mod.strong	mod.	mod.	readily available	Highland plantations
11.	Grevillea/Silky Oak	.58	soft	very weak	slow	mod.	mod.available	Highland plantations and farms
12.	Hagenia/Mumondo	.62	mod.hard	mod.strong	slow	severe	mod.available	Mt.Kenya, Mt.Elgon, Elgeyo
13.	African Pencil Cedar/ Mutarakwa	.56	soft	weak	rapid	mod.	readily available	Ol Posimuru, Aberdares, Marmanet, Mau, Mt.Kenya
14.	Nkoba/Mukongoro/ E.A.Walnut	.66	mod.hard	strong	rapid	little	scarce	N.E.Mt.Kenya
15.	Musizi/Mutere	.46	soft	weak	rapid	mod.	scarce	Kakamega, Nandi forests
16.	E.A.Camphorwood/Muzaiti	.59	soft	mod.strong	mod.	mod.	readily available	Mt. Kenya
17.	E.A. Olive/Musharagi	.90	very hard	very strong	slow	mod.	readily available	Elgeyo, Ol Posimuru, Aberdares, Mau, Mt.Kenya
18.	Loliondo/Elgon Olive	.80	mod.hard	strong	mod.	mod.	mod.scarce	Kakamega, N.E.Mt.Kenya
19.	Pine	.48	soft	weak	rapid	mod.	readily available	Highland plantations
20.	Podo/Musengera	.51	soft	weak	rapid	mod.	readily available	Aberdares, Mt.Elgon, Ol Posimuru Mt.Kenya, Mau. Marmanet, Elgeyo,
21.	Mutati/Muhuruhuru	.38	soft	very weak	rapid	mod.	mod.available	Transmara, Mau, Elgeyo, Nandi
22.		.75	very hard	strong	slow	severe	readily available	Mt.Kenya, Mau, Ol Posimuru, Elgeyo Mt.Elgon
23.	Mtandarusi	.88	very hard	strong	rapid	mod.	scarce	Coastal forests
24.	Vitex/Muhuru/Meru Oak	.50	soft	weak	rapid	little	scarce	Mt.Kenya, (natural forests and plantations)

CONT. .

Common Timbers in Kenya - cont.

No.	Market Availability (sawn timber)	Workability	Durability	Treatability	Uses
1.	available	mod. difficult	mod. durable	resistant	furniture, flooring, joinery, cabinets, tool handles, b
2.	scarce	mod. easy	very durable	very resistant	furniture, joinery, carved Arab doors, boats
3.	available	mod. easy	mod. durable	permeable	joinery, boats, mouldings
4.	scarce	mod. difficult	very durable	very resistant	carving, flooring
5.	available	mod. easy	mod. durable	very resistant	construction, flooring, tool&brush handles, power-pole cro
6.	available (from Ug.&Tz.)	easy	durable	very resistant	furniture, joinery, cabinets, boats, flooring
7.	scarce	mod. easy	mod. durable	permeable	flooring, construction, plywood
8.	readily available	easy	mod. durable	mod. resistant	construction, plywood, joinery
9.	available	mod. easy	mod. durable	-	tool handles, ladders, boats, flooring
10.	scarce	mod. difficult	mod. durable	mod. resistant	posts and poles, (if sawn, construction and flooring)
11.	available	mod. easy	mod. durable	mod. resistant	construction, furniture
12.	available	mod. easy	mod. durable	resistant	flooring, furniture
13.	readily available	easy	very durable	resistant	joinery, cabinets, flooring, boats, oil extracts, posts
14.	scarce	easy	mod. durable	very resistant	furniture, joinery
15.	scarce	easy	mod. durable	mod. resistant	furniture, joinery, plywood
16.	available	mod. easy	mod. durable	very resistant	furniture, joinery, lorry bodies, boats
17.	available	mod. difficult	mod. durable	mod. resistant	flooring, tool handles, heavy construction
18.	available	mod. difficult	very durable	mod. resistant	furniture, joinery, flooring
19.	readily available	easy	perishable	permeable	general construction, boxed, plywood
20.	readily available	easy	perishable	-	joinery, cabinets, construction, plywood
21.	available (plywood)	easy	perishable	-	boxes, crates, tea-chest plywood
22.	scarce	mod.easy	mod. durable	resistant	heavy construction, flooring
23.	scarce	mod. difficult	mod. durable	very resistant	flooring, construction, boats
24.	available	easy	mod. durable	-	furniture, cabinets, joinery.

Uses. The various uses to which each timber can be applied are summarized in the last column. It should be noted that the uses recorded are not complete but are merely general indications of suitable applications.

The names of the timbers in the first column are not transferred to the next page, but only the number of the species.

Felling of timber.

Trees used for building purposes should be felled as soon as possible after reaching maturity. If felled prematurely, the wood is not durable and contains an excess of sapwood. If cut after its prime, it produces timber which is brittle and the central portion especially may show evidence of decay. The time taken before trees reach their prime varies very much.

Seasoning.

Timber cannot be used for either carpenters' or joiners' work immediately it has been felled because of the large sap content. Most of this moisture must be removed, otherwise the timber will shrink excessively, causing defects in the work and a tendency to decay. Elimination of the moisture, as mentioned previously, increases the strength and also the durability and resilience of the timber, the wood is lighter in weight, easier to work with the saw and other tools, it maintains its size and is not so liable to split, twist or warp. The process of removing the moisture is called seasoning or maturing.

In Kenya, one of the main reasons why wood is not well accepted by architects, engineers and building contractors is because the timber industry does not supply a stable, seasoned and graded product.

Methods of seasoning. Fans and supplementary heating can be used for a fast and controlled seasoning but in Kenya natural air drying is preferable. That means that the timber is allowed to dry in the open or in a shed. The climate here is suitable for air drying and this is the cheapest way to do it.

The main points are to avoid rain and strong sun shine on the timber. Rain will make the timber swell and shrink, and the heat from the sun makes it dry very fast so it splits and cracks. The timber should dry with a reasonable speed. Boards 2.5 cm. of cedar, podo, pine or cypress take approximately 30 - 40 days to dry under cover (roof) well ventilated.

The horizontal box stacking method is the most common method of stacking timber which is to be air dried, and this method is recommended in Kenya.

Foundation: The timber stack must be placed on foundations at least 30 cm off the ground. The foundations must be strong enough to support the stack of timber; secondly it must be durable. Durable timber can be used for this, but bricks or blocks of stone or concrete are better. The blocks must make a flat foundation to avoid bending and twisting of the

Horizontal stacking for air seasoning

Figure 6a Top view

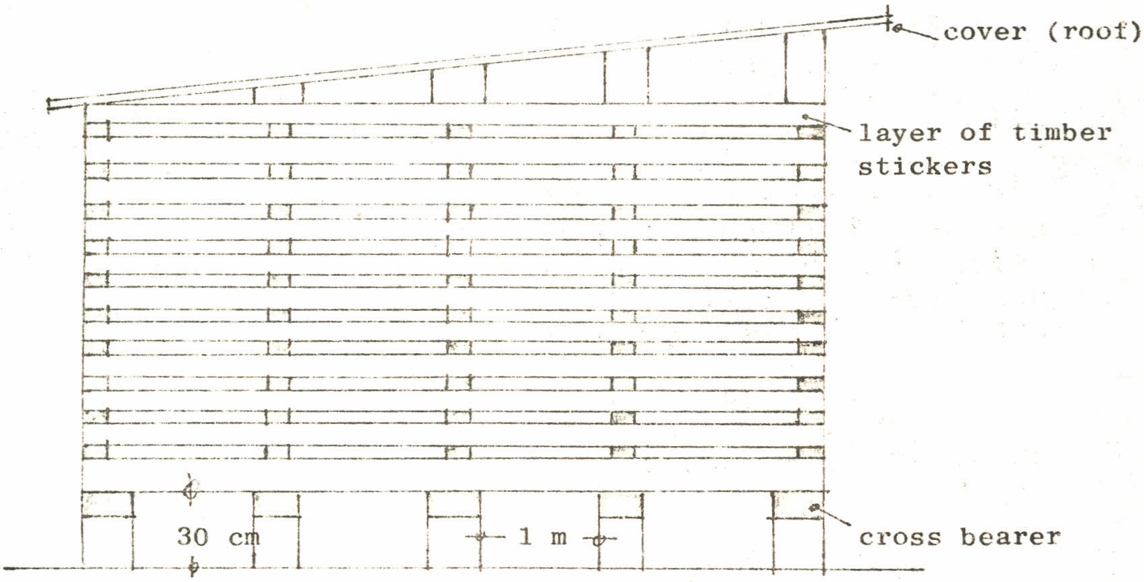


Figure 6b Side view

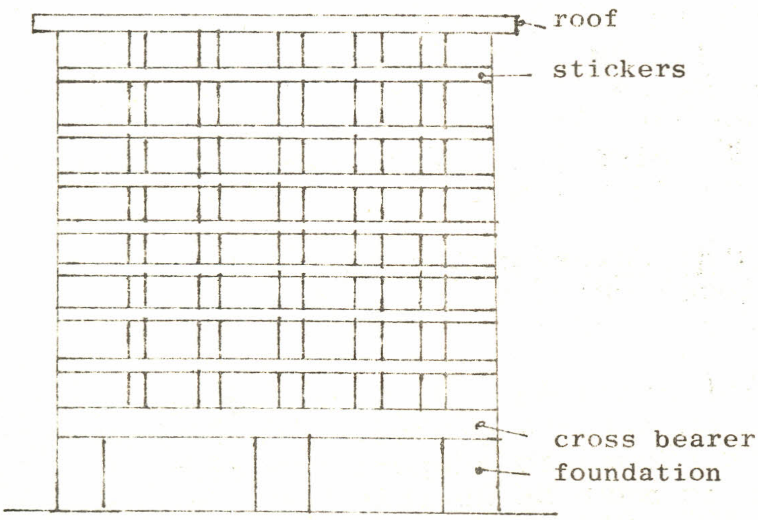


Figure 6c End view

timber placed on top for drying. The area under the stack must be kept clear so as to allow air to flow and for drainage.

Stacking: The timber should be placed in a uniform pattern so as to allow both vertical and horizontal circulation of air. The boards are placed in layers separated by stickers or the smallest boards which are to be dried. In each layer the boards are separated so as to form vertical channels.

Stack Cover: The stack can be placed under a permanent roof, but as that is often not available, a temporary roof of two layers of low grade material can be used. When there is a lot of timber to be dried often there is a house to be built later, and the roof covering material can be ordered in advance to be used to cover the stack.

Timber preservation.

The main structual soft wood timbers of Kenya are not naturally durable. If used in conditions subjected to fungal, insect or termite attack, they will fail after some time. To avoid this the timber used in permanent structures should be treated with a preservative.

Effective preservation depends on the preservative employed and its application. An effective preservative should be poisonous to fungi and insects, permanent, able to penetrate sufficiently, cheap and readily available. It should not corrode metal fastenings, etc., nor should the timber be rendered more flameable by its use. It is sometimes desirable to have a preservative-treated surface which can be painted.

If a structure is correctly designed and built, and the moisture content of its timber does not exceed 20% then a preservative treatment is generally unnecessary as protection against fungal attack. Where the above conditions are not present however, there will be a risk of fungal decay, and proper preservation is recommended.

One point to consider is the cost of replacement. This involves the cost of timber, labour and disruption of occupancy and danger of collapse.

Wood destroying fungi that occur in Kenya vary in detailed appearance, but they all produce a soft, brashy surface on the attacked timber, and cause a complete loss of strength. In confined spaces these fungi produce a musty odour.

The dry wood termite (Cryptotermes dudleyi Banks Kalotermitidae) lives within the attacked timber, and need no contact with the ground. All food requirements are contained in the host timber. No timber is immune to attack, although the heart wood of some (e.g. mvule and cedar) is extremely resistant. In rough sawn timber it is very difficult to tell whether the timber is sound or not, but in dressed timber it is easier to see the "exit" holes

The surest way to identify an attack is by the faecal pellets. These are ejected from the timber in large quantitites. They are oval, hard and variable in colour from buff to black. In size they are about 1 mm long and 0.5 mm in diameter.

The ground termites (Coptotermes amanii Sjost. Thinotermitidae and Odontotermes badious Har. Termitidae) live in under ground nests and forage above the ground for their nutrition. The former species can, however, live within damp coral or mud walls, without any connection with an under ground nest. Their foraging trails are mud covered galleries. They attack timber readily and rapidly, but are resisted by durable species. Coptotermes can forage over considerable distances and inhospitable surfaces.

The powder post beetles (Lyctidae and Bostrichidae) attack the sap wood of many hard woods and some soft woods, and in some cases the heart wood may also be attacked. Their attack is recognised by numerous exit holes and fine powder-like frass. They may completely destroy susceptible timber.

The pinhole borer - ambrosia beetles (Scolytidae and Platypodidae) attack fresh-cut timber and logs only. Their borings are free from frass, and except from fresh borings they are stained dark brown to black. They cannot live in seasoned timber.

The long horn borers (Cermambycidae):

1. Oemidagahani Dist. may begin life as a larvae in a living tree and remain there when the tree is made into timber and subsequently into structures. Seasoned structural timber may also be directly attacked. It is commonly found in cypress, podo and cedar, though a wide range of timber is susceptible to attack and may suffer serious damage from larvae borings.
2. Stroatium barbatum Fab. has so far only been found at Mombasa, but may attack many timbers, the larvae causing extensive damage by their tunnelling. Their life cycle is long and damage is usually not seen until the new adults leave timber by their large oval shaped holes.

Substances used for wood preservation.

Creosote is an effective general prupose preservative being cheap and widely used for external work, and to a lesser degree internally. It is a black or brownish oil produced by the distillation of coal-tar. It has many of the properties we require of a preservative, but it increases flammability, is subject to evaporation, and creosoted wood can not be painted. It should not be used internally if the characteristic smell would be a nuisance.

Coal-tar as a preservative is not so effective as the creosote produced from it. Tar is less poisonous, it does not penetrate the timber because of its viscosity, it is blacker than creosote and it is unsuitable for internal wood work.

Unleachable metallic salts are mostly based on copper salts. A combination of copper/chrome/arsenate is used. The copper and arsenical salt are the toxic preservatives which are rendered unleachable (cannot be washed out) by the chrome salt acting as a fixing agent. The timber is impregnated by "vacuum pressure".

Preservation by metallic salt is being increasingly used. Treated surfaces can be painted or glued, evaporation is negligible, the liquid is odourless and non-oily.

Water soluable preservatives. These are not satisfactory for external use, as they are liable to be removed from the timber by rain. They are, however, very suitable for interior work, as they are comparatively odourless and colourless, and the timber can be painted.

The following schedule shows various types of preservatives which are tested and recommended for Kenya:

Class A. Tar Oil Preservatives
Creosote in accordance with British Standard Specification 144.

Class B. Organic Solvent Preservatives
1. Containing 3% copper napthenate with 5% dieldrin
2. " 5% pentachlorophenol " 5% "

Class C. Water Soluble Preservatives
Copper chromarsenate in not less than a 3% solution

Class D. Emulsion Preservatives
B.M.T. emulsion containing not less than 8.7% pentachlorophenol with 5% dieldrin

Class E. Diffusion Preservatives
Boron solutions containing boric acid at sufficient strength to suit the size of the timber

Class F. Gaseous Fumigants
Methyl bromid (with 2% chloropicrin as a warning agent) applied at a suitable normal dosage to the required concentration/time product.

Methods of wood preservation.

The timber should be seasoned before being subjected to a preservative process, as the presence of moisture prevents the penetration of the preservative. To be effective the preservative must sufficiently penetrate the timber.

There are three main methods of preservation.

1. Pressure. The timber is placed in a steel cylinder having a door at each end. The cylinder is fixed horizontally at ground level, and a storage tank containing the preservative and steam coils for heating it, is connected to it. Creosote is the main preservative used.
When pressure is applied in the tank the preservative is forced into the cells of the wood.
   a. The full-cell process is when the creosote remains in the cell after the process.
   b. The empty-cell process or Rueping process is when most of the preservative is removed from the cells by vacuum.

2. Non-Pressure. This treatment is known as steeping, or soaking or open tank, and is used for relatively small quantities of timber when a pressure plant is not available. A water

tight tank, open at the top, contains the preservative and the full length of the timber is steeped into it. On a small scale a drum can be used and the ends of the timber or posts can be steeped in.

a. Hot and cold steeping. The tank with the preservative and timber in is heated to nearly boiling (90 - 95°C). The temperature should be maintained for one to two hours and then allowed to cool. During the heating period the cells and the air in the cells expand and some of it is expelled. As the timber and preservative cool the timber contracts and the partial vacuum created causes the liquid to be gradually absorbed into the timber.

b. The timber can be steeped in hot or cold preservative, but it is not so effective as hot and cold steeping. Creosote or metallic salt can be applied by these methods.

3. Superficial. These include dipping, spraying and brush application. None of these surface treatments are as effective as the pressure and open-tank systems, as the preservative only slightly penetrates the timber. The wood must be seasoned and the surface should be dry and clean before application. Greater penetration generally results if the preservative is applied hot, especially if creosote is used. The timber should have two coats at least; the first coating allowed to dry before the next is applied. Creosote is the most common preservative used for this method.

PAINT

Paint preserves, protects and decorates surfaces and enables them to be cleaned easily.

Paint is composed of pigment suspended in a liquid. Pigment gives colour and opacity. The liquid (known as a medium or vehicle) is composed mainly of a binder and thinner. The binder fixes the pigment to the surface being painted and is responsible for the gloss and waterproofing characteristics etc. Thinners reduce the viscosity of the paint and aid its penetration. A drier is included in the medium to hasten drying. Natural pigments are: iron oxides, ochres, umbers, etc. Chemically manufactured pigments are: chromes, Prussian blue, sinc oxide, etc. Mediums used are oils, varnishes, resin, bitumen and cellulose derivates. The most common thinner or solvent is turpentine, its subsitute white spirit is also used.

Adequate preparation of the surface to be painted is essential. The surface should be smooth (not shiny for this would not give a good anchor), clean, dry and stable. Old, loose paint from previous painting should be brushed off before the new coat is applied.

The paint film is usually built up with three coats, but sometimes more.

