An Autonomous Housing Prototype for Low Income Families

Housing Research and Development Unit - University of Nairobi

HOUSING RESEARCH AND DEVELOPMENT UNIT list of selected publications.

THE KIBERA EXPERIMENTAL SELF-HELP SCHEME.. **15/-**
Explanatory notes on the planning of a low-cost housing scheme in Nairobi.

O. Kaszner, March 1976, 18 pages.

The Kibera project is for 520 housing units in a peri-urban area of Nairobi. The scheme is commissioned by the Ministry of Housing and Social Services and the implementation and financing is the responsibility of the National Housing Corporation. The initial design and design co-ordination has been carried out by the Housing Research and Development Unit. The notes broadly describe the considerations behind the site planning and house design. The scheme has been planned for basic modern public and private services which has determined a dense overall development. In the design of housetypes the aspect of partial subletting have been considered. The houses are planned with a view to a gradual improvement and they will be built on a self-help basis.

THE PLANNING OF A MAJENGO - MASAKU SWAHILI VILLAGE.. **30/-**
Recommendations based on a study of socio-economic, technical and environmental health aspects of the area.

Marja C. Hoek-Smit, March 1976, 103 pages.

A report covering a detailed study of a traditional urban squatting area (Majengo) in Masaku Town and formulating a planning advice aimed at a controlled improvement of the area.
The study is based on surveys of legal, socio-economic, technical and environmental health aspects of the area. Where appropriate, the information obtained has been compared to data collected during similar surveys of a newly-built low-income residential area in Masaku Town

HOUSING BY-LAWS IN THE KENYA BUILDING CODE.. **12/-**
J. Eygelaar, September 1975,

6 pages text
6 pages summary sheets

The two sets of building By-laws (Grade I and Grade II) are legal documents covering a large range of buildings. The paper aims at a simplified systematic presentation of all clauses relevant to the planning, design and erection of houses as a first step towards an illustrated explanatory manuai.

DESIGN FOR MEDICAL BUILDINGS.. **60/-**
A manual for the planning and building of health care facilities under conditions of limited resources

P.J. Mein, August 1975, 146 pages

The manual contains design, construction and cost guide-lines for the building of medical facilities in rural areas where architectural expertise is not readily available. The full range of architectural activity is covered from initial feasibility studies to supervision of the building work on site. The guiding principle throughout is that, for medical buildings, the expenditure of material, monetary and manpower resources should be reduced to the lowest level consistent with adequate and acceptable medical care.

DESIGN FOR CLIMATE.. **60/-**
Guidelines for the design of low cost houses for the climates of Kenya.

C. Hooper, January 1975, 135 pages

An analysis of the impact of the different elements on house design. Division of Kenya into six climatic/comfort zones: Semi-Desert, Savannah, Coast, Lake, Highland and Upper Highland. Climatic description of each zone with climatic data sheets for representative locations. Guidelines for the design of low cost housing in each zone.

NATIONAL HOUSING CORPORATION RENTAL SCHEMES.. **60/-**
A technical / user-reaction survey and analysis

Lucy J. Kamau, June 1974, 229 pages

At the request of the National Housing Corporation the HRDU has surveyed and analysed a series of schemes, designed by the Corporation.
The report covers eight different schemes in towns, Meru, Embu, Nyeri, Murang'a, Kisii and Kakamega. The houses are rental, one storey, detached or semi-detached designed for single family occupation.

HOUSING POLICY GUIDELINES FOR AFRICAN COUNTRIES.. **41/-**

N.O. Jorgensen, November 1972, 41 pages

This paper, which was requested by the UN Centre for Housing, Building and Planning includes sections on general housing policy considerations, priorities, land financing, administration, construction, training and research.

UNIVERSITY OF NAIROBI
HOUSING RESEARCH AND DEVELOPMENT UNIT

"AN AUTONOMOUS HOUSING PROTOTYPE FOR LOW INCOME FAMILIES"

PHILIP MEIN R.I.B.A.

The printing of this report is fully funded through a Rockefeller Foundation Grant to the Department of Architecture for the development of locally based and relevant teaching material in the field of housing and community studies.

Housing Research and Development Unit, University of Nairobi.

Director - K.B. Andersen, M.A.A.

P.O. Box 30197, Nairobi, Tel. 27441 Ext.212.

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INTRODUCTION

background

In June 1976 the Housing Research and Development Unit was approached by the United Nations Habitat and Human Settlements Foundation concerning the possibility of developing a brief for a prototype low-cost dwelling unit which could be built for experimental and demonstration purposes. Accordingly a brief was formulated in which the aims were to develop a housing unit which could meet the needs of low-income groups, which would be based upon the principles of conservation and which would maximise the use of local materials and skills. From this brief a prototype design was made, a description of which forms the basis for this report. It is hoped that the implementation of three houses as a pilot project will follow.

framework

ref: 4

The project is set within the general financial and organizational framework of the National Housing Corporation's site and service guidelines except for some technical aspects and the fact that the target population is limited to those earning between KShs.300/- and 800/- a month. The other main parameters arise from the original brief namely:

Autonomy - The prototype is designed to be independent of mains services (water supply and sewerage).

Conservation - Water is to be conserved by the collection of rain-water from the roof and by the installation of a 'dry' composting toilet.

Economy - The constructional design is such that inexpensive, indigenous materials and self-help methods can be used extensively.

Finance - The prototype is planned to provide for partial letting by the owner which will in effect subsidize his means for loan repayment.

Each of these aspects is elaborated in the relevant sections of this report.