Priming Coat — This is the first layer of paint. It must suit the back ground and adhere to it. It must be compatible with subsequent layers.

Undercoats — These are supposed to build up an adequately thick paint film to obscure the primer. It must have a tint suitable to match with the final coat.

Finishing Coat — This gives the desired colour and finish to the surface. Finishes vary from flat (matt) to egg shell to oil-gloss to enamel (high gloss). Gloss paints are more durable for exterior use and are easier to clean than matt paints. Matt paint is not so shiny and does not emphasize irregularities in the surface painted.

Types of paint.

1. Oil Paints are the traditional type having a linseed oil medium. The primer has white lead, a small amount of red lead and extender (a white pigment used to increase bulk, prevent sedimentation and improve spreading). The lead base is for external use, leadless pigments for internal use. Undercoats - linseed oil, while lead (tinted if required) and a high quality drying oil. Finishing coat - oil varnish, pigment of desired colour and perhaps extenders and thinners. Finishes vary from matt to oil gloss. Oil paints dry by evaporating of the solvent and by oxidation.

2. Synthetic Paints have a chemical compound medium. They set more quickly than oil paints and are more durable. They also have a better flow which makes them easier to apply. Drying is by evaporation of the solvent, by oxidation and chemical change.

3. Water Paints, also known as distempers, are used mainly on internal walls and ceilings and most of them give a flat finish. They are prepared on the site by adding water to make a paste. They have a drying oil or varnish medium mixed with water, glue or other fixatives. The cheapest type, known as soft or ceiling distemper, contains only a glue size vehicle and tinted powdered chalk. It can be removed by washing or brushing and so it is used mostly for ceilings.
   Oil bound distemper is a better quality having a mixture of linseed oil, pigment and extender. It will withstand limited careful washing.
   Another type is cement paint, often used externally, it contains white or coloured Portland cement with a waterproofer, accelerator and extender.

4. Cellulose Paints are synthetically produced from cellulose compounds and most of them have to be applied as a spray. They are not suitable for general building work, but can be used for furniture and fittings in the house. They are widely used in the motor-car industry.

5. Emulsion Paints have the pigments and the medium dispersed as small globules in water, oil, synthetic resin or bitumen. They are used mainly on walls.

6. Varnishes are either oil or spirit based. They are used to give a transparent film to a surface on furniture etc.

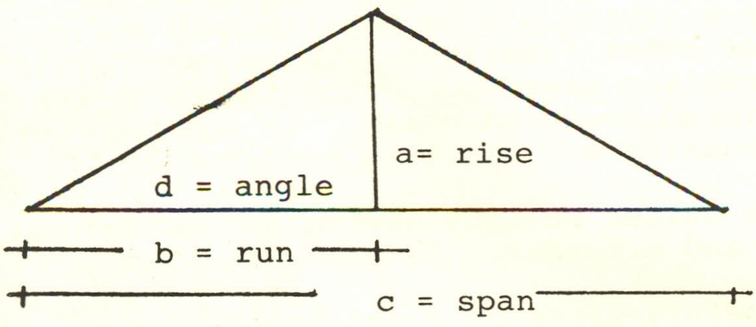
Besides these paints there are many other special paints like aluminium paints, anti-condensation paints, bituminous paints, chlorinated rubber paints, fire resistant paints, fungicidal paints, gold size, heat resisting paints, etc.

The cost of painting is a big item which limits the use of paint on buildings in rural areas. On these buildings we hardly see any painting today. The places which should have priority when some painting can be afforded are where there is risk of rot and decay because of rain and moisture, places which should be clean and easy to wash such as the kitchen and inside the dairy. The sitting room or a workshop could also be painted inside with a light colour to make the room lighter. White, or another light colour, reflects more light than a dark colour. Iron sheets used as roofing should also be painted when they begin to rust.

ROOFING

Terms:

Covering	is the external material laid or fixed on the roof to protect the building.
Span	is the horizontal distance between the internal faces of the walls supporting the roof.
Run	is half the span.
Rise	is the vertical height measured from a line from the wall plate on one side of the house to the other side, to the ridge of the roof.
The angle	is measured between the horizontal line and the roof.
Slope	is rise : run.
Pitch	is rise : span.



$\frac{a}{b}$ = slope

$\frac{a}{c}$ = pitch

Figure 7

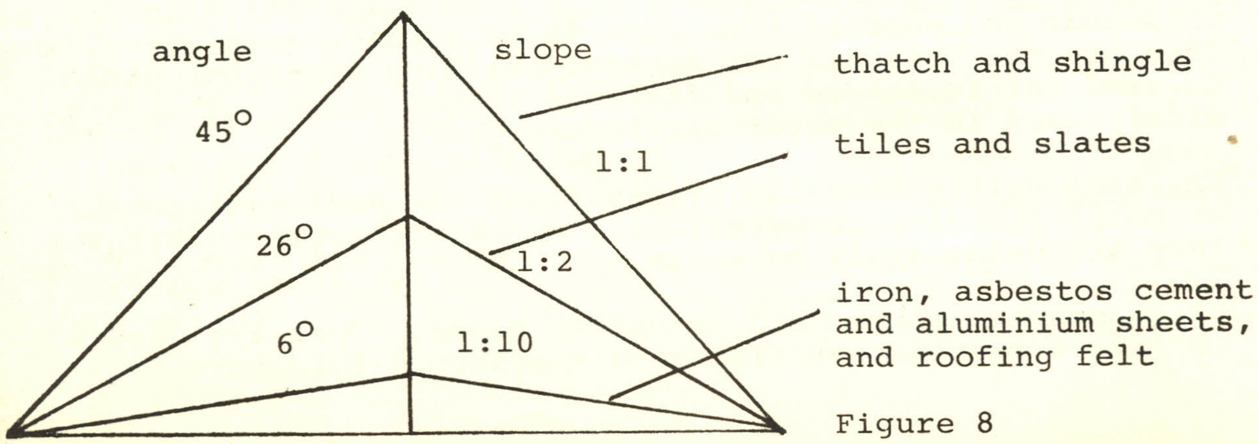


Figure 8

Roof covering materials.

There are many types of roof covering material to choose between. Their properties vary very much, and so do the prices. Because of this there are two types most commonly used for roofing in the rural areas, these are thatch and corrugated iron sheets.

1. Thatch. This includes grass of various kinds and palm leaves. The quality of the roof depends greatly on the work done and the type of thatch used. As this is the traditional roof covering the use of it does not need very much description. The thatch is laid and tied on top of a frame work of wooden sticks or rails, starting at the eaves. The grass is often tied into bunches and palm leaves are tied to form mats. The grass bunches are laid to overlap the layer underneath by half to two thirds of the length, which means there will be two to three layers of bunches. The thickness of the roof is 20 - 20 cm. The mats of palm leaves are laid to overlap the underlaying mats by at least three quarters of their length. The thickness of this thatch is about 5 cm.

   The slope of thatched roofs has to be rather steep, to drain off the rain water. The minimum slope should be 1 : 1 or 45^{o} angle between the roof and a horizontal line across the house. (See Fig. 8)

   Thatch is generally cheap; people can thatch their own houses with very little expense. It is a good insulator.

   The life of a thatched roof varies very much, depending on the kind of grass used and how the work is carried out. Palm leaves last only 2 - 4 years, but some kinds of grass can last much longer. Thatch can harbour insects, posts and snakes. It can also catch fire easily and during heavy, long lasting rain leakage may occur.

2. Large Unit covering. This includes corrugated sheets of iron, asbestos cement and aluminium. East sheet covers one square metre or more, which makes this type of roof covering easy and quick to mount. They are light in weight. The minimum slope of the roof should be 1 : 10 or 6^{o}.

   a. Corrugated iron sheets have a coating of zinc which is called galvanizing. If the coating is damaged the iron will rust. When the first signs of rusting are seen, the sheet may be painted with a lead based paint to stop rusting; this is usually after 1 - 2 years. The sheets are sold in lengths from 1.20 m to 3 m and width 65 and 75 cm. Thickness normally used on roofs are 26, 28 and 30 gauge. The higher the number the thinner the sheet. Iron sheets are quite durable if they are maintained with paint. They are light for transport, handling and roof construction. They do not need very stable and strong timber support. They do not burn or rot. An unskilled labourer can easily mount them, and they can be dismounted and used again. They are not expensive to buy and mount. The disadvantages are that they will rust after some time, they need maintenance, they are poor insulators and make noise during heavy rain.

The laying of the sheets has to commence from the lowest part of the roof completing the first row before continuing with the next row up. An overlap of 1 or 1½ corrugations is usually good enough at the sides, and 10 - 15 cm end or head overlap. More overlap is required for a roof which is fairly flat compared to a steep one. The sheets are fixed through the crown of the corrugations with galvanized nails with curved washers.

b. Asbestos cement sheets can be supplied in a variety of corrugations, but the standard type have corrugations a bit bigger than corrugated iron sheets. They have normally a natural grey colour from the cement and asbestos fibres, but they can be supplied in many different colours. The standard sheets are 75 cm wide and from 105 cm to 300 cm long. The thickness is 0.6 cm. End overlap 10 - 15 cm and side overlap 1½ corrugations. The sheets are fixed with galvanized screws, curved washers and lead washers. Asbestos cement sheets are very long lasting. They do not burn, rot or rust and there is very little corrosion. They are good insulators for heat and cold and they do not make noise during heavy rain. They can be worked with normal carpentry tools. The main reason they are not more widely used in the rural areas is that they are rather expensive. They are heavy for transport and difficult to handle because they are brittle. A strong and stable roof construction is required to support the sheets. An unskilled labourer should not mount these sheets.

c. Aluminium sheets normally used are corrugated and look like corrugated iron sheets. The same sizes are also supplied. When new, the sheets have a bright reflective surface, but after a year or so there will be an oxidation on the surface which takes away the glare. There is never any need to paint aluminium sheets for protection. The sheets are also processed in colours, often pale green or grey, but they are more expensive.
Aluminium sheets are very light and easy to handle and mount. They are mounted in the same way as iron sheets and do not need very good timber support. They do not rot, rust or burn, and are extremely long lasting. They are not very good insulators, but better than iron sheets as long as they are not painted. The reason they are not widely used is the high purchase price. They are also noisy during heavy rain.

d. Plastic sheets are shaped like the sheets of iron, asbestos cement or aluminium and are used to replace some of the sheets in a roof to give overhead light inside the house. They are transparent or translucent and give a good light inside big halls, workshops, etc.
They are long lasting, simple to mount and give a cheap light, though the sheets are expensive. They are burnable and have to be cleaned occasionally.

3. Roofing felt. Bituminous roofing felt is supplied in rolls containing a sheet 90 - 100 cm wide and 20 - 30 m long, with various thicknesses - 1, 2 or 3 ply. It is layed on a wood or concrete roof deck and nailed to the roof or pressed into hot, bituminous solution. It can be used on nearly flat roofs.

The roofing felt itself is not very costly but the roof deck required makes it costly and not very suitable for farmers in Kenya. This roof needs to be frequently inspected for tears and punctures, and a fresh coating of bitumen every few years may be necessary. A top dressing of grit or sand of light colour reduces thermal movement and gives the roof a better appearance.
This roof is a good insulator and is not noisy during rain. It is not very long lasting, it can burn and it cannot be removed and used again.

4. Small Units roof covering.

   a. Tiles and slates are made of clay or concrete. There are many sizes and shapes. The tiles are red like bricks. Slates may have any colour, but often are red, green or blue. About 20 pieces are required to cover 1 sq.m. Because of their weight and many joints, a very strong and often an expensive construction of timber is required. They are long lasting, do not rot, rust or burn, and they are decorative.
   Because of the high price this type of roof is not constructed nowadays. Skilled labourers are required for construction, many joints may cause leakage and strong wind may cause damage to this kind of roof.

   b. Shingles are made of wood and like small slates. They are used at forest stations and in forest areas where suitable timber is available. They are layed like shells on the roof, lapped twice and nailed with galvanized nails to a roof deck or battens. Preservative treatment is not normally used. They are decorative and can last 10 - 15 years without maintenance depending on the species of wood used. Cedar may last for 20 years. They are light in weight, do not need very good timber support or skilled labourers for mounting. It is a good insulation and does not make noise during rain.
   It is expensive if the material has to be bought, but people can do most of the work themselves. Many joints may cause leakage and it can also burn.

Site Organisation and Setting Out

After the plan of the new building is ready and a suitable site is chosen there is a lot of organisation and planning to do before the actual work can begin.

Materials. Most of the materials required for the building should be brought near to the site, or it should be checked from local sources which supplies are available and can be delivered at short notice.

Access road. Is it possible to transport materials for the building to the site? A temporary road may have to be built. The possibility of laying a permanent road should first be considered.

Water supply. If concrete is to be used in the building, water must be available. Collect water during the rainy season if possible, if there are no other natural sources.

Building Materials Available and Used in Kenya

	Sand	Ballast	Stone	Concrete Blocks	Stone Blocks	Coral Blocks	Coral Stones	Bricks	Mud Blocks	Sawn Timber	Timber Off-cuts	Posts, Rails	Grass, Palmleaves	Corrugated Iron Sheets	Doors and Windows
Coast Province															
Kwale	au	au	au	a								au	au	au	au
Mombasa	au	au	au	a			au	au					au	au	au
Kilifi	au	au	au	a		au	au	u		a		au	au	au	au
Lamu	au			au		au	au					au	au	au	au
Taita	au	au	a	a					au			au	au	au	au
Taveta	au		a	a						a	a	au	au	au	au
Eastern Province															
Kitui	au		au	au				au	au			au	au	au	au
Machakos	au	au	au	au	au			au				au	au	au	au
Embu	au	au	au	a	a			a		au	au	au	au	au	au
Meru	au	au	au	a	au				au	au	au	au	au	au	au
Central Province															
Kiambu	au	au	au	au	au				au	au	au	au	au	au	au
Muranga	au	au	au		au			au	au	au	au	au	au	au	au
Nyeri	au	au	au	a	au					au	au	au	au	au	au
Kirinyaga	au	au	au	a	au			au	a	au	au	au	au	au	au
Nyandarua	u	au	au		au					au	au	au	au	au	au
Rift Valley Prov.															
Kajiado	au	a	au	a										a	
Narok	au	au	au	a	a					a	au	au	a	au	au
Nakuru	au	au	au	au	au					au	au	au	au	au	au
Kericho	au	au	au		au			au		au	au	au	au	au	au
Baringo	au		au		au					au	au	au	au	au	au
Nandi	au	u	au					au		au	a	u	au	au	au
Eldoret	au	au	au	au				au		au	au	au	au	au	au
Kitale	u	au	au	au	au			au		au	au	au	au	au	au
Laikipia	au	au	au	a	au					au	au	au	au	au	au
Nyanza Province															
South Nyanza	au	au	au	a	au			au				au	au	au	au
Kisii	au		au	au				au				u	au	au	au
Kisumu	au	au	au	au	au			au		a	a	au	au	au	au
Siaya	au	au	a	a	a							au	au	au	au
Western Province															
Kakamega	au	au	au	a				au		au	au	au	au	au	au
Busia	au	au	au	a	a			au				au	au	au	au
Bungoma	au		au	a	au			au				au	au	au	au
Northern and Eastern Districts	a		a	a					au				au		

Northern and Eastern Districts include: West Pokot, Elgeyo, Marakwet Turkana, Samburu, Marsabit, Isiolo, Garissa, Wajir and Mandera

Key: a - means the material is available (found or made) in the district.

u - means the material is used to a certain extent nowadays.

Labour. Make sure that the required labour is available and arrange the date you want them. Make an agreement with the labour about the work, salary, etc. before they start.

Tools and equipment. These should be at the site or readily available before the work starts.

Setting out. Setting out means measuring on the ground the size shown on the drawing and marking these with pegs and lines and in other ways so that the work will be level and plumb, true to line, square and the correct size, and so that the building erected will be exactly where it is wanted.

1. Make sure tools and other things needed are ready for use: measuring tape, wire or string, hammer and nails, pegs and spade.

2. Fix the corners of the planned building approximately with sticks.

3. Clear the ground, remove all rocks, roots and topsoil from the site and at least 1 m outside the site on all sides to give space for transport and easy movement. Topsoil removed may be used for garden or levelling around the house.

4. Make line boards around the house to have some fixed points which do not need to be removed during the building period.

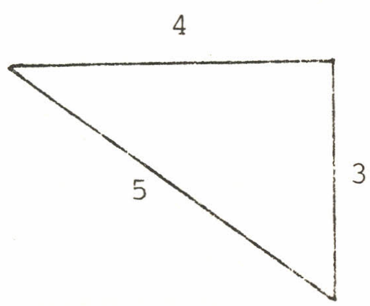
5. Stretch the wire or string from the line boards on one side to the other, to fix corners of the house, dividing walls etc. Make marks in the line boards so the wire can easily be stretched later to find the corners and dividing walls.

6. Dig the trenches for the foundations (or holes for the posts). This subsoil may be used for filling up the floor inside the house.

7. Make the bottom of the trenches level, or in steps if the site is sloping. If the foundation is to be made of concrete and filled directly into the trenches, the width should be the width of the foundation required. If work forms are to be used for the concrete, or blocks are going to be used, the trenches must be wider to ease the work.

8. Fix the place for the foundation exactly.

9. Check that there are correct measurements, right angles and equal diagonals. Pull the tape tight and keep it level. To get a right angle make a triangle of boards, the sides being 3, 4 and 5 m (or any other unit) long.



$$\sqrt{3^2 + 4^2} = 5$$

Figure 9. Right angle.