SECTION ONE - THE SITE

Three main aspects were considered with relation to siting and plot development namely: regional considerations, location possibilities and site planning.

regional considerations

In developing the prototype design, regional variations were considered from the point of view of the availability of building materials, climatic conditions in general and rainfall characteristics in particular. Due to the basic requirement that rainwater falling upon the roof must provide for the minimum daily water requirements of the occupants, the last mentioned consideration (rainfall) becomes the most critical.

rainfall

As shown in appendix three only those areas with mean annual rainfall of over 750 mm can possibly meet this requirement properly. This in effect limits the direct applicability of the prototype to those regions of Kenya which fall within the Upper Highland,

ref: 5

Lake and Coast climatic zones. Although in geographical terms this limitation is fairly severe (covering less than 20% of the land area) in demographic terms almost 90% of the population is covered

ref: 3

(see fig.1).

building materials

Following indirectly from the above, these same areas of higher population and rainfall tend to be well provided with the means of production and distribution of common building materials such as mud and wattle, timber poles, g.c.i. sheeting and cement. The question of availability of materials does not therefore present any further regional limitation.

climatic conditions

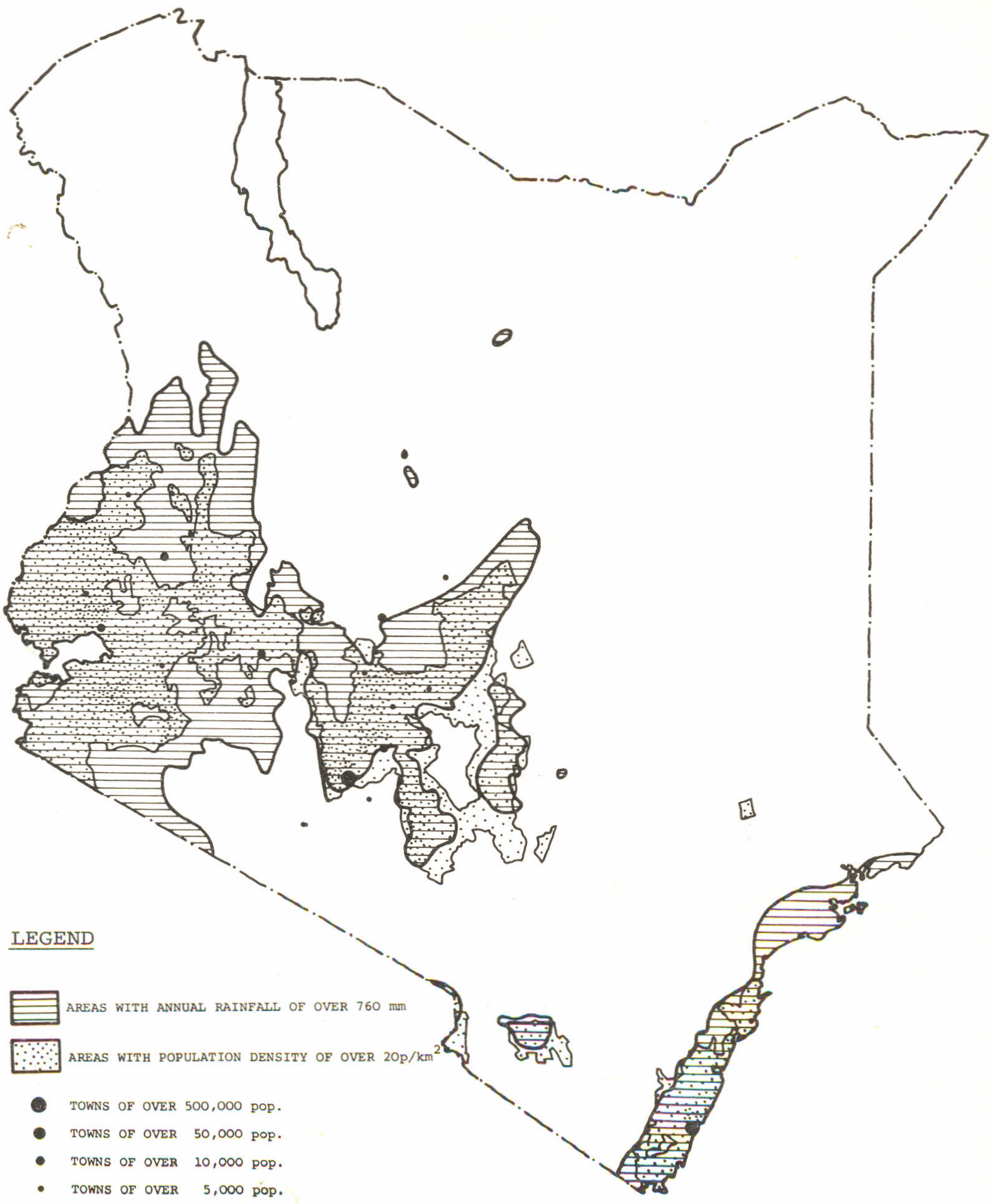
As far as the climatic conditions affecting human comfort are concerned, the structure of the house is designed in such a way as to allow various wall infilling materials and methods to be used so that the thermal capacity of ventilation can be adjusted to meet the local requirements. Similarly the roof structure is designed to simplify the fixing of a ceiling, whether of indigenous materials or manufactured board, should this be necessary for climatic reasons.

location possibilities

Within the wider regional context there are further constraints which favour certain types of location and mitigate against others. The first limitation is created by the basic form of the dwelling which is only adaptable to a certain range of densities.

FIGURE 1

map of Kenya showing rainfall and population distribution



plot size

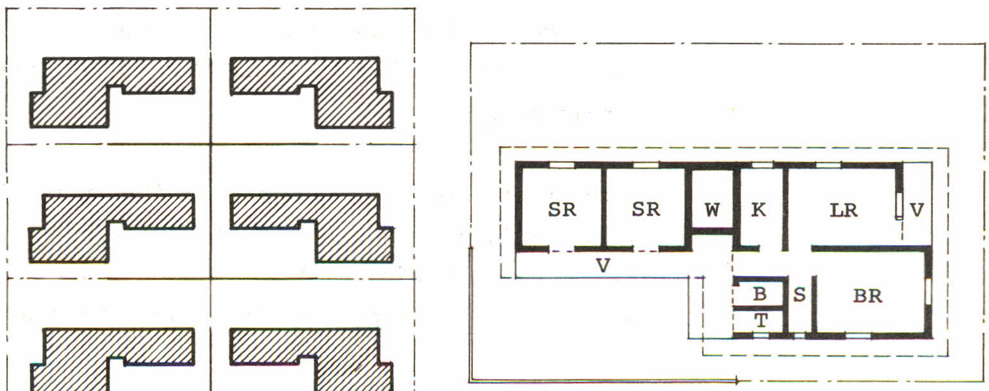
The prototype was initially developed as a detached house for which an acceptable minimum plot size would be 216 m^2 (see fig.2). This would inevitably limit its application to rural or semi rural areas. However by slightly adapting the plan form, substituting an external water tank and developing along the plot boundary a considerably higher density courtyard type of development can be achieved with a plot size as small as 128 m^2 (see fig.3). This would require that the composting type of toilet be considered equivalent in environmental terms, to a water closet connected to a sewerage system. In the absence of particular reference in the building by-laws to mouldering toilets it is more likely however that they would be considered, at least initially in the same light as a pit latrine.

ref: 2

If this turned out to be the case then a much larger plot size of 260 m^2 would have to be adopted.

FIGURE 2

detached house
on reasonable
minimum plot



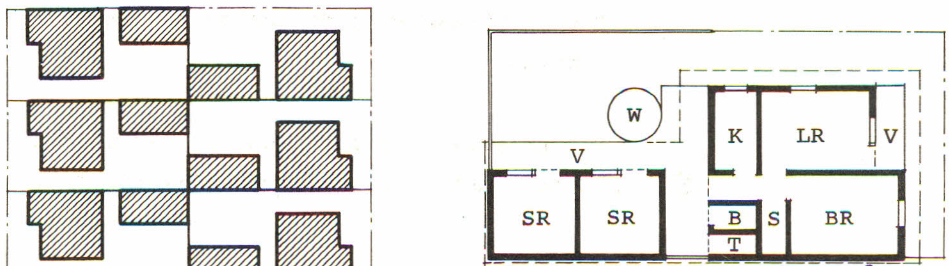
Plot size 12 x 18m = 216 m^2

LEGEND

LR - living room
BR - bedroom
SR - separate room
K - kitchen
B - bathroom
T - toilet
S - store
W - water tank
V - verandah

FIGURE 3

plot boundary
house on absolute
minimum plot



Plot size 8 x 16m = 128 m^2

There are two further limitations as far as location is concerned. Firstly an owner in the income bracket KShs.300/- to 800/- will need to supplement his income from partial letting which means that the project would be more viable in areas where there is employment or easy access to employment for potential tenants. Secondly the concept of autonomy in housing would only be considered an intermediate measure in Kenya and therefore locations which already have mains services would be automatically excluded.

In summary, the prototype can be considered generally applicable to those parts of the country which have moderate to high rainfall and to those locations in, or near small towns or in the peri-urban areas around larger towns and cities where employment opportunities can be found but where land is often not serviced and is developed at low or medium densities.

site planning

Within the regional and locational framework there are several possibilities for plot development meeting differing density requirements (see fig.4). Each alternative is however based upon the following layout principles:-

- The clear identification of owner and tenant zones, each with their own access, which is intended to produce a living environment conducive to the owners continued residence on the plot thus detering absentee landlordship.

- The provision of out door activity areas which are the essential adjuncts to internal spaces in low-income housing schemes. Thus each layout has a courtyard for everyday household activities both working and social, a shamba area for cultivation and a front garden area.

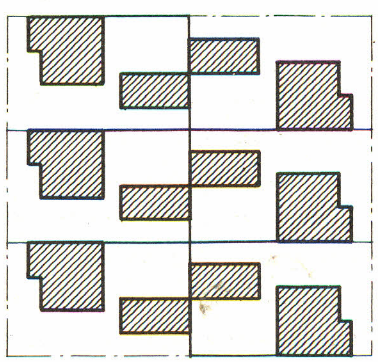
- The provision of a protected, though external, means of circulation between the rooms and the sanitary facilities.

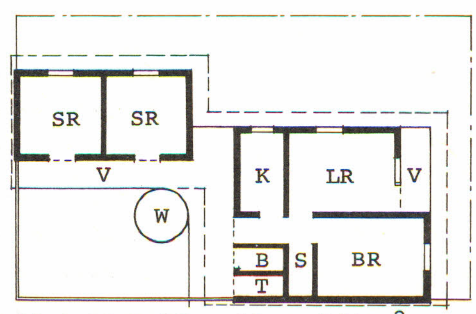
- The maintenance of North/South orientation for the main windowed elevations.

- The provision of a reasonably narrow plot frontage bearing in mind that at least water services will probably be added at some future date.