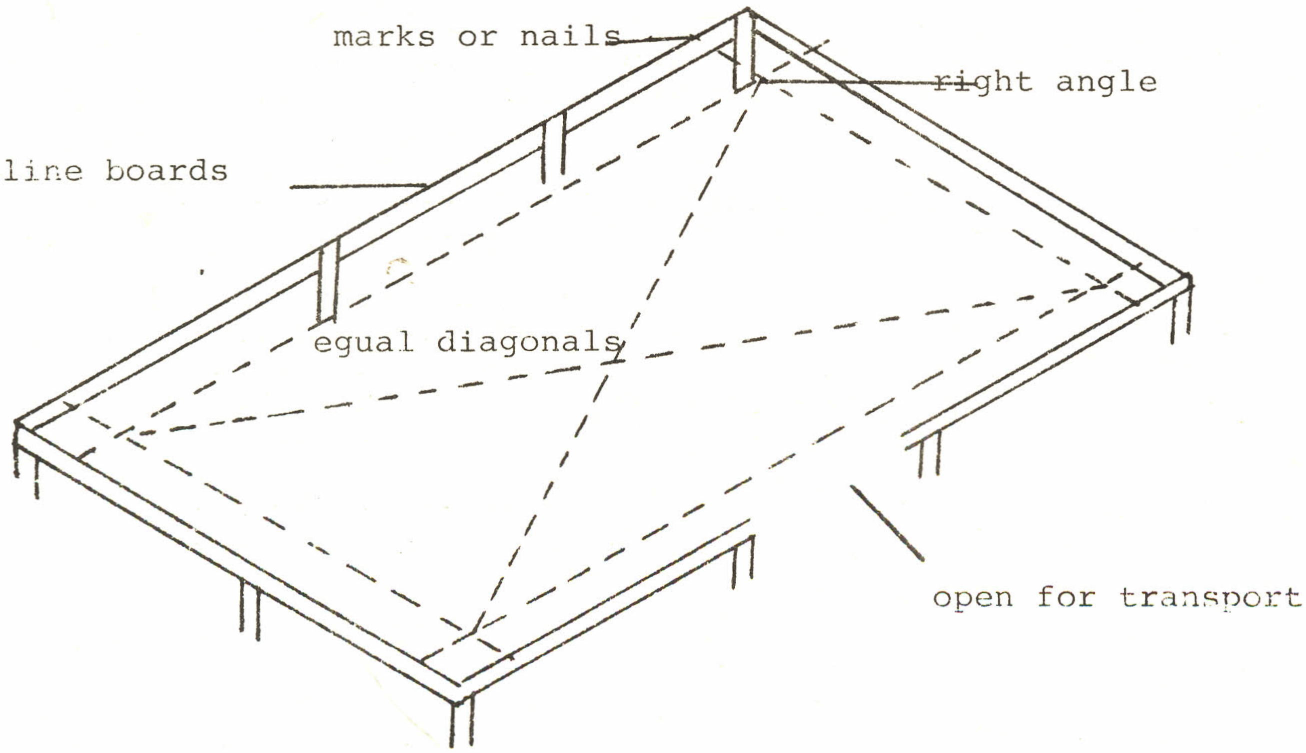


Figure 10. Setting out.

Foundations

Foundations must provide a level and firm base capable of carrying the weight of the building without distortion. It must not break or twist under the load, disintegrate in the presence of water, sag or crack because the ground is not firm or crack because of large tree roots.

Foundations may be made of solid concrete, concrete or stone blocks or even wooden poles can be used if rot and termite resistant timber is available.

The foundation should be based on firm soil, murran or rocks. In case of soil the trenches for the foundation should be dug 1 m deep for a heavy building, but in order to make it cheaper for light and simple buildings, the trenches may be dug only deep enough to reach firm subsoil, which might be only 20 - 30 cm.

Figure 11 a. and b. shows a foundation. The depth under ground level might be anything between 20 and 100 cm depending on the weight of the building and firmness of subsoil. After the trench is dug 30 - 40 cm wide, pegs are put in the bottom to reach 15 cm above the bottom. The tops of the pegs are carefully levelled and the concrete is filled in the trench to the top of the pegs. Use ratio 1:4:8 and in order to spare concrete, stones can be put at the bottom of the trench and also inside the concrete itself. For heavy buildings 2 iron bars of 10 mm diameter should be laid in the concrete for reinforcement, to avoid cracks. Blocks of concrete or stone are then laid on the concrete until the foundation reaches a level between 20 and 50 cm above ground level at the highest point of the surrounding ground. The width of the foundation might be 15 or 23 cm. The former being sufficient for most farm buildings.

Figure 12 a. and b. shows another way to construct a foundation which normally is cheaper than the type shown in Figure 11. The

FOUNDATIONS

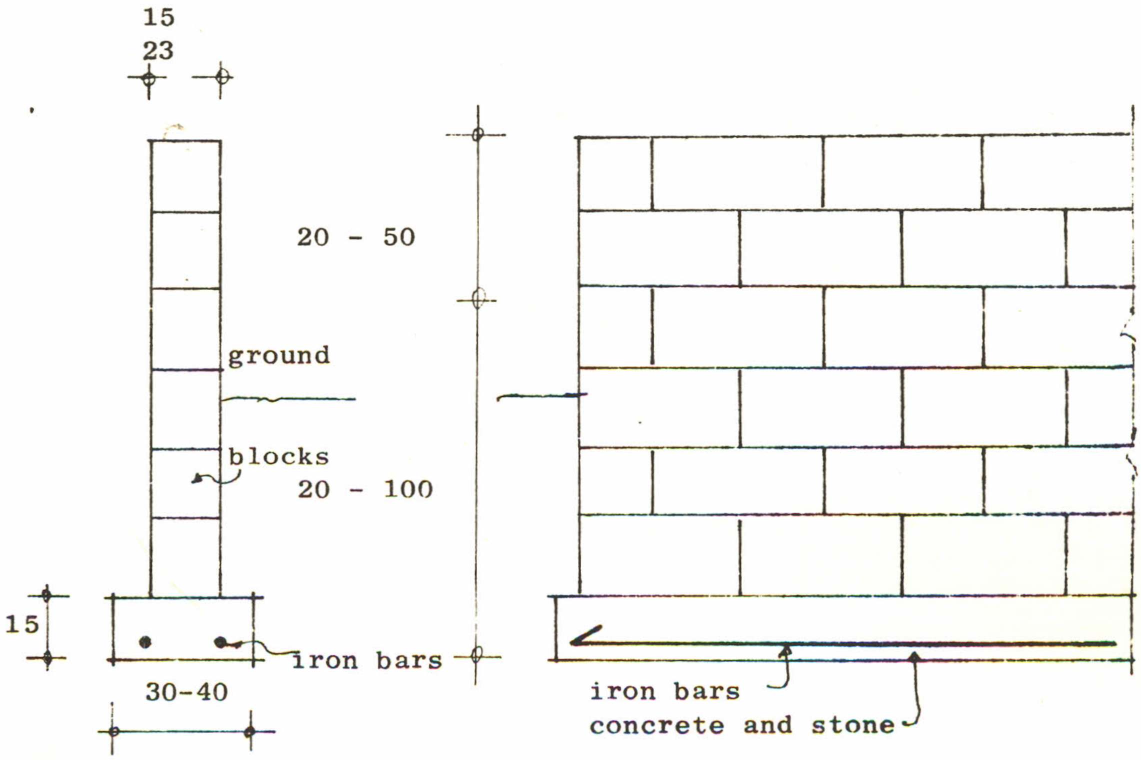


Figure 11a Section   b. side view

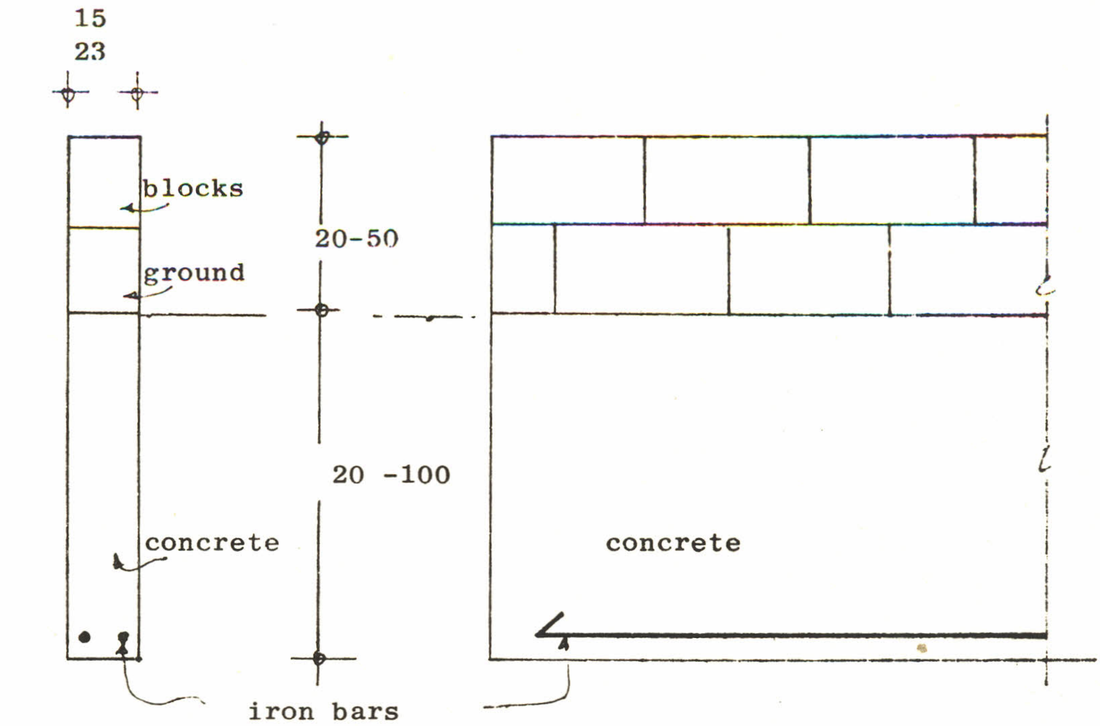


Figure 12 a Section   b. Side view trenches are dug 15 or 23 cm wide, just so wide as the foundation is planned to be. Concrete, ratio 1:4:8 is filled into the trench up to ground level. Stone might be put in the concrete to reduce the amount of concrete needed. Iron bars should be put inside the concrete at the bottom for heavy buildings. Be careful when filling in the concrete so soil from the sides of the trench does not mix with the concrete. Empty cement bags can be used to cover the sides of the trenches. From ground level and 20 - 50 cm up, blocks of concrete or stone are laid to complete the foundation.

Floors

Wooden floors are comfortable and can have a pleasant appearance, but because of lack of suitable timber at a reasonable price and skilled people to construct the floors, they are used very little in Kenya. So for economic reasons and convenience concrete floors are to be recommended for most of the farm buildings.

When making a concrete floor, after finishing the foundations fill up inside the house with hardcore or subsoil to floor level. The soil should be applied in layers of 10 cm thickness, sprayed with water. rammed and compacted to become firm. This way of making foundations for floors is good enough for most farm buildings. Using stone or hardcore is not normally necessary. If there is any risk of moisture rising up through the concrete floor, a sheet of thin polythene can be stretched on the ground before the concrete is applied. Thickness of floor 5 - 8 cm using ratio 1:3:5. Make the floor slope 1 - 2% towards door or drainage to ease washing and cleaning.

To make the concrete floor smooth and plain a steel float trowel is used on the surface. This makes it easier to keep the floor clean. A floor where animals and people are to walk should be made a little rough. A broom can be used to roughen the surface before the concrete is hard. A smooth surface becomes very slippery when it is wet.

If a strong and smooth surface is required, e.g. in a dairy or dwelling house, a thin layer of finishing mortar should be applied.

Walls

There are various different ways to construct a wall and many different materials can be used. Factors which determine the type of wall to be used:

a. The materials available at a reasonable price.
b. Craftsmen capable of using the materials in the best way.
c. Climate.
d. The use of the building.

The height of walls should allow people to walk freely and work in a room without knocking their heads into the ceiling, beams, etc. A height of 2 m is sufficient. In dwelling houses 2.20 m is a suitable height. Too low roofs or ceilings in a living room feel rather depressing. Too high walls are a waste, especially in warm climates where it is easy to get good ventilation.

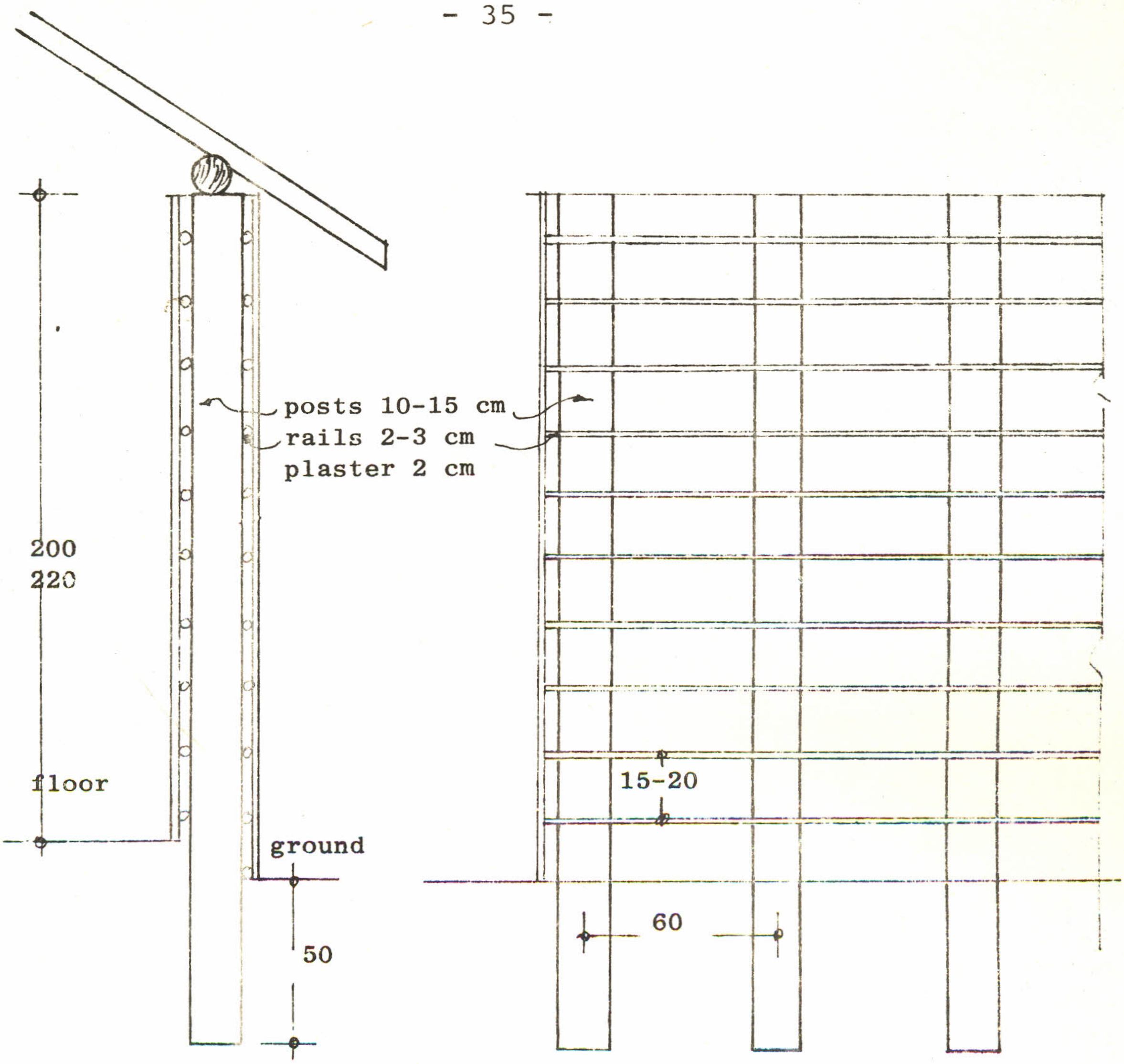


Figure 13 Mudwall-section and side view

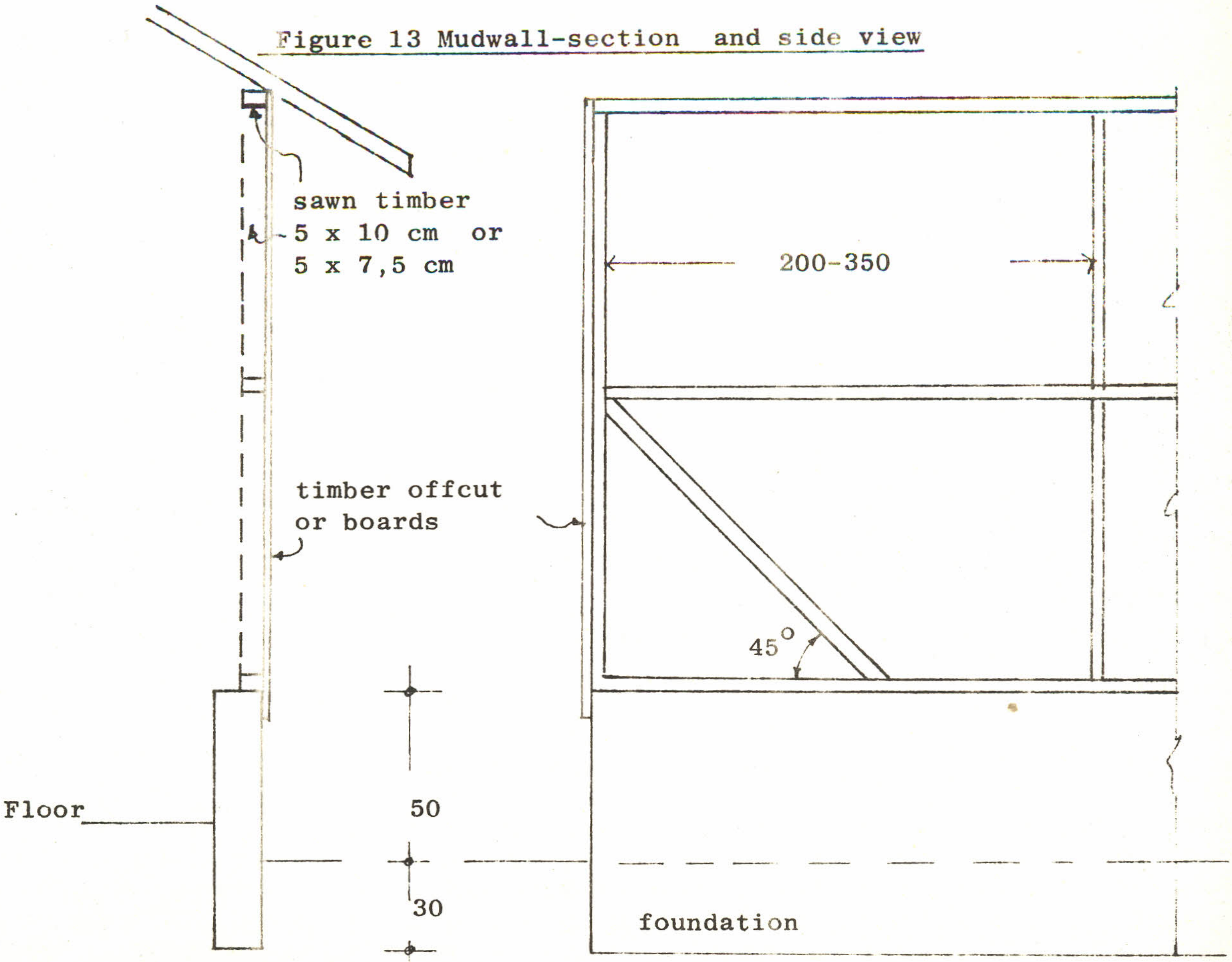


Figure 14 Timberwall - section and side view

Mudwalls.

Mudwalls are the most commonly used walls in Kenya. They are used for living houses, kitchens, stores and lavatories. They can also be used to a certain degree in poultry and pig houses, but the lower parts will need some kind of protection.

Mudwalls are cheap to build, draught proof and fairly good insulators, but they are not very strong and long lasting, and not very hygenic. They can be improved by various ways of plastering inside and out. It is important to keep the walls dry and avoid touching them.

Figure 13 shows the most common mudwall in Kenya. It has a framework of unsawn timber, uprights (posts) 10 - 15 cm diameter, 60 cm apart and dug 50 cm into the ground. On both sides of the uprights, sticks or rails 2 - 3 cm thick are nailed horizontally, 15 cm apart. Ordinary soil is mixed with water and kneaded to a plastic bulk and filled in between the posts and sticks of the wall. Then it is left to dry and after some time we have a hard, solid wall.

Plastering mud walls. Normally the walls are plastered on both sides. The traditional way to do this was to apply a layer of the same mud as used for the walls. Sometimes cow dung was mixed into it to make the plaster more tough, and white ash or sand was mixed in to make the walls lighter in colour.

To improve the mudwalls and make them last longer it is better to plaster them with 2 cm thick layer of concrete, ratio - cement:sand, 1:6. Methods to reinforce and make the plaster stick to the walls:

a. Before the mudwall is dry, small sharp stones, 5 cm long (from ballast) are put in the mud so half of the stone remains outside and serves as an anchorage for the plaster when applied. The stones are placed 10 - 15 cm apart.

b. Wire netting (chicken wire) is stretched on the wall and to the framework before the plaster is applied. The netting reinforces the plaster and keeps it in place.

Timber walls.

Timber walls can be made in many different ways. A cheap and simple construction is made of timber off-cuts as cleading on a timber frame. The sawn side of the off-cuts should normally face inwards. Unsawn timber may also be used in the framework, but this makes it difficult to make a straight and good looking wall. In the framework the dimensions 5 x 7.5 cm is strong enough: 5 x 10 cm can be used for bigger and more important buildings.

The wall should not reach down lower than 40 cm from the ground to avoid rain splash from the ground which will make the timber rot. This is a light wall which does not require very good foundations. It can be recommended for poultry houses, dairies, stores, pig pens and calf sheds. It will also make a good dwelling house. To improve the walls in the dwelling house the off-cuts can be covered inside with polythene sheets to prevent draught through the slots, or with hardboard nailed to the frame.

This type of wall should be encouraged where timber off-cuts are available at a reasonable price.

Hessian-concrete walls.

These have a timber frame like the timber walls, but the uprights should be placed at 60 cm intervals. Frame work of 5 x 7.5 cm is strong enough. Unsawn timber will also serve the purpose. On the framework outside, hessian dipped in cement-water is stretched and nailed. On top of the hessian, chicken wire is stretched and nailed. Finally the wall is plastered with concrete 2 cm thick, ratio 1:6. This will cover the chicken wire and hessian. The chicken wire is to reinforce the concrete. The wall can be painted or whitewashed to give it a good appearance and give more light inside.

This type of wall is rather expensive, but if it can be afforded, the wall can be used for poultry houses, dairies, stores and dwelling houses. If the framework is covered with hard board on the inside, it makes a very good dwelling house. It is a light wall which does not need a very strong foundation.

Block walls.

Block walls may be made of concrete or stone blocks. The blocks are joined together with mortar. The outside walls are normally made 15 cm thick and the inside walls 10 cm. These are heavy walls which require a firm and strong foundation. To prevent cracking of the walls, a rim of reinforced concrete is laid on the top of the walls, 2 bars of 10 mm can be used. If a concrete floor is provided in the house, the floor is normally laid on top of the foundation before the wall is erected.

The quality of concrete blocks may vary very much and the walls should be plastered. Stone blocks are of a more even quality and they do not normally need plastering. The walls also have a better appearance without plastering.

These are expensive walls and can be recommended only for dwelling houses and sometimes for pig pens.

Brick walls.

Brick walls are made of burnt clay bricks. External walls are 23 cm and internal 11 cm thick. The bricks are joined together with mortar, but lime mortar and mud is also used. These are heavy walls like the block walls and need firm and strong foundations.

The quality of these walls depends very much on the bricks, the burning and the type of clay used. Locally made bricks are not always of a good quality, but they are cheap and can be recommended for all types of buildings. Bricks are porous and "suck" water. In areas with heavy driving rain, therefore, the walls should be plastered.

Mud brick and mud block walls.

These are joined together with mud and used in the same way as other bricks and blocks. Because the walls have a smooth surface they are difficult to plaster properly and must be protected by large eaves or used in dry areas. They have mainly the same properties as mud walls with a wooden framework and can substitute those in many cases.

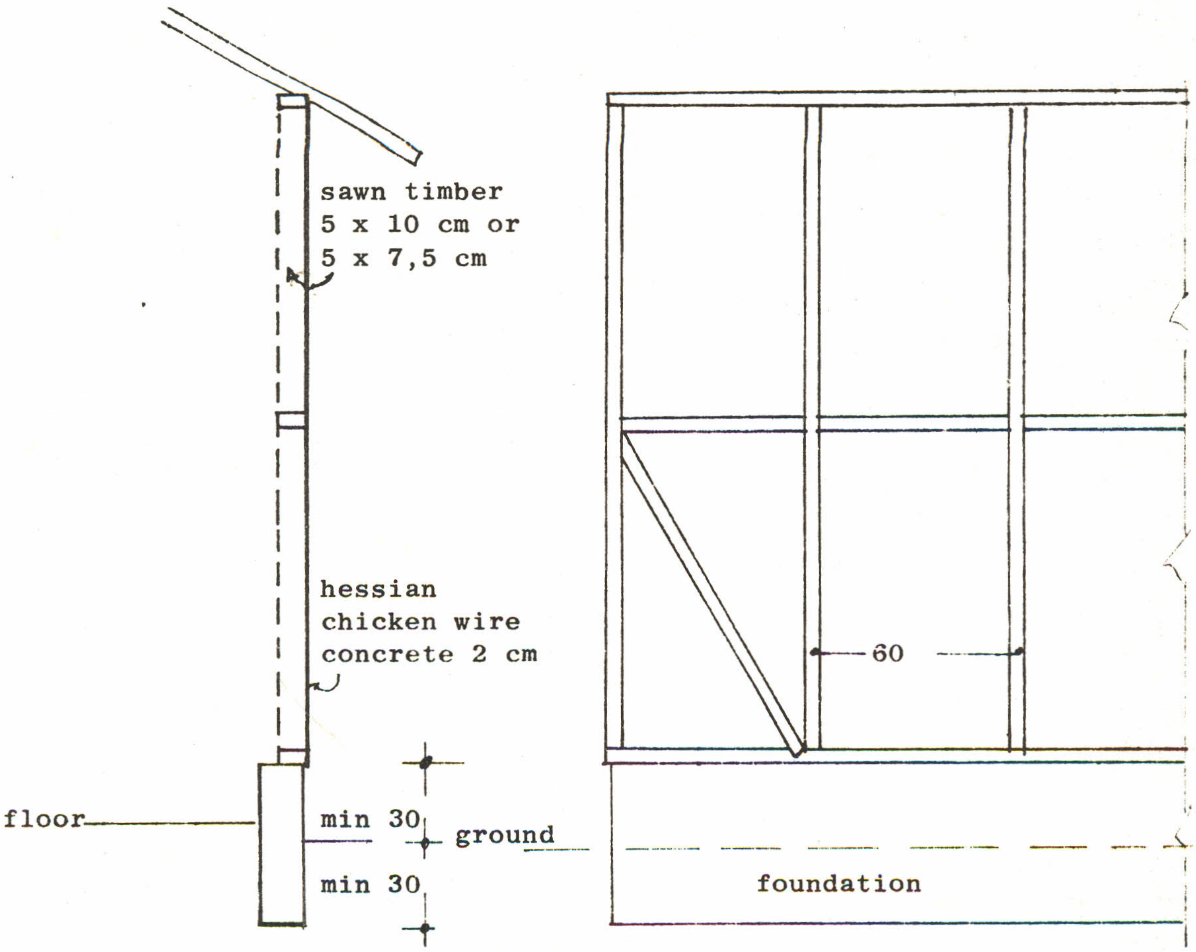


Figure 15. Hessian - concrete wall-section and side view

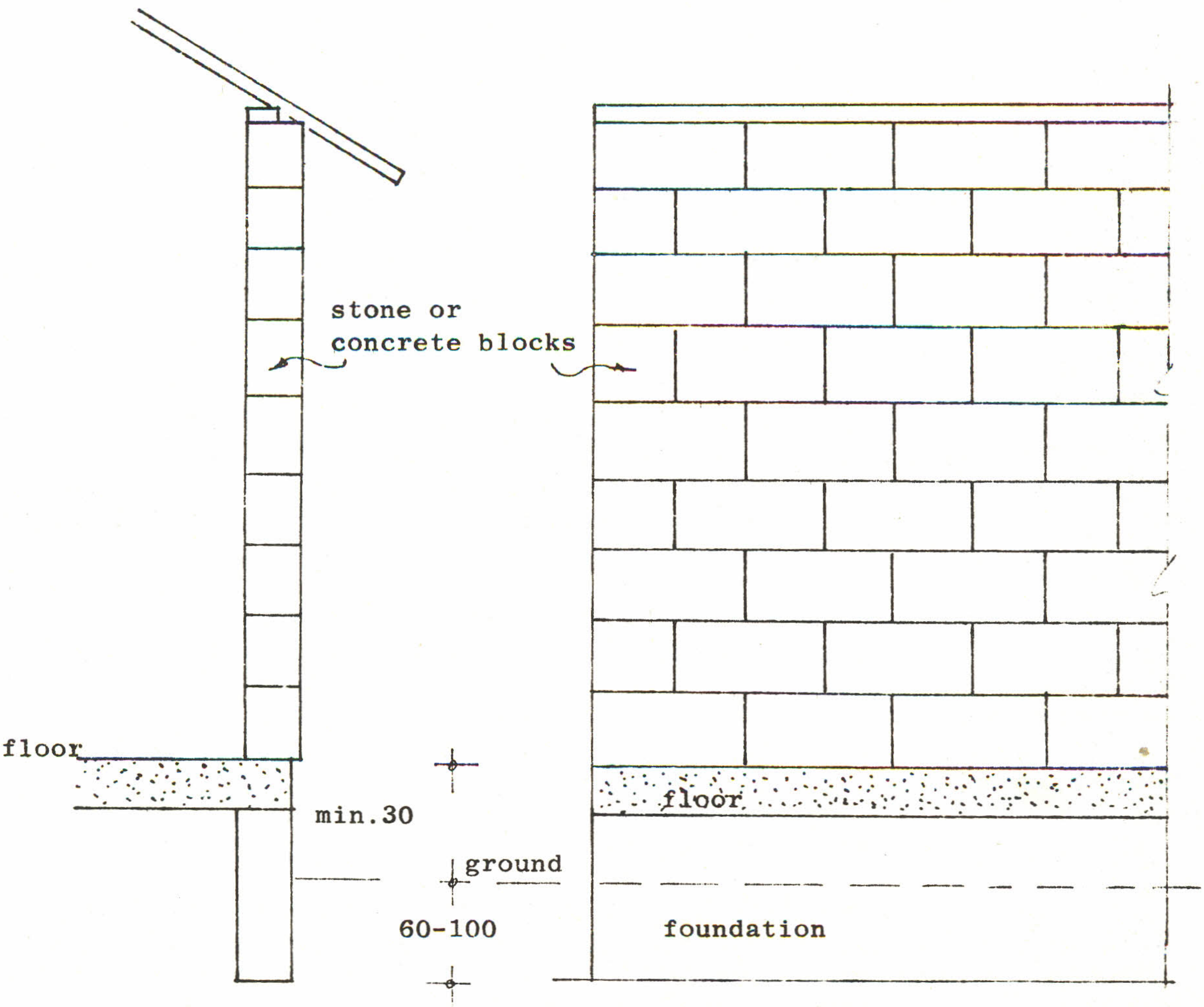


Figure 16. Block wall- section and side view

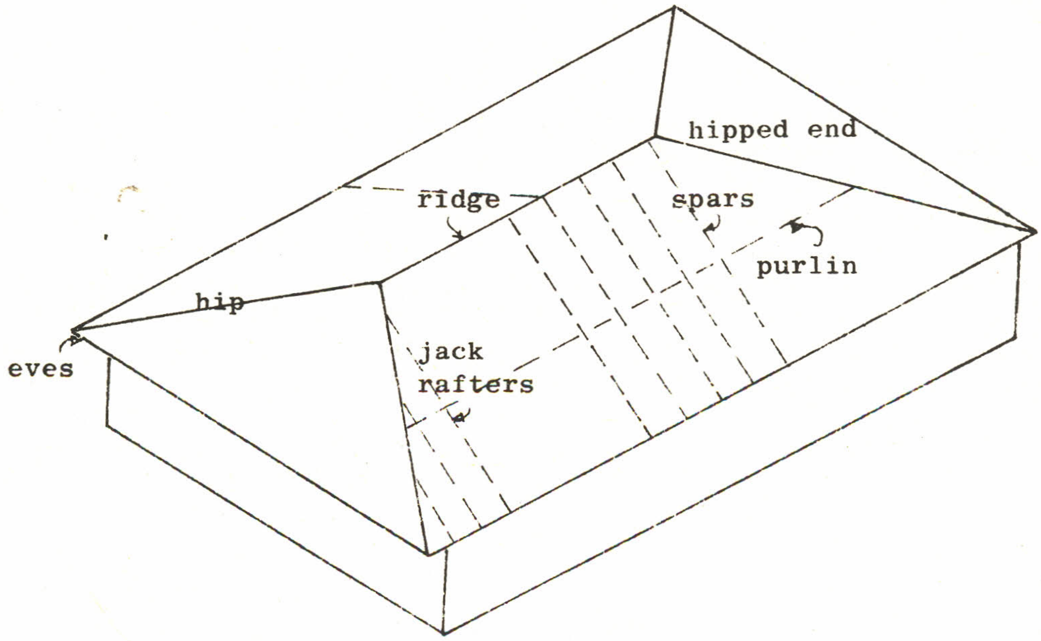


Figure 17. Hipped roof

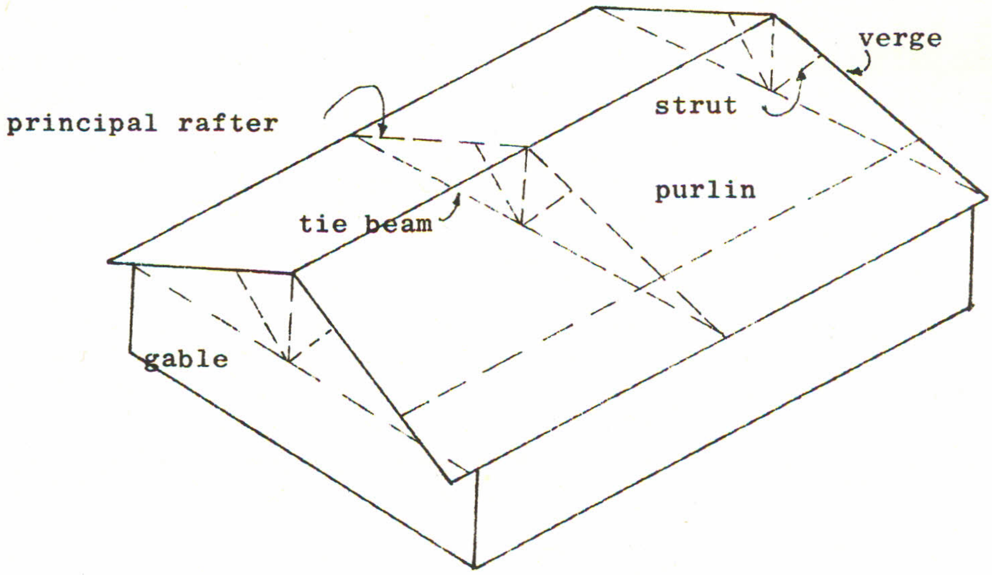


Figure 18 Gable roof

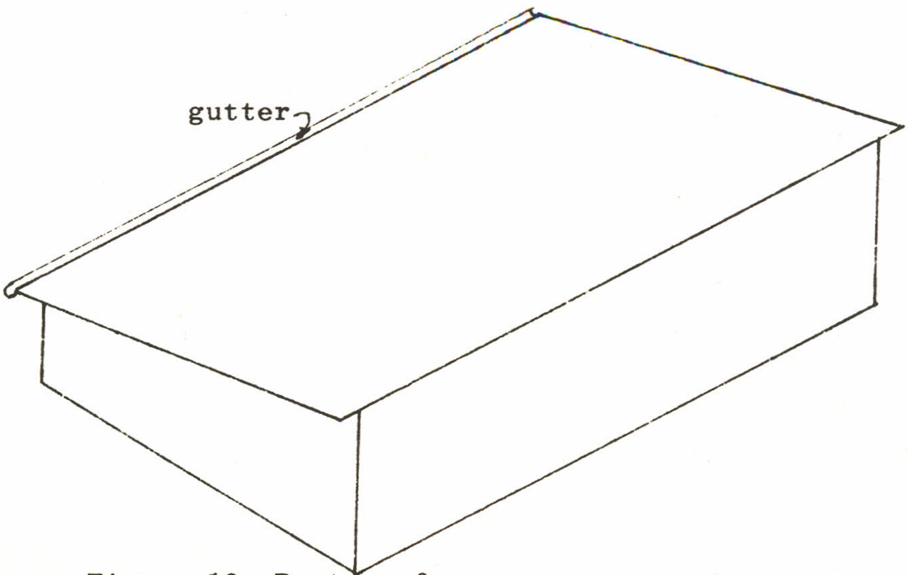


Figure 19. Pent roof

Roofs

The roof is to shed water quickly, without leaking, provide shade and sometimes light, keep out grit and dust and insulate against heat and cold.