FIGURE 4

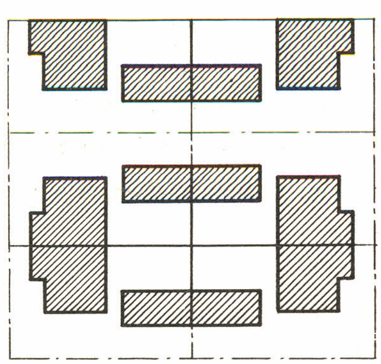
plot boundary house

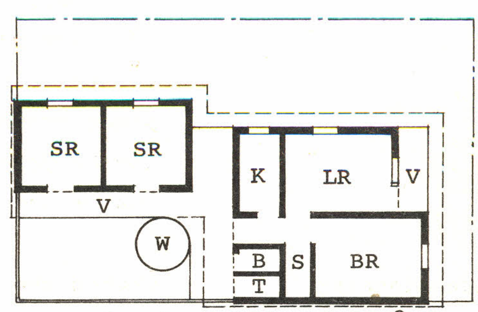




Plot size 10 x 16m = 160 m^2

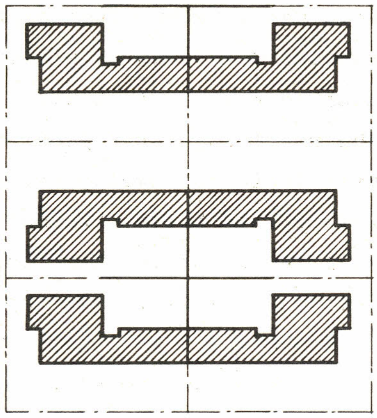
semi-detached house

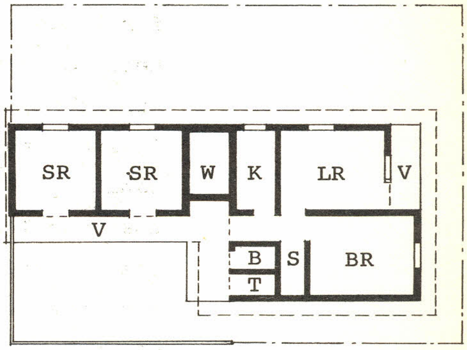




Plot size 10 x 16m = 160 m^2

semi-detached house





Plot size 12 x 16m = 192 m^2

SECTION TWO - THE HOUSE

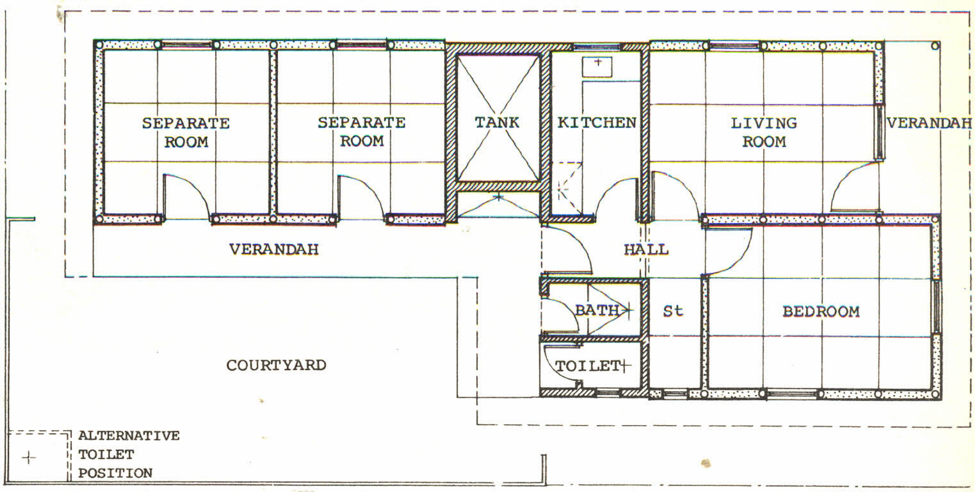
Four major aspects were taken into account in the design of the house itself namely: the accommodation required, the arrangement, size and occupancy of rooms, the possibility of phased development and the overall form of the building.

accommodation

The house in its fully developed form comprises four habitable rooms (living room, bedroom and two separate rooms) a kitchen, bath-room, toilet and store. Four habitable rooms can be considered a minimum if the owner is to have proper accommodation and still be able to supplement his loan repayments by partial letting. On the other hand, more than four rooms would put too great a stress on the sanitary facilities especially considering that a fairly high occupancy rate might be expected (see fig.5).