Overhang is the lower portion of the roof which is outside the walls. This is to protect the walls from heavy rain and make shade. Protection is most important for mud walls and brick walls. The overhang varies from 30 to 60 cm. Too big overhang will prevent light from reaching the windows and make it dark inside the house.

There are various ways of roofing a house, depending on the climate, size of the building and materials used in the walls.

1. Hipped roof (Figure 17), has a ridge in the middle and four slopes. This type is hard to set out and build. There are many joints which weaken the structure and may cause leakage. At the hips the covering material has to be cut at an angle to make it fit. This is an expensive type of roof. Four gutters are also needed to collect the rain water from the roof, but that does not mean that there is any increase in the amount of water collected. Because this is an expensive and difficult way to roof a house, it should be recommended only where it is necessary to protect mud walls or unplastered brick walls against heavy driving rain and for huge buildings to reduce the height of the walls.

2. Gable roof - double pitch (Figure 18), has a ridge in the centre and is sloping two ways. It is not so hard to set out and build as a hipped roof, so it is also cheaper. The end walls - gable walls - are higher than the other walls. Two gutters are required to collect the water from the roof. Leakage may occur at the ridge. This type of roof can be used on all kinds of buildings.

3. Pent roof - one pitch (Figure 19), is sloping only one way and has no ridge. This one is easy to set out and build and is cheap to build and maintain. Only one gutter is needed. Because it is cheap and simple to construct, this type of roof should be recommended for use on most of the buildings on a small farm. On very wide buildings this type of roof requires a very high front wall which, of course, is a waste.

4. Flat roof can be used in areas with little or no rain. If roofing felt is used and properly mounted, it can also be used in rainy areas. Used on small buildings this is a simple and cheap roof.

Insulation and ventilation.

Insulation of the roofs is necessary in very few areas of Kenya. A simple way to do it is to nail chicken wire underneath the roof and fill with straw and grass between the chicken wire and roof covering. One problem is that this insulation will harbour rats, insects and snakes.

Good and controlled ventilation will normally solve the problem of insulation. A simple way to provide ventilation is to leave spaces of 10 - 20 cm between the walls and roof. This will give a flow of air through the house. The slot should be covered with insect mesh to keep pests out. In cold areas it should also be covered with a flap which can be used to regulate the flow of air. In hot areas and where very good ventilation is required, a slot could also be made in the ridge of the roof. The top of one side of the roof should cover the top of the other side to prevent rain from getting in. Doors and big windows will also provide good ventilation when they are open.

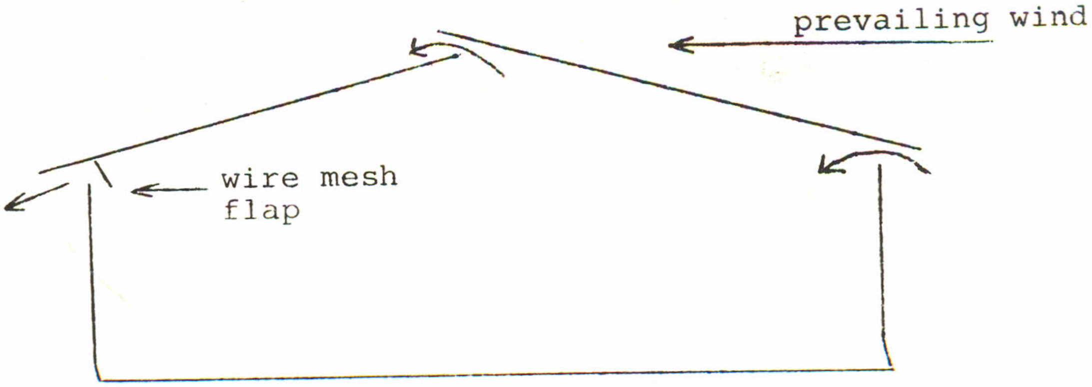


Figure 20. Ventilation.

Doors

Doors should be wide and high enough to allow easy transport and movement. The width depends on what transport is supposed to pass through, but it should not be less than 70 cm. The height should be sufficient to let the tallest person in the district pass through without bending. A height of 2 m is suitable. If tall machinery etc. is to pass through, the doors of course, have to be made higher.

Doors should be hinged on the side and turn the way which makes the easiest passage. It is difficult to give any rules for this; it has to be judged in each case.

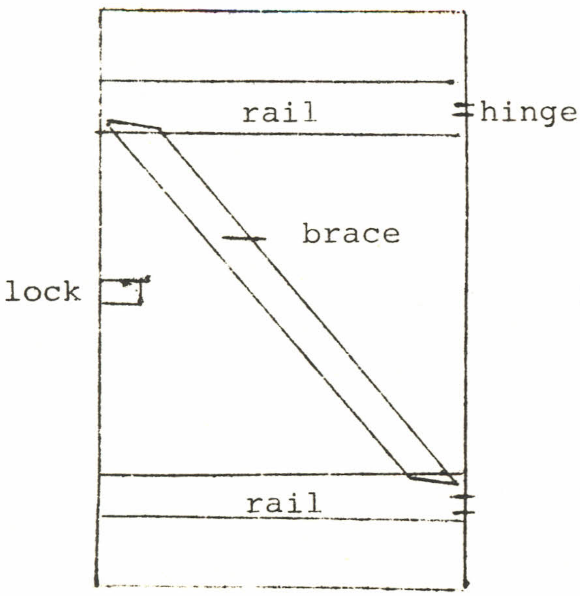


Figure 21. Single door.

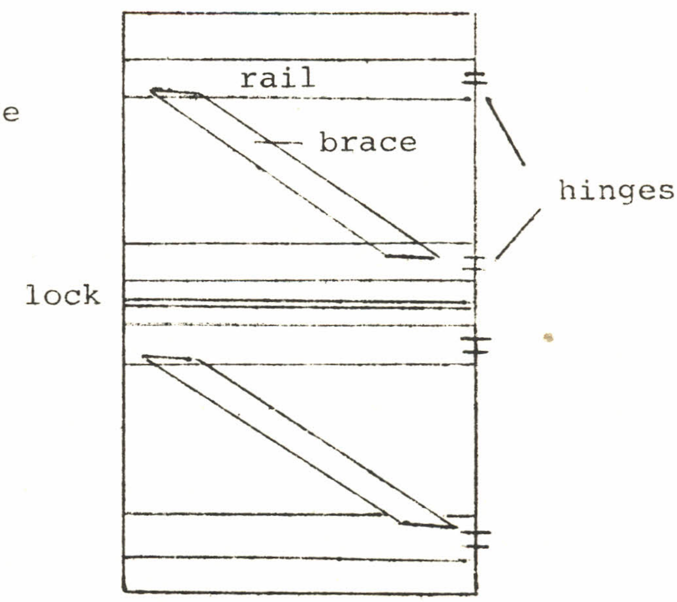


Figure 22. Half doors.

Notice the direction of the braces. They should get support at the hinges. Figure 22 could be a full height door or it may be two half doors, cut horizontally in the middle.

Windows

The windows should provide ample light in the house and also ventilation when necessary. Glass is rarely used in the windows of houses in rural areas; wooden shutters are normally fitted and these are usually quite satisfactory. During the day they often are kept open to let in light and air, at night they are shut as there is no light anyway. If the windows are open at night for ventilation, it would be beneficial to cover the opening with insect mesh to keep out pests.

The windows used in the rural areas are generally too small, and too few. In sitting rooms and working rooms it is important to have ample light and ventilation. For these rooms each window should be about 1 m square. The window area should be at least 10% of the floor area of the room. If glass is to be used in the windows, frames of steel or wood are obtainable. Steel frames are strong and stable, but rather expensive. To encourage use of local materials, wooden frames should be recommended. They are satisfactory for most buildings.

Plans for various buildings on a small scale farm

In the following chapters you will find plans for various buildings on a small scale farm. The aim has been to make simple and cheap buildings which the farmer can afford to build.

Local materials are suggested where they are likely to serve the purpose adequately. Of course, there are many materials which could be used; one kind could be the most beneficial in one area and another one in a different area. It is up to you to find out which materials are available at which prices and estimate the cost, taking into account transport costs and the cost of labour capable of carrying out the work. In most cases where sawn timber is prescribed in the structures, unsawn round timber can very well substitute the sawn timber.

The size of the buildings, of course, has to suit the present need and the need in the near future.

Dairy

To provide good hygiene and ease the work, every farmer having dairy cows should have a dairy. To do the milking and feeding of concentrates in the open or in a temporary shed is unhygenic and inconvenient. The dairy should contain a milking shed, feed store and milk room. The sizes of these rooms are determined by the number of cows in milk.

The milk room should be as dust proof as possible and have ample light and ventilation. In this room the milk is sieved and cooled and sometimes stored for awhile, and the utensils are washed and stored. Detergent, milking jelly and a milking coat are often kept in the milk room and a small cupboard should be made to keep these things in.

The feed store should be big enough for the storage of concentrates and a small cupboard. Minerals, medicine and chemicals for spraying could be kept in the cupboard. The store should be well ventilated and dry. Not much light is required, so a small window will do. The store should be mice and rat proof.

The milking shed should be light and well ventilated, but should be sheltered enough to keep dust and strong wind out. How many walls, if any at all, is determined by the conditions - whether it is a windy and dusty area or not. The floor should be dry, clean and sloping to provide drainage for water and urine. If possible, there should be a milking bay for each of the cows in milk and troughs for feeding concentrates.

Description of the dairy shown in Figure 23.

The first figure shows a perspective view of the dairy before the yokes and troughs are mounted.

Foundation: 20 cm deep concrete or stone blocks or concrete blocks, 15 cm wide.

Walls: Timber frame with timber off-cuts for cleading; the lower part made of concrete or stone 10 - 15 cm thick to prevent rotting. It should be at least 20 cm from the floor to the timber wall. The uprights at the end of the milking shed should also stand on 20 cm high stones or concrete, or cedar poles could be used and last quite well. There are no walls for the milking shed. In windy and dusty areas it may be necessary to have walls on one or two sides.

Floor: The milk room and the milking shed should have concrete floors 5 - 8 cm thick on hardcore or firm soil. Do not make the floor in the shed too smooth. Make the floor slope 2% towards the drain. Although the floor becomes very slippery when water and milk is spilt, it should be smooth so that it can be thoroughly cleaned. The store can have a soil floor, but a thin layer of concrete will ease cleaning and prevent rats from hiding in the ground.

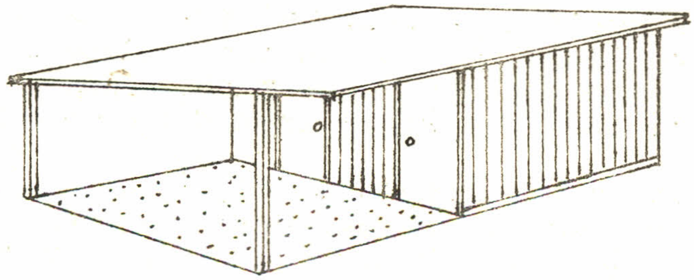
Roof: A pent roof sloping to the back, covered with corrugated iron sheets, is the best and cheapest construction for this dairy. Gutter mounted at the back of the roof will prevent rain splash and the water could be used if collected in a tank.

Ventilation: A gap should be left between the roof and the top of the wall in the milk room, for ventilation. The gap should be covered with insect mesh.

Doors: Two single doors, 70 x 200 cm, are hinged to allow easy passage. If they were hinged on the opposite side, they would block the cupboard when opened.

Windows: One big window with wooden shutters for the milk room. One smaller one for the feed store.

Plan for small-holder dairy



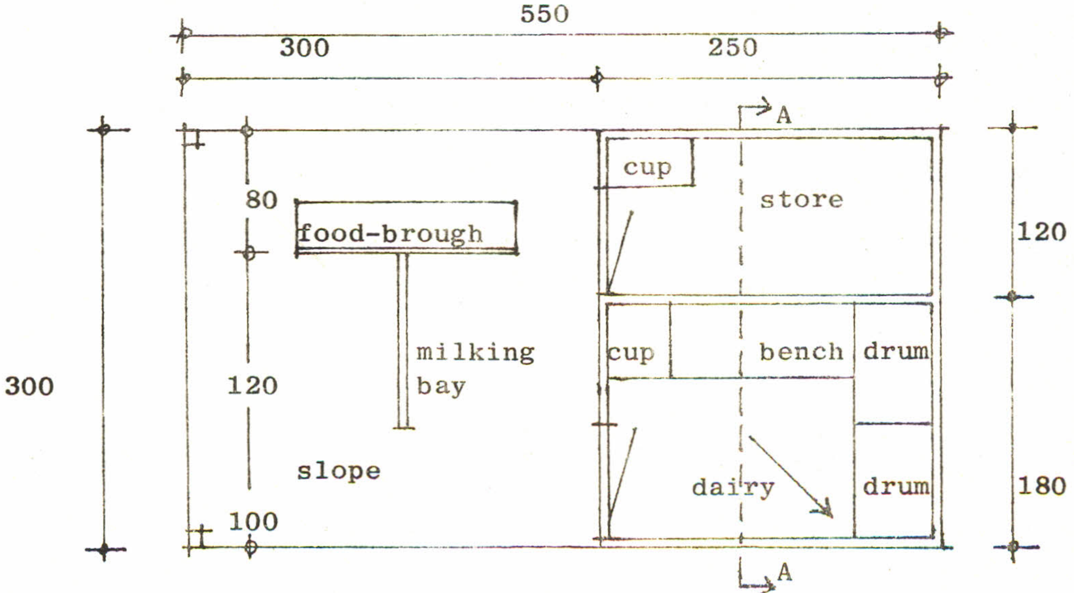


Figure 23a Groundplan

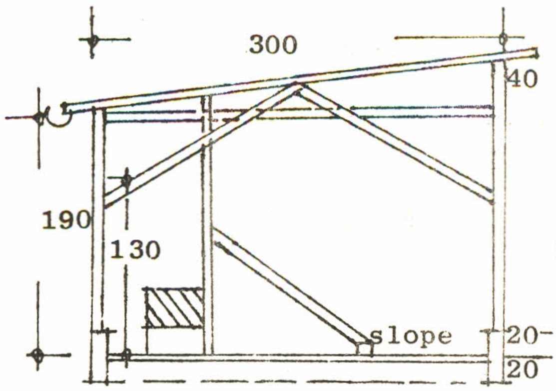


Figure 23b Side elevation

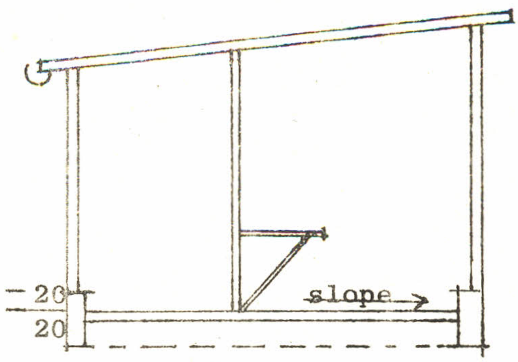


Fig.23c. Section A-A

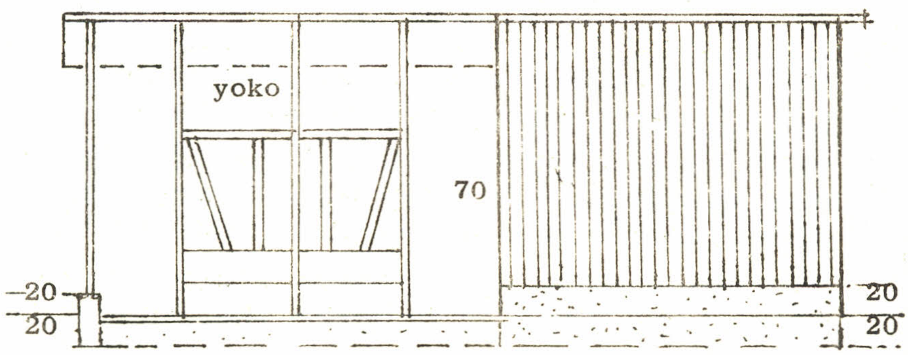


Figure 23d. Front elevation

Pig Houses

The pig has little protective covering and is sensitive to temperature change. It requires dry, comfortable quarters maintained at an even, warm temperature and it is particularly important that the quarters are free from draughts. The pig can stand a reasonably high temperature, but at too high temperatures the animal becomes uncomfortable and will cease to do well. Similarly the pig will stand a great deal of cold, but in so doing it will burn up a lot of expensive food for maintaining body heat.

The following are the most suitable temperatures:

a.	Piglets	20 - 24°C.
b.	Growing pigs	14 - 18°C.
c.	Breeding animals	12 - 16°C.

There is a great deal of controversy between advocates of free range pig keeping and those of the intensive housing system. Big numbers of pigs on free range is cheap and healthy, but there is a danger of African Swine Fever. Free range keeping is best for boars, dry sows and gilts, as they need some space for exercise to keep healthy. Intensive housing and carefully controlled pig production is better for fattening and farrowing, as these pigs should be kept calm and do not need much exercise. They are also sensitive to temperature and draught. In small scale pig production the compromise between the two systems is the use of a divided open yard and covered sleeping quarters. This house can be used as a dual purpose pig house, if the lay out and construction is made for it.

Description of dual purpose pig house - Figure 24.