ref: 7

FIGURE 5
prototype house plan

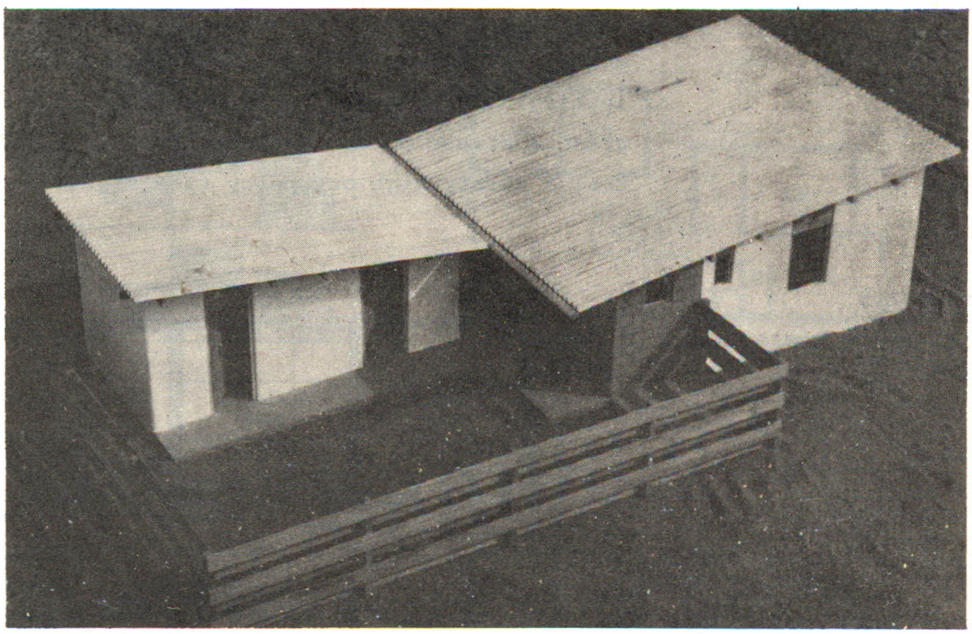


It is appreciated that there is an often expressed preference for larger (say 6 roomed) dwellings by allottees arising from the need for maximum economic return. It should however be borne in mind that, due to the resulting large plot population, unfavourable living conditions are likely to develop especially if only one sanitary unit is provided. In these circumstances it is unlikely that the landlord will remain on the plot thus leading to an even less controlled situation. The financial implications of dwelling size are dealt with in section 6 where it is shown that, in most circumstances, the letting of two rooms is sufficient to make the house affordable to the target population.

plan arrangement

The principal design consideration for the plan arrangement is that the house is expected to be occupied by an owner household and one, or more probably two, tenant households. In order to avoid the undesirable situation of the owner letting the whole house and becoming an absentee landlord the house is planned to provide the owner with an identifiable and virtually self-contained house (the shower and toilet are shared) with its own front door and verandah. In addition two separate rooms are provided with separate access, for letting purposes or for the use of extended family members who might be staying there.

the completed house



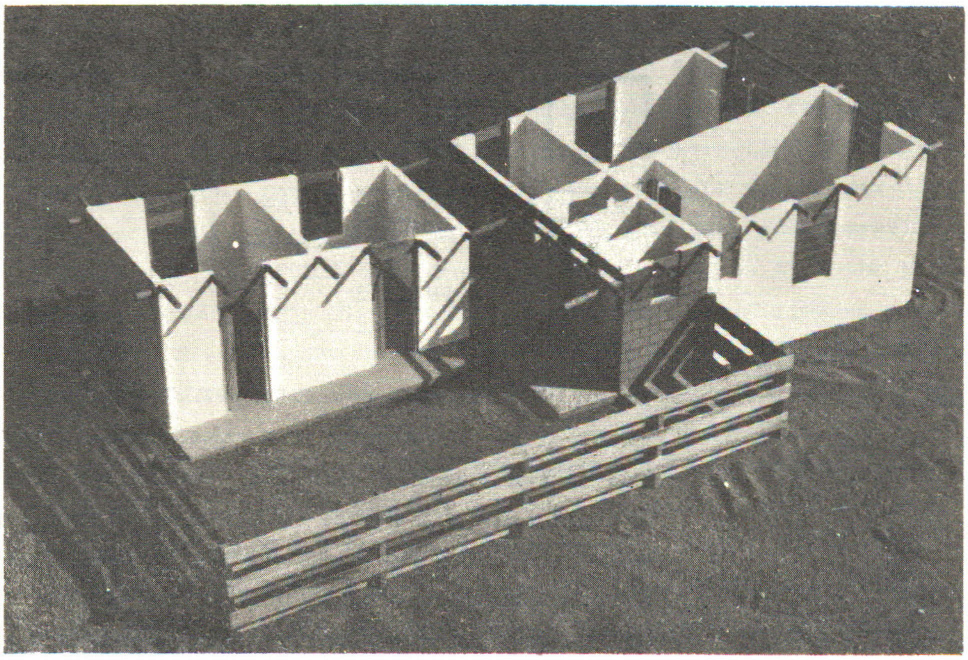
The overall plan which is L - shaped has the advantage of forming two sides of a courtyard (the other two sides being fenced) which is an integral part of the house providing an activity space and protected access between the rooms and the sanitary facilities.

room sizes

ref: 6

The room sizes are based upon the recommendations contained in the H.R.D.U. publication 'Guidelines for Room Types in Low-cost Housing'. Thus an overall planning module of 1 m square is used based upon a bed-space dimension of 1 x 2 m. This allows maximum flexibility whether for living, sleeping or multi-functional use. It is anticipated that the living room would be used for living/dining purposes, the bedroom for sleeping and the separate rooms for multi-purpose use by one or two occupants. Thus the maximum occupancy of the house could be taken as 10 people (i.e. an owner household of six members and two tenant households of two members each).

the completed house showing room layout



kitchen

ref: 2

It is commonly found, and can therefore be anticipated, that in situations where partial letting occurs the kitchen is monopolised by the owner household. Thus the kitchen is situated in the main part of the house although it is nevertheless accessible via the back door and corridor and so could be used by the occupants of the separate rooms. The kitchen is well above the minimum size ($4.4\ m^2$ as opposed to 2.3^2) and as such could allow for shared use if necessary. Furthermore a splash area is provided for the use of tenants should they be excluded from the kitchen proper.

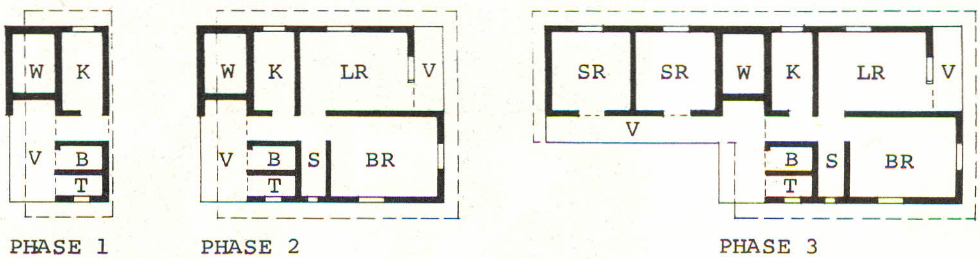
toilet

Considering the number of occupants, it can be anticipated that the toilet and bath-room will be subject to fairly intensive use. Accordingly, although they form part of the main structure of the house, they open into the outside air thus avoiding the nuisance to the occupants of smell and noise. In case a number of prototypes are built, the experimental nature of the proposed toilet may make it prudent to relocate the toilet to an external position meeting the by-law requirements for a pit latrine (i.e. 4.5 m from a habitable room). A store ($2m^2$) is located within the house for security reasons.

phasing

In compliance with the site and service concept, the prototype was designed to be built in phases. In spite of the fact (demonstrated in section six) that phasing may not be as advantageous financially as supposed, it nevertheless remains a positive feature of the design that it is suitable for piecemeal development (see fig.6).

FIGURE 6
phasing plans



phase 1

Three main phases are envisaged. The first would consist of the shell of the core only, i.e. the kitchen, bath, toilet, water tank and multrum chamber omitting some of the finishes such as painting and glazing. Due to the relative complexity of the building work associated with the sanitary facilities, this phase would preferably be contractor built and it is for this reason that the extent of the work is minimised by, for example omitting some finishes. The core would however be secured (doors, burglar proofing etc) so that building materials for the next phase could be stored safely.

phase 2

In the second phase, the core would be finished off and the living room, bedroom and store would be added, thus providing a complete two roomed house meeting the grade II by-laws. It is considered that all the work in this phase could be carried out by self-help methods, that is to say either by self-building or by the hiring of direct labour. At this stage the two habitable rooms are separately accessible thus allowing the owner to occupy one and let the other as an intermediate step.

phase 3

The third phase would be the erection of the two separate rooms, again preferably by self-help methods which completes the full house. At this stage the owner would take over both the living and bedroom and probably let the two separate rooms. A detailed breakdown of the suggested phasing is given in the cost analysis in appendix one.

climatic considerations

Within the general areas for which the prototype is designed there prevails a common and indeed prerequisite climatic condition, that of abundant rainfall. There are also however a number of climatic variables of environmental impact which consequently demand a degree of flexibility in the house design.

lake and coast zones

The lake and coast zones can be taken together (the latter being the more critical) in that they both share high air temperatures coupled with relatively high humidity and a low diurnal temperature range. In order to maintain a comfortable environment, particularly at night, it is essential that the walls have a low thermal capacity, that there is a large amount of ventilation and that the roof is insulated. The closely spaced timber pole construction for both walls and roof allows for this through the use of light weight materials (e.g. timber) and louvre infilling and by the easy incorporation of a ceiling. In addition the house can be oriented so that the windows face north and south cutting down insolation, and the rooms positioned such that the necessary cross ventilation can be attained, provided that the houses are sufficiently well spaced.

ref: 8

highland zones

In the highland and upper highland zones, the requirements are less critical, the main one being that the walls should have a high thermal capacity to reduce over-heating during the daytime and conserve heat for the cooler nights. This would mean infilling between the poles with a heavy material such as concrete block or mud and wattle. Ceilings are also welcome in these areas.

insolation

As the problem of insolation is critical in all areas, except perhaps the upper highlands, it was studied in some detail particularly with regard to the amount of protection afforded to windows by the roof overhang. Tests were carried out in the Faculty of Architecture Design and Development's Architectural Science laboratories where it was found that a roof overhang of 500 mm would give adequate protection. At the same time it was ascertained that sufficient day-lighting is provided to the rooms by the fairly small (0.9 x 1.2 m) windows. The full results of these tests are given in appendix two.