Ground plan. There are three pens of the same size and shape, but they are used in different ways. Pen A is arranged as a farrowing pen. The removable creep rails are mounted parallel, about 70 cm apart, from the trough to the door between the pen and the dung passage. The walls are kept in this position for 4 - 5 days after farrowing. This means that the sow can not move about and step on the piglets. The piglets can move freely under these walls. After 4 - 5 days one of the walls is swung to the side to make a triangular crate for the piglets and give the sow more space (Pen B). The crate should be covered with rails or wire netting and straw to keep the piglets warm. The piglets and sow can stay with this arrangement up to weaning. After weaning the removable walls can be taken away and the litter kept for fattening (Pen C).

There is an opening for passing from the pens to the dung passage, and normally the pigs will dung in this passage. The opening is closed only when the passage is to be cleaned. When the gates in the passage are opened, they are closing the openings into the pens. The pigs are kept in their pens so the passage can be cleaned without any disturbance from the pigs. Behind the dung passage there is an open yard with simple fencing around to give the pigs exercise. It should be possible to close the opening from the dung passage to the yard with a gate.

The feeding is done from the front through shutters or through slots between rails. For piglets, movable troughs should be used, which are easily taken out for washing. One end of the main trough could be used as a water trough if necessary.

Section. At the top of the wall on two sides of the pen there should be a gap, at least 10 cm wide, for ventilation. It should be possible to regulate the ventilation with a flap when necessary. In cold areas the roof should be extended to cover the dung passage, and a wall made to enclose the dung passage in the house.

Figure 25 shows the same type of pig house but with a double line of pens and a feeding corridor in the middle. The feeding is done through slots between rails in the slanting front walls of the pens. The corridor is covered by the roof.

Floor: Can be made either of concrete or timber. Concrete floors are long lasting and easy to clean. The concrete surface should not be too smooth, because when it is wet it becomes slippery. In cold areas the concrete floor should be insulated. If timber is used it must be sawn timber, because a rough surface will harm the legs of the pigs. The floor in the pens and the dung passage should slope 1 - 2% towards the drains. Thickness of the floor 5 - 8 cm on hard-core or rammed soil.

Walls: There should be a foundation of concrete or stone blocks 20 - 30 cm deep. The lower portion of the wall, at least 20 cm, should also be made of concrete or stone blocks. The rest of the walls may be constructed of timber off-cuts. If the timber reaches down to the floor, it will easily rot. The entire wall may be made of concrete or stone blocks, but this will make an expensive pig house.

Partitions: These may be made of the same materials as the walls, but only 110 cm high. In case of farrowing crates they should be approximately 70 cm wide and the lowest board 20 cm above floor level in order to allow the piglets free movement underneath. If the house is a double line of pens with a feeding corridor in the middle, the front partition (to the corridor) should be made of rails or steel pipes. The lowest pipe could be used for water. See Figure 26.

Roof: The pens and troughs are covered with a pent roof (one way slope). Corrugated iron sheets, gauge 30, are fairly long lasting and not too expensive as roof covering. In hot and very cold areas the roof may be insulated with chicken wire stretched under the roof and loose grass/straw packed between the netting and the sheets. However, good and controlled ventilation is as important as insulation. Thatch or shingle roof could also be used. Asbestos cement and aluminium sheets are good, but rather expensive for pig houses.

Troughs: Troughs should be made of concrete with a hard, smooth surface or alternatively hard timber. It is very important to get the right size and shape of the troughs so the pigs can easily reach the food and also prevent the pigs from entering the trough.

Plan for a dual purpose pighouse-single line.

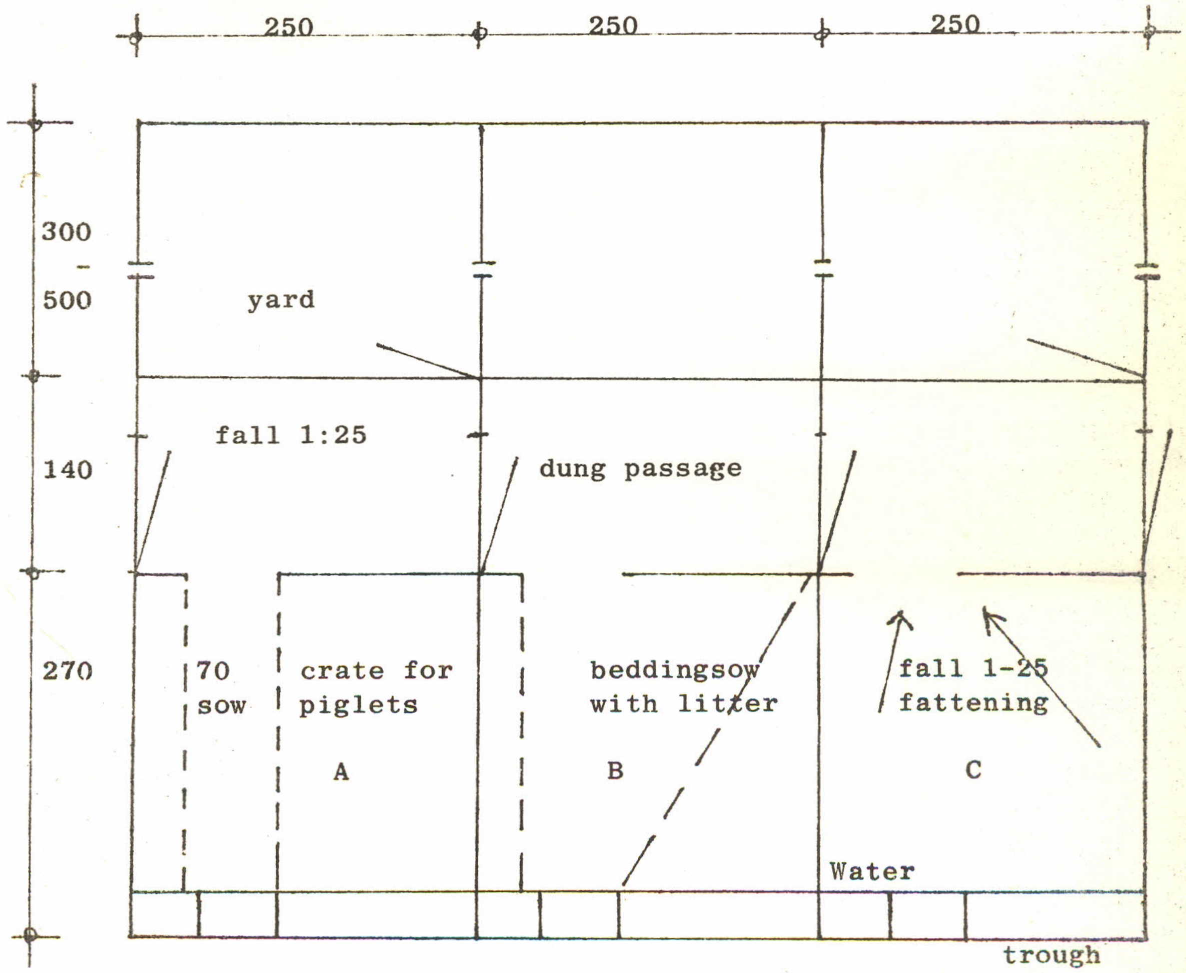


Figure 24a Groundplan

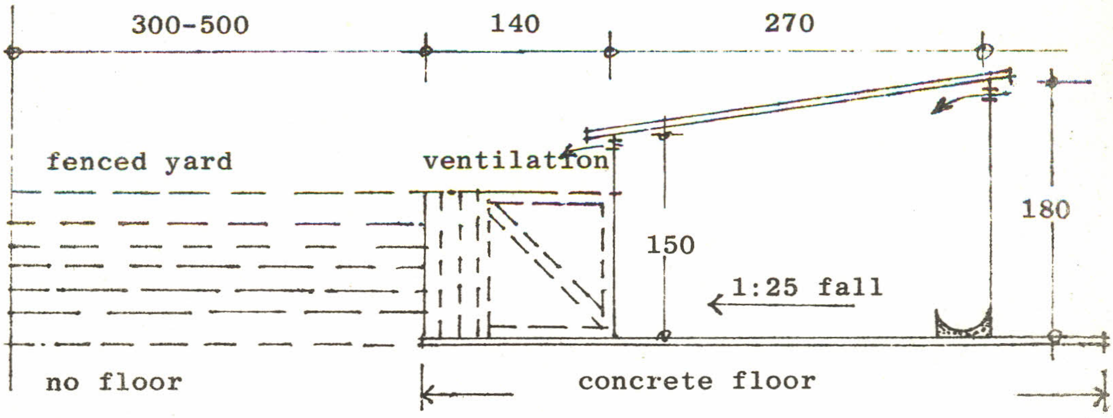


Figure 24b Section

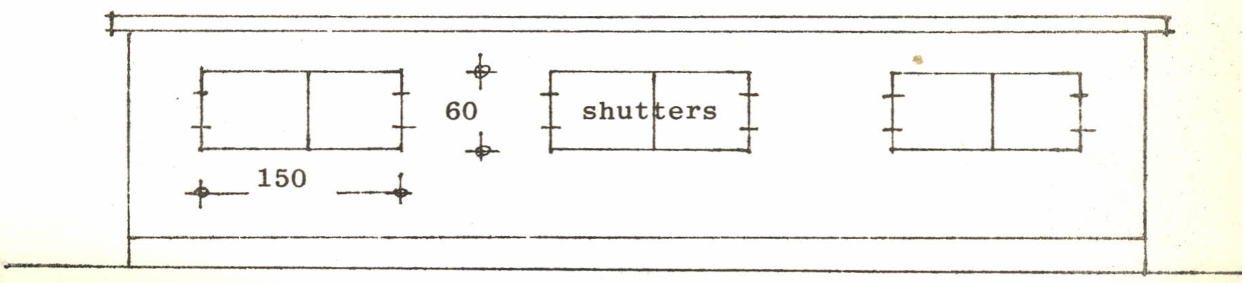
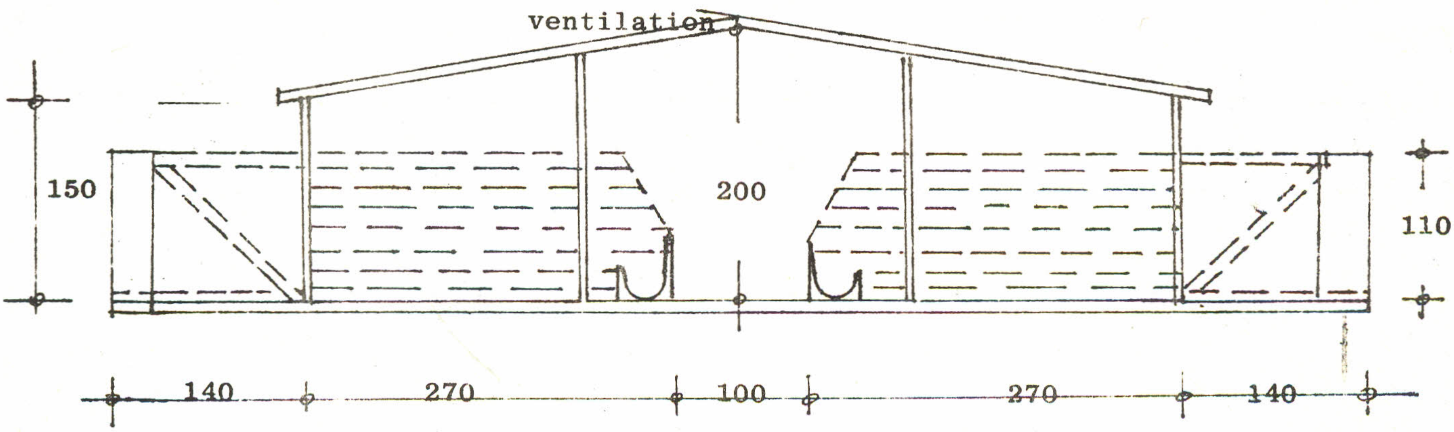


Figure 24c Front view

Figure 25. Dual purpose pighouse-double line



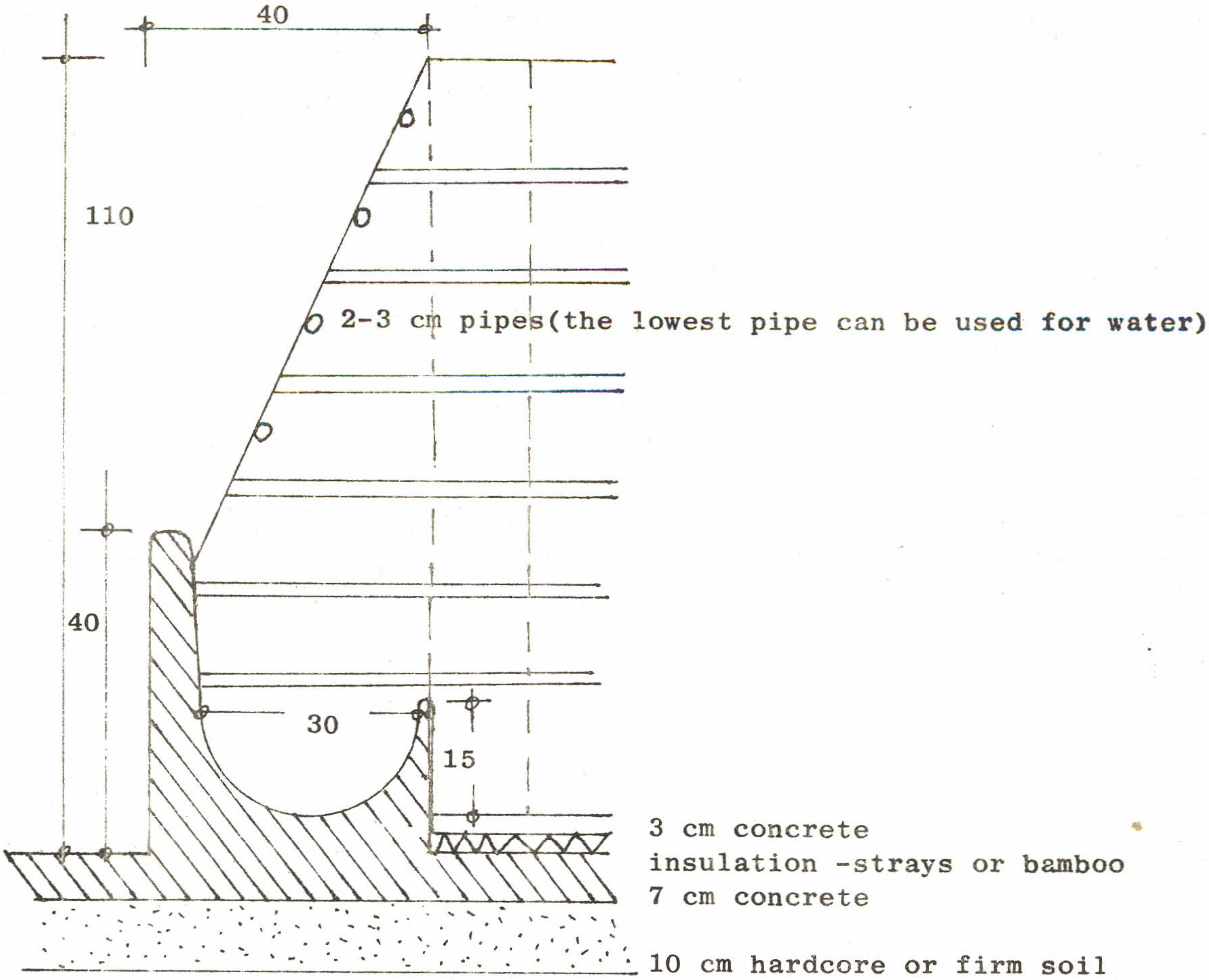


Figure 26.Trough and frontwall of pigpen.

Space requirements.

Area per pig, including dung passage:

a.	Dry sow or boar	5 - 6 sq.m.
b.	Sow and piglets	9 - 11 sq.m.
c.	Growing pigs 20 - 50 kg	1 - 1.2 sq.m.
	50 - 120 kg	1.2 - 1.4 sq.m.

Trough length per pig : weight

20 kg	- 20 cm.
60 kg	- 30 cm.
120 kg	- 40 cm.
Sow/boar	- 50 cm.
1 litter	- 100 cm.

Licensing.

By law all pig producers have to be licensed by the Director of Veterinary Services, who must inspect any pig house or paddock before a licence is given. The aim of the legislation is to control African Swine Fever which is carried by wild pigs, and this is done by preventing the wild pigs and domesticated pigs coming into contact with each other.

The specifications for pig-proof buildings, paddocks and passages are as follows:

Buildings. The walls and doors shall not be less than 110 cm (3 ft. 6 in.) high and shall be either:

a. of solid construction; or
b. made of posts not more than 120 cm (4 ft.) apart, with rails of timber, off-cuts or poles not more than 8 cm (3 in.) apart, the bottom one being not more than 8 cm (3 in.) from the ground at any point; or
c. made of posts not more than 120 cm (4 ft.) apart, with standard pig or sheep wire netting not lighter than 15 gauge, not more than 8 cm (3 in.) off the ground and barbed wire running along the top and bottom of the wire netting.

Paddocks and passages shall be bounded by continuous fences at least 110 cm (3 ft. 6 in.) high and not more than 8 cm (3 in.) off the ground at any point, and of one of the following constructions:

a. made of posts not more than 5.5 m (6 yds.) apart, with standard pig or sheep wire netting not lighter than 15 gauge and barbed wire running along the top and bottom of the wire netting and at least three droppers evenly spaced between every two posts; or
b. made of posts not more than 5.5 m (6 yds.) apart, with seven strands of barbed wire at the respective heights of 8 cm (3 in.), 18 cm (7 in.), 30 cm (12 in.), 45 cm (18 in.), 60 cm (24 in.), 80 cm (32 in.) and 110 cm (42 in.) from the ground and three droppers spaced evenly between every two posts; or
c. made of posts and rails, the posts being not more than 3 m (10 ft. apart and the rails not more than 10 cm (4 in.) apart, the rails being off-cuts, sawn timber or poles of at least 8 cm (3 in.) diameter.