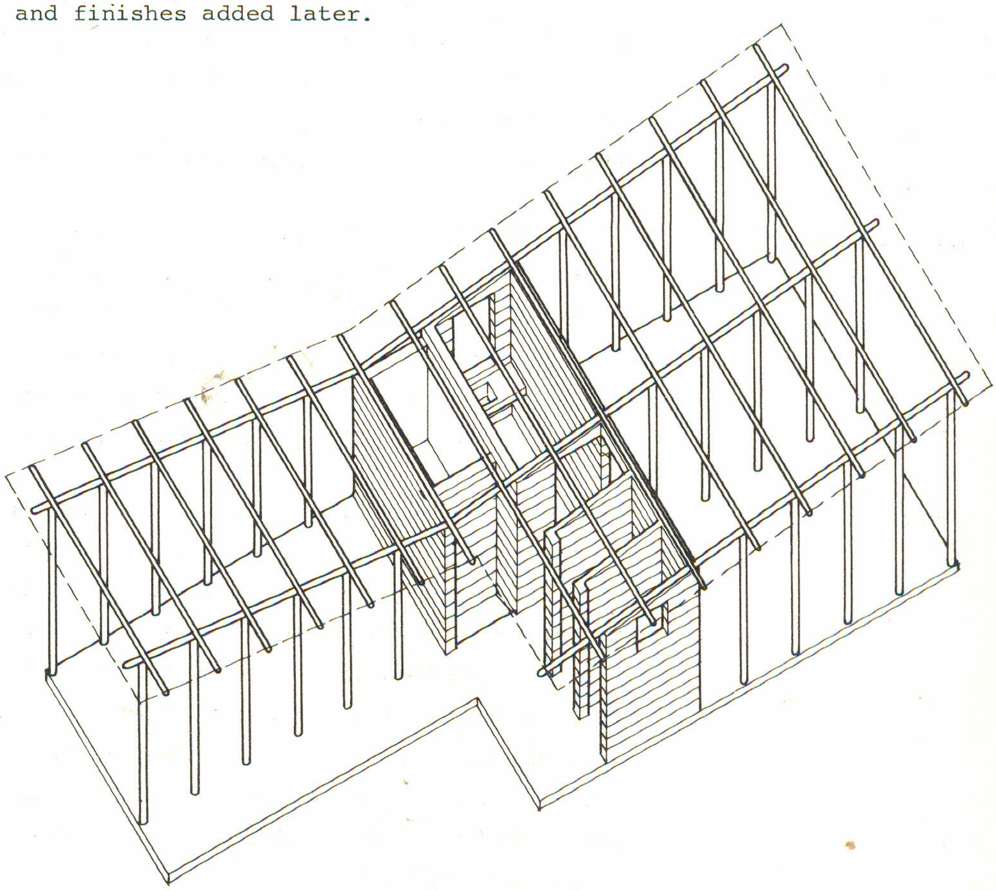
SECTION THREE - CONSTRUCTION

There are a number of basic building principles which can be said to be mandatory in the construction of low-income housing namely: minimum cost, maximum use of indigenous materials, use of self-help methods and in-built improvability. Each of these principles is inter-related and can be applied to the various stages of the building process.

the core

The structural system for the house is based upon the concept of a core element of permanent materials acting as a stabilizing unit at the centre of the house to which the lighter structural elements are connected (see fig.7). Thus the core consisting of the kitchen, bath, toilet, multrum chamber and water tank would be built of concrete blocks, burned brick or stone depending upon local availability and price. The foundations would be conventional concrete strip footings. It is most probable that the core would be contractor built, being the most specialized element, although it could be done by labour directly employed by the owner. In either case the shell only need be completed initially with the fittings and finishes added later.

FIGURE 7
structural system



structural frame

The structural system for the rest of the house consists of a timber pole (or alternatively sawn timber) framework of columns, set in concrete bases, supporting a grid of rafters and purlins. This system gives several advantages; it is relatively cheap especially when foundation costs are taken into account, it is well suited to self-help construction, it allows for future improvement of walls and secondary elements (windows etc) without affecting the stability of the structure, it provides a framework to which cladding materials such as timber boarding can be easily fixed and finally it is made from a material (timber) which is widely available.

roof covering

ref: 8

The roof covering for the whole house is standard profile g.c.i. sheeting. This is considered the only reasonable material bearing in mind the design criteria. It is inexpensive (28 swg can be used due to the 1 m purlin spacing) it can be laid to a shallow pitch and is ideally suited for rainwater collection, it is generally available and of all the sheet materials is best suited to self-help construction methods. The poor thermal quality of a g.c.i. roof can be mitigated by the inclusion of an inexpensive ceiling of local materials such as papyrus.

floor

The main choice for flooring materials is between rammed earth and concrete. A concrete floor on well compacted sand or hard core, would be essential for the core and apron immediately surrounding it. It is also recommended for the floors to the rooms in that it provides a stable and hygienic base on which the walls can be built. In cases where extreme economy is a prerequisite it would however be tolerable to make do with a rammed earth floor until such time as future upgrading to concrete was possible.

infilling

In order to arrive at a detailed cost breakdown on which to base a proper financial analysis, a sample specification is given in appendix one. In practice however the materials used would vary for a particular location according to the parameters outlined in the first paragraph in this section. As far as the core, superstructure, roof covering and floor materials are concerned the choice is limited as described above but for the infilling materials the choices are much broader.

walling

The close spacing (1 m) of the timber columns, by providing frequent and easy fixing possibilities, gives a high degree of flexibility in the choice of walling materials. Thus according to local availability and climatic conditions, mud-and-wattle, sun-dried bricks, timber off-cuts or various sheet materials could be used in the first instance. (see fig.8). Future up-grading to say, concrete block, burned brick or timber weather boarding can be carried out later without disturbing the support structure of the roof (see fig.9).