Poultry House

Poultry do not need very strong and expensive housing in Kenya. The main point is to keep the hens fenced in to avoid damage to crops and having their faeces dropped all over the compound and inside the houses. On free range they may also possibly be killed by dogs and other animals. Some kind of roof should also be provided to protect the hens from sun and rain. It is most important that the house for poultry is dry and well ventilated and has ample light. The hens can stand both low and high temperatures, but the optimum temperature is between 15 and 20°C. One problem is keeping rats and snakes, which eat feed and eggs, out of the poultry house. This problem has to be considered when building a poultry house.

The hens must be given enough floor space for movement, enough space at the feed and water trough and on the perches to avoid fighting. A sufficient number of nests must also be provided, otherwise the hens will lay the eggs in the litter on the floor.

Space requirements for laying hens:

				Per Hen
Troughs:	All mash method	- straight trough		7 cm
		- round		5 cm
	Meal and grain method	- straight		4 cm
		- round		3 cm
Drinkers:		- straight		2 cm
		- round		1 cm
Perches:	(25 - 40 cm between perches)			15-20 cm
Nests:	(1 nest for every 7 hens)		Width	30 cm
			Height	35 cm
			Length	40 cm

Figure 27 shows a simple and cheap poultry house for 30 laying hens It is mainly made of local materials. For labour this is not a very good plan; every time you are to feed, collect eggs or clean you have to open the door and go into the house. The house is also low so it is not easy to move about in it. However, the labour does not mean so much when keeping poultry on a small scale. There is deep litter. The food trough should be 40 cm above the floor, placed on legs or hanging on wires from the roof to avoid getting litter in the troughs and to make more floor space. The nests are placed along one wall near to the floor. The perches are placed along the opposite wall, 80 - 100 cm above the floor.

Description of the construction of a small poultry house:

Foundations: Concrete or stone blocks, 10 - 15 cm wide, 20 cm deep.

Floor: Firm subsoil or hardcore, alternatively with 3 - 5 cm concrete on top.

Walls: Lower portion made of concrete or stone blocks 10 - 15 cm wide, 20 cm high. Bricks could also be used. The next 30 cm is timber off-cuts and the upper part, 50 cm, the gables and the door is fine mesh wire netting.

Roof: Double pitch, thatched with grass or palm leaves or corrugated iron sheets. Thatch will insulate better than iron sheets. To prevent rats and snakes from hiding in the thatch and getting into the house, fine mesh wire netting could be nailed to the framework before the thatch is applied.

Figure 28 shows a bigger poultry house with space for 120 laying hens and store for eggs and feed. The feeding and collecting of eggs is done from the store which saves you time. The nests have flaps to open for the collection of eggs. The feed troughs could be raised 30 cm above floor level to save floor space and avoid litter getting into them. The perches are placed along the back wall, the lowest one 1 m above floor level. In this way the perches are no obstruction for the work, changing litter etc., and the birds also get the opportunity to sit high up at night which is quite natural to them.

Description of the construction of a poultry house for 120 laying hens:

Foundation: Concrete or stone 20 cm deep, 10 - 15 cm wide.

Floor: Firm subsoil or hardcore, alternatively, with 3 - 5 cm concrete on top. Deep litter.

Walls: Timber off-cuts, bricks or mud blocks. The back wall must be completed up to the wall plate, whereas the frontwall is built only half way up. The upper part has only fine mesh wire netting to let in light and air. The end walls may be made in the same way, or like the back wall in cold and windy areas.

Roof: Single pitch with corrugated iron sheets on purlins of split bamboo. Under the framework kavirondo matting is nailed for insulation.

Stores

The store must be dry and well ventilated. Grain and other things which are stored may not be completely dry when put into the store so it should be possible for it to dry during the storage period. Rats and mice can do considerable damage to the stored crops if they are not kept out.

The size of the store must be estimated so it can hold the crops and other things which are to be kept there. The foundation and the floor must be strong because there will be a great weight when the store is filled up with, for example, maize.

Description of a store (Figure 29):

Foundation: Pillars of stone or concrete are best, but cedar posts will also last quite long. They are dug 30 - 40 cm in the ground and concrete is filled around to make them firm. The pillars should reach at least 60 cm above ground level. Tins, 40 x 40 cm are placed on the top of the pillars to prevent rats and mice from climbing up into the store.

Floor: Timber floor with beams 7.5 x 15 cm c/c 200 cm, purlins 5 x 10 cm c/c 60 cm and 3 cm thick boards.

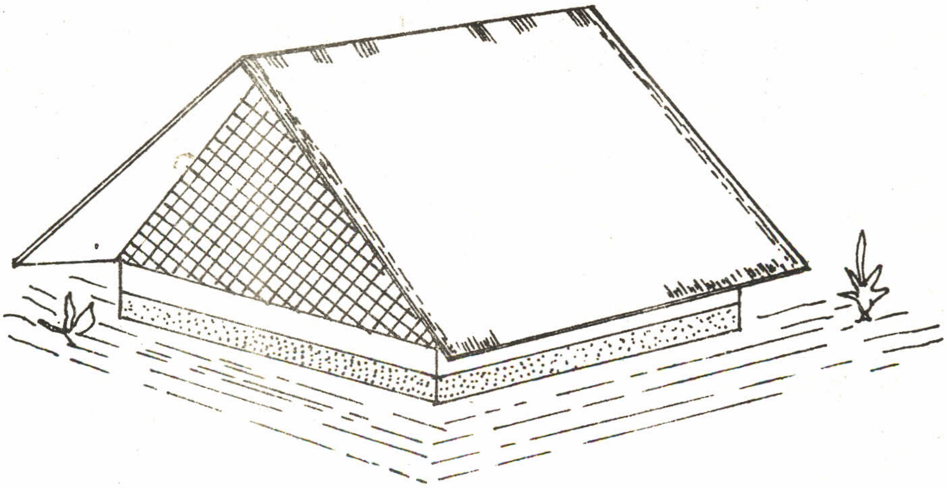


Figure 27a Perspective view

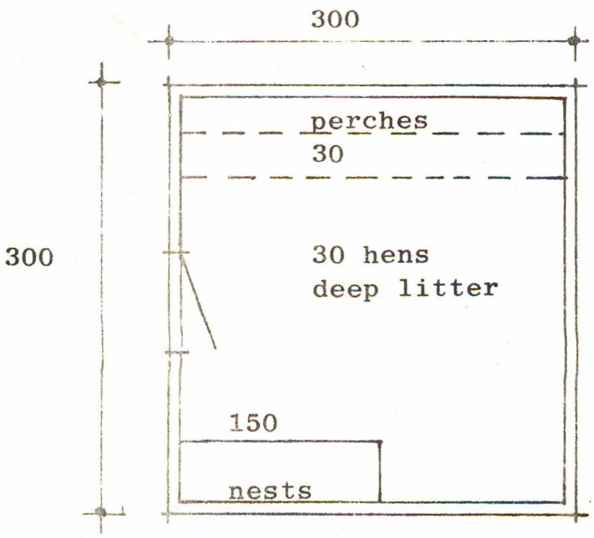


Figure 27b Groundplan

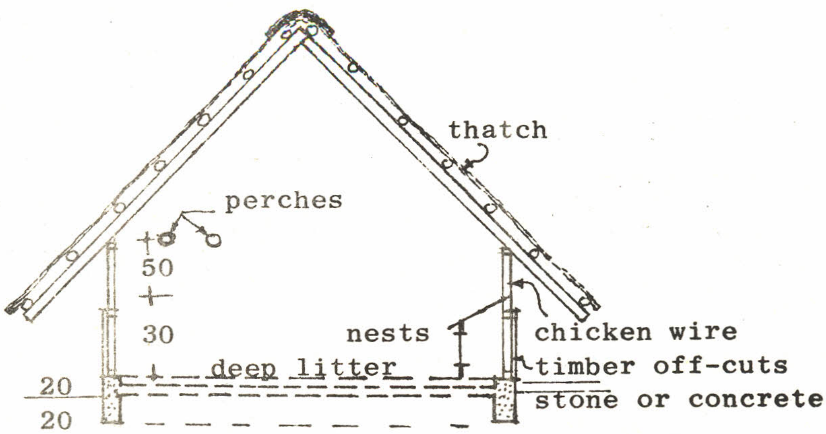
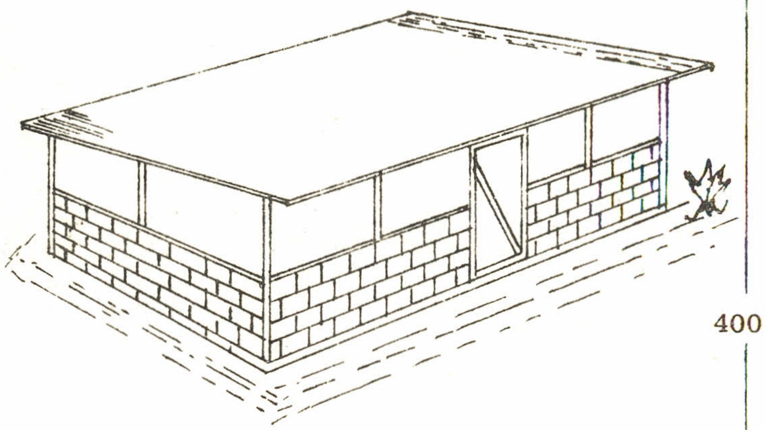


Figure27c Section

Figure 28a Poultry house



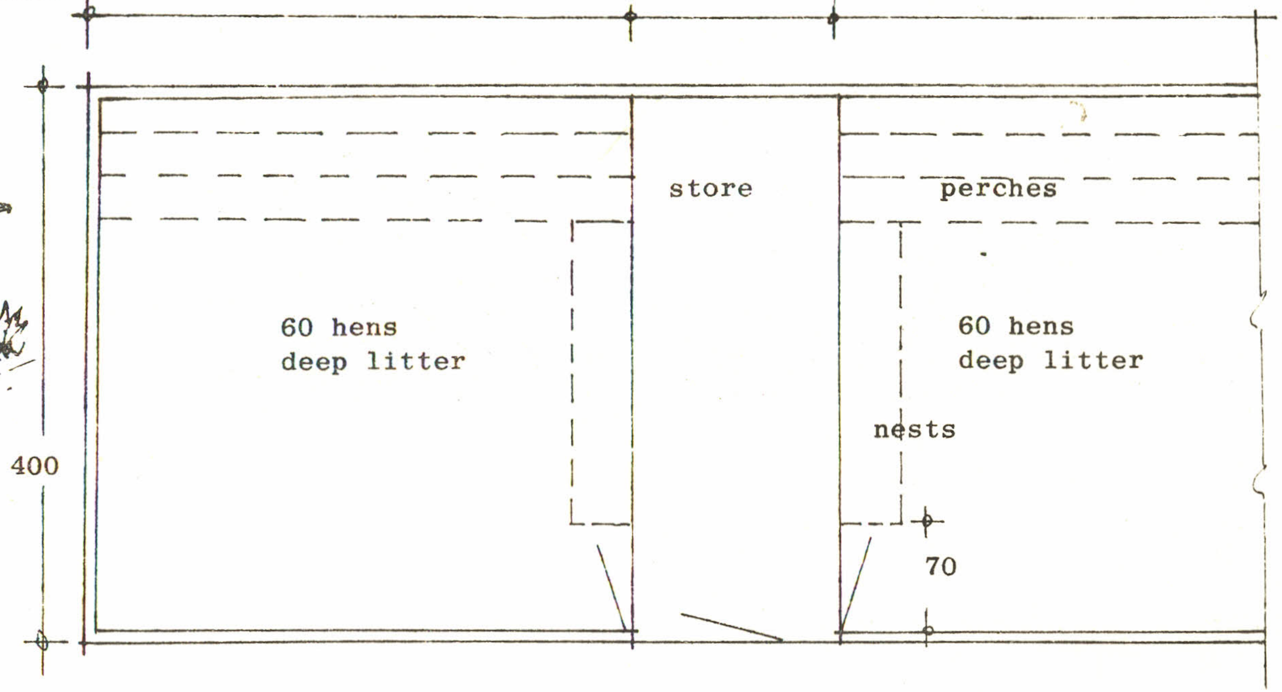


Figure 28b Groundplan

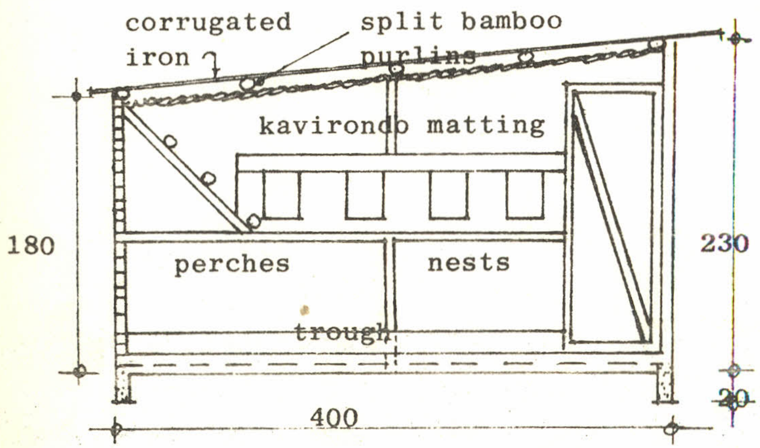


Figure 28c Section

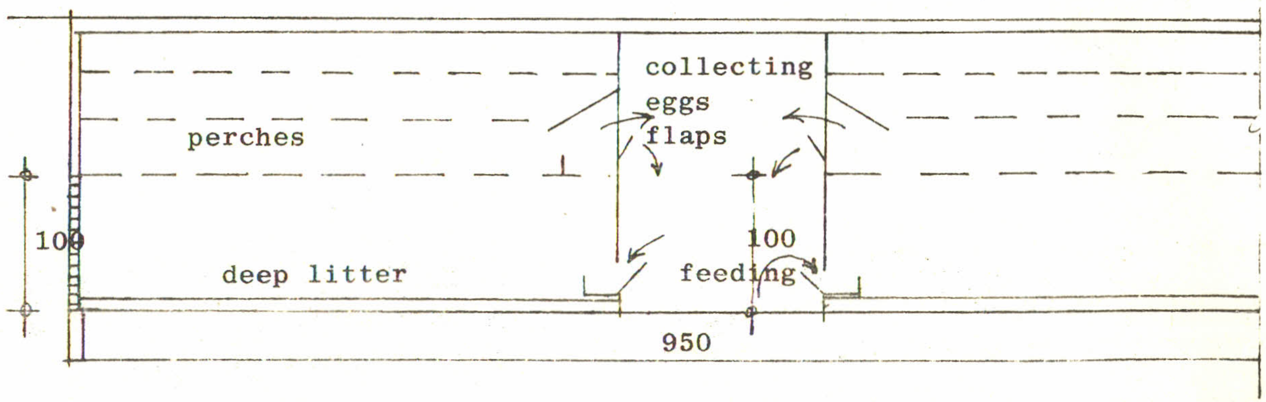


Figure 28d Longitudinal section

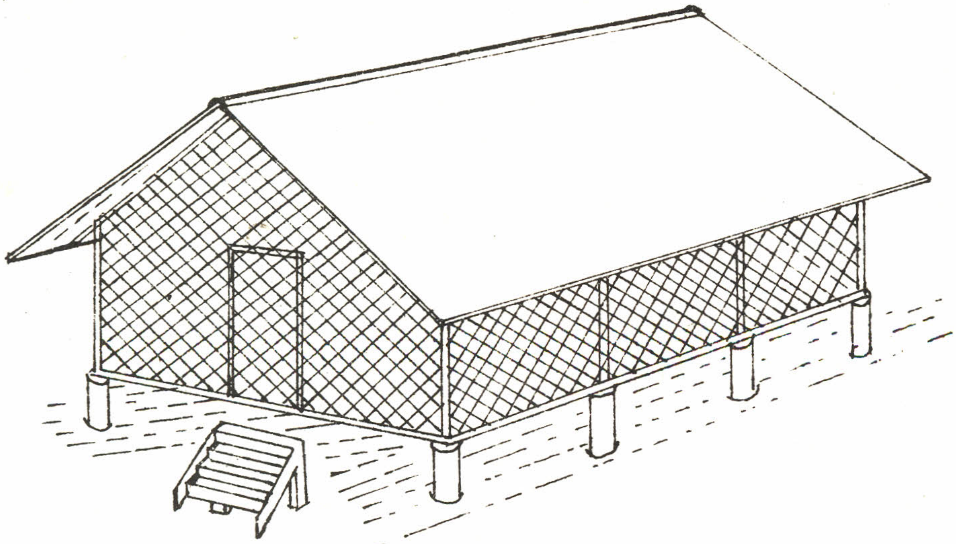


Figure 29 a Store

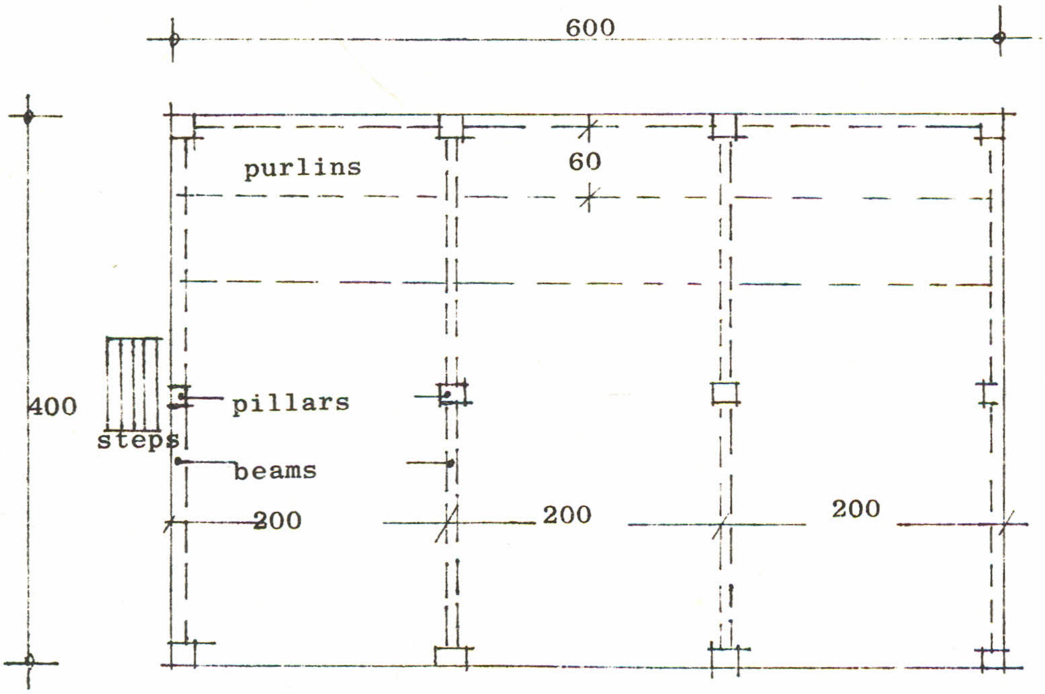


Figure 29b Groundplan

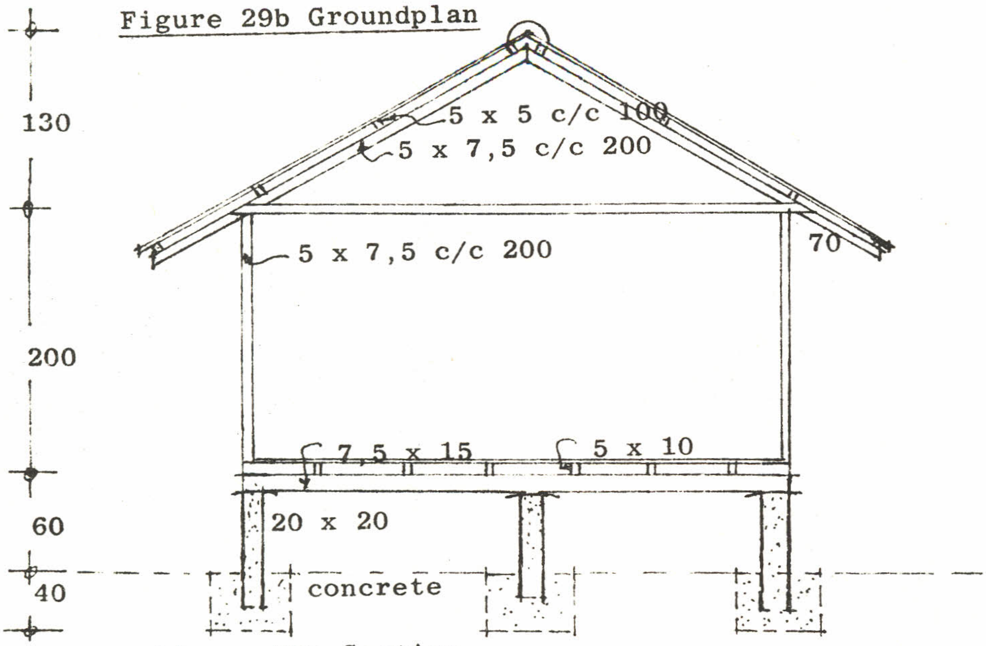


Figure 29c Section

Walls: Timber frame 5 x 7.5 cm and fine mesh wire netting.

Roof: Double pitch roof covered with corrugated iron sheets. At least 70 cm eaves to protect the stored crops from driving rain.

The steps outside the store should be completely separate from the store with a gap og 40 cm to prevent rats and mice from entering the store.

Dwelling Houses

There is a great variation in layout, construction and materials used in dwelling houses. This is due to the fact tha not all people like the same type of house and also because some people use unconventional building methods which are not always successful. Of course, it is important that people who are to occupy the house, perhaps for a life time, are satisfied with their house, but there are some general points we should aim at and mistakes we should try to avoid when building a dwelling house.

Choose a good site which is dry and gives a good view of the surroundings. There must also be an easy access to the road and to water if possible. If there is a strong prevailing wind in the area, the house should be placed so it is sheltered by hills or trees.

Which materials to use in a dwelling house depends on the local sources, prices and capital available, so most of the building materials mentioned earlier can be used.

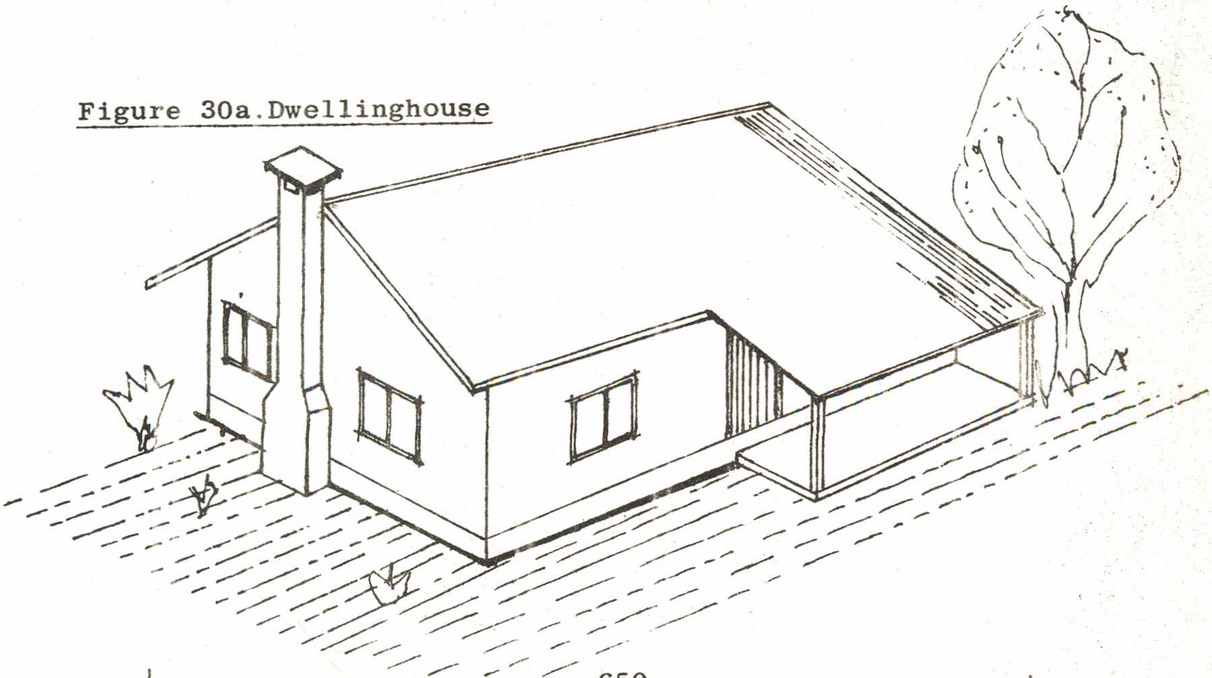
A dwelling house should have a fairly big living room, with ample light and situated so people sitting in it can have a good view from the windows and so they can know what is going on in the compound. The bedrooms may vary in number and size; two or three bedrooms of 5 - 10 sq.m each is often satisfactory. Apart from the floor space occupied by beds, cupboards and wardrobes, much floor space is not required. The windows can also be half the size of those in the living room because much light is not necessary.

The house should also have a bath or some kind of washing room (4 - 5 sq.m), especially if there is piped water to the house.

For convenience the kitchen should also be in the house and next to this a store. Minimum size of the kitchen should be 5 sq.m and the store 2 sq.m.

The fireplace should have a chimney or other means of easy exit for the smoke. Figure 31 shows a fireplace for cooking. The practice of having the fireplace on the floor should be abandoned because it is inconvenient for cooking and dangerous for the children. It should always be elevated at least 40 cm from the floor. The simplest way to do this is to make a block of mud which dries and becomes firm. On the top bricks or stones can be arranged with space between them forming a slot for the fire and support for the cooking pots.

Figure 30a.Dwellinghouse



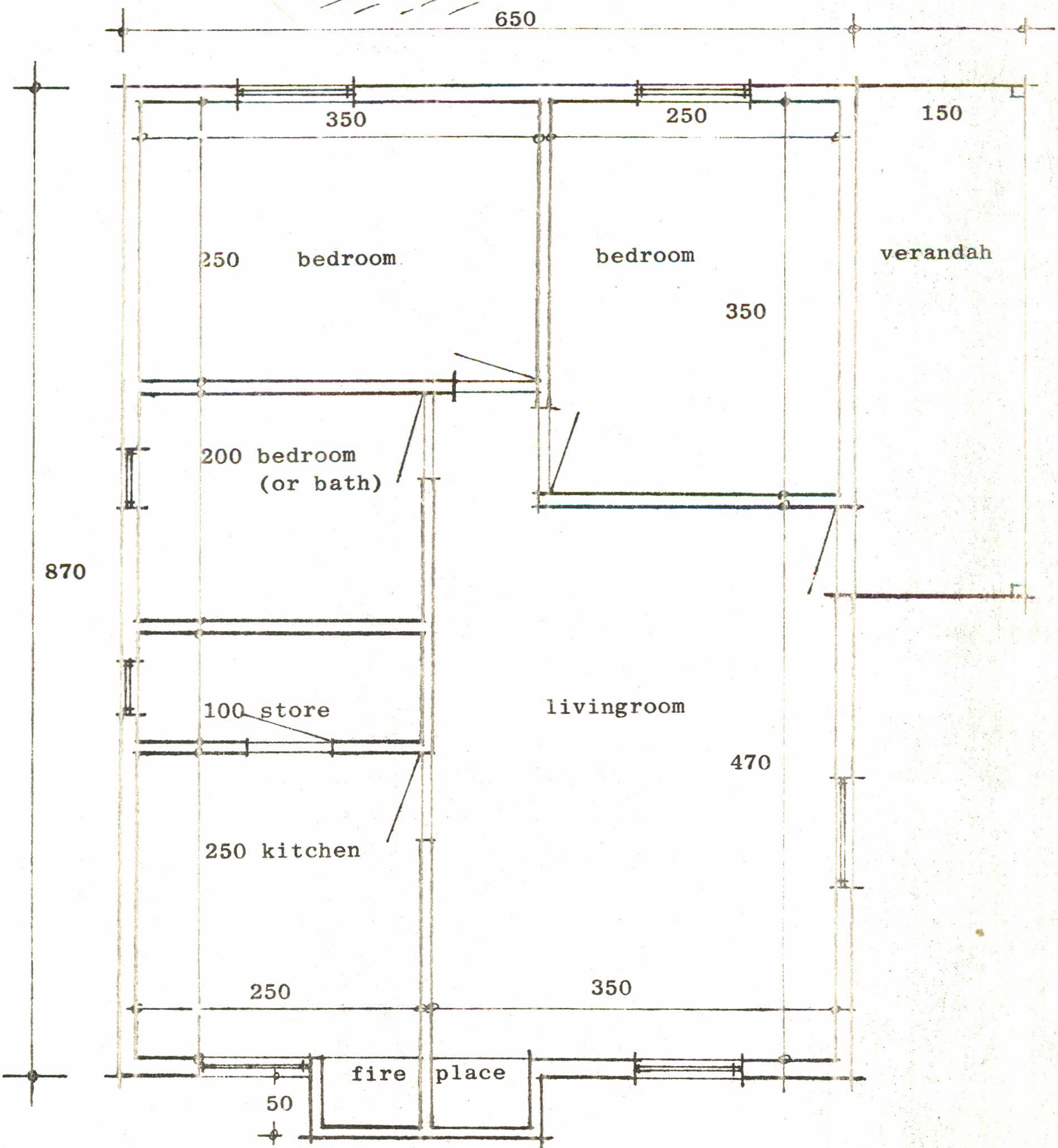


Figure 30b.Groundplan

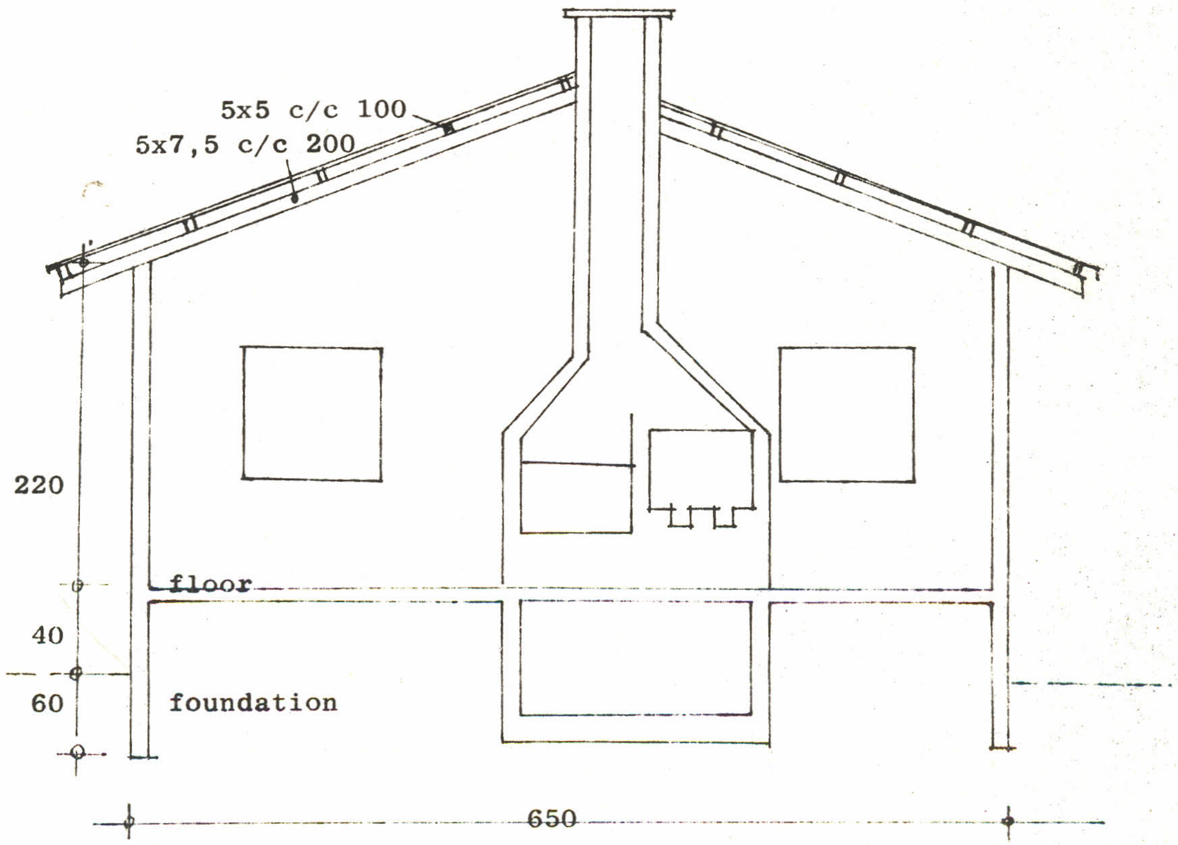


Figure 30c Section

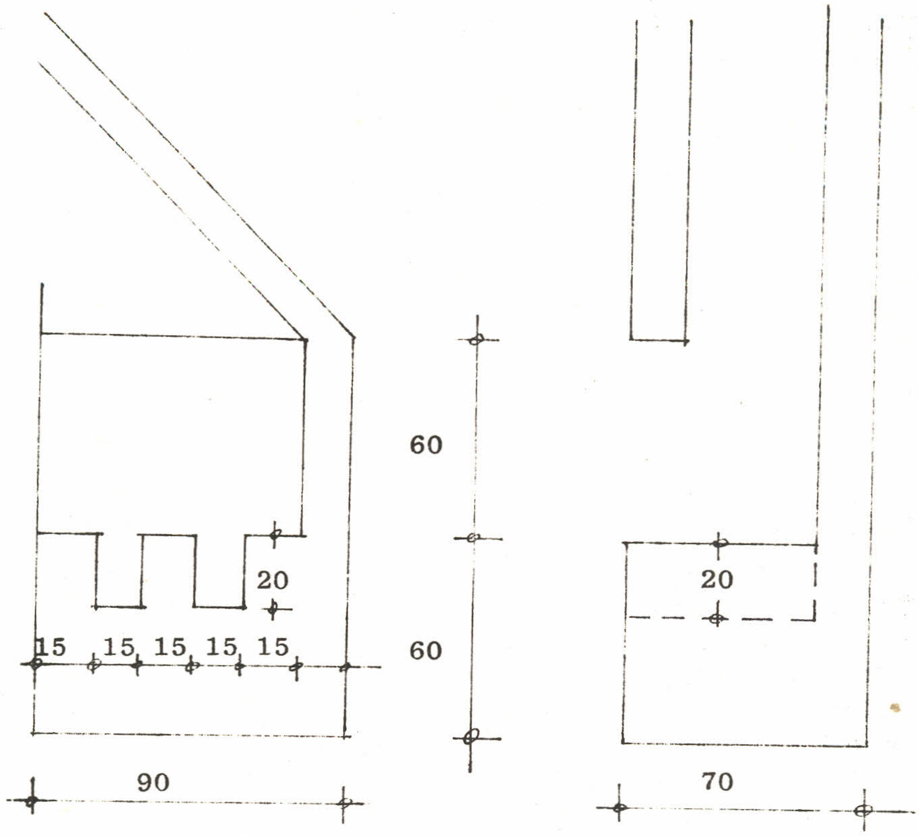


Figure 31. Cooking place-front view and section

Description of fireplace shown in Figure 31.

The fireplace and chimney are basically made of bricks or blocks. The fire wood is burnt in two slots in the fireplace and the pots are placed on top of these for cooking. Weldmesh or tins (debes) with holes in them for the pots could be placed across the slots to ease the cooking and utilize the heat better.

Description of dwelling house - Figure 30.

Foundation: Concrete or stone blocks. Width and depth depends on what type of wall is used. The chimney must have a strong foundation at least 60 cm deep. The bottom of this foundation should have a 20 cm thick plate or concrete reinforced with weldmesh.

Walls: Any of the walls described under the chapter "Walls" can be used. Inside height minimum 220 cm.

Roof: Gable roof thatched with any of the roof covering materials described previously.

Ceiling: 1 cm thick soft board.

Ventilation: If ceiling is used there should be holes in the walls near the wall plate, covered with insect wire mesh. If ceiling is not used, a gap should be left between the roof and the wall plate and covered with insect mesh.

Doors: Single, wooden doors, 70 x 200 cm.

Windows: Wooden shutters 100 x 100 cm. Half size in store and the smallest bedroom (bath).