FIGURE 8

mud and wattle and timber off-cut walling

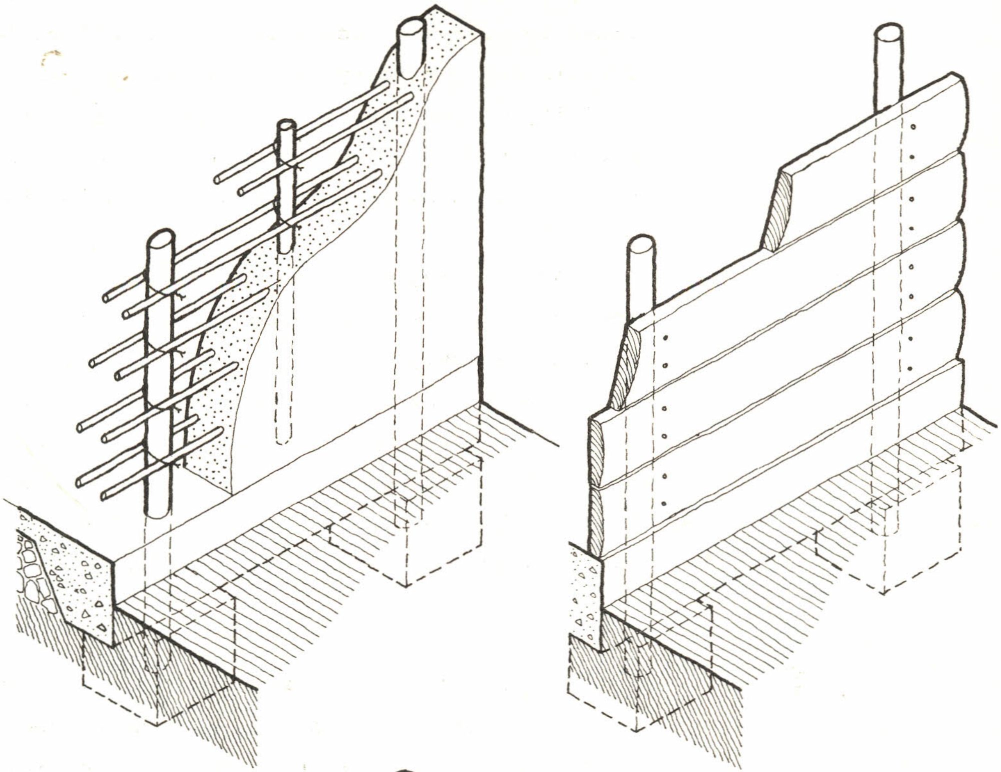
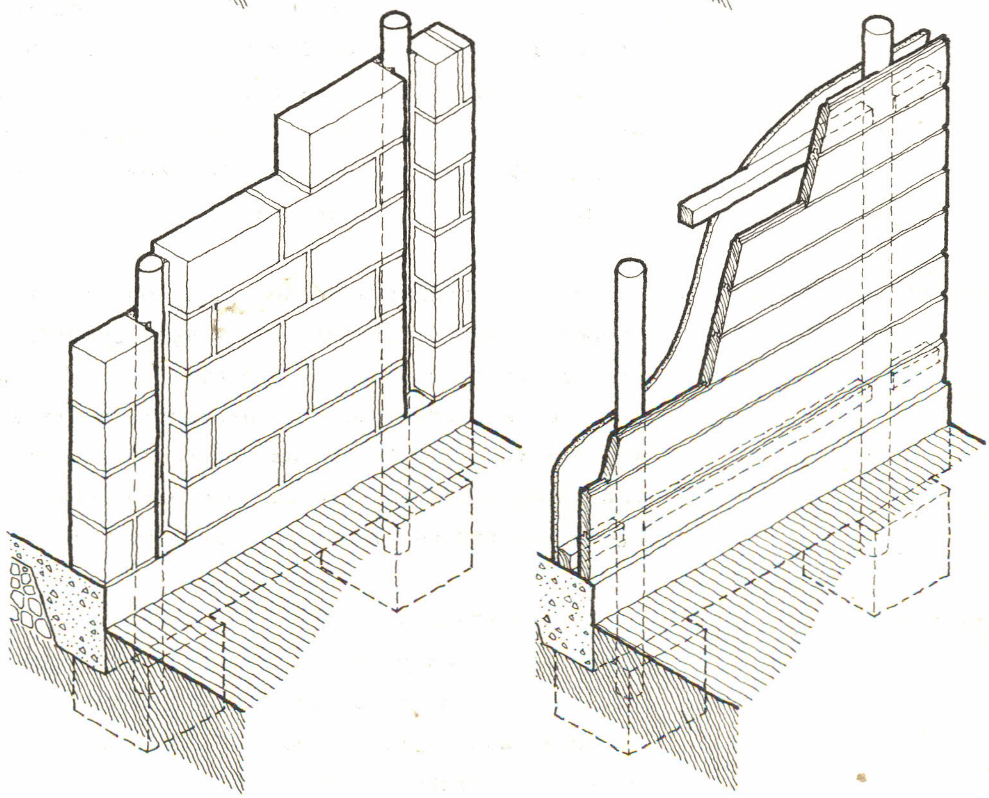


FIGURE 9

blockwork and T and G board walling



windows

Door and window units fall within the 1 m module and thus could readily be upgraded by replacement. Glass louvre windows are however considered the best solution on the grounds of cost, function and availability. They also have the advantage of being adaptable to any opening width and so can be fixed directly to the structural frame even though its precise spacing may vary. The doors would be timber ledged and braced.

finishes

The range of finishes is determined by the infilling materials but broadly speaking the floors would be concrete trowelled smooth. The walls would be finished with emulsion paint (one a cement/sand bagwash in the case of masonry) internally and with lime wash externally, except for the toilet and shower rooms where full plastering is desirable with a gloss paint finish to at least 1.6 m above the floor. Ceilings for the prototype are papyrus reeds fixed with battens directly to the purlins but other indigenous materials could be considered. Upgrading to soft board or expanded polystyrene sheets is easily possible.

SECTION FOUR - SERVICES

One of the major design aspects of the prototype is that it should be independent of mains services (water and sewerage) for reasons of economy, conservation and flexibility of siting. In order to achieve this the roof is designed to collect water into a large storage tank and human waste is processed on the plot by the use of a 'multrum' type mouldering toilet.

rainwater collection

As far as both quality and quantity are concerned, the collection of rainwater for general use can only be considered as an intermediate measure between the manual transportation of water from often polluted river sources and the provision of a properly protected piped water supply. Nevertheless rain water conservation would be of great value in many areas of Kenya either as a first step in water provision or as a supplementary source with the advent of a mains supply which, even when provided, may be sporadic.

collection system

The design of the roof is such that all water flows to a central large capacity gutter from where it discharges through a screened outlet into the tank directly below. In this way, for each 1 mm of rainfall, 90 litres of water is collected. In central province for example this would theoretically give an average daily amount of about 24 l/person/day, assuming an occupancy of 10 persons. In order to provide water throughout the year taking into account a 10% loss due to evaporation, a 4,500 l storage tank is needed which will enable a supply of 12 l/person/day to be maintained through the dry season. This figure can be taken as an acceptable minimum amount considering available statistics on water use for communities without piped water. This aspect and the implications for the other regions of Kenya are dealt with more fully in appendix three.

ref: 11

storage tank

The storage tank proposed for the prototype is built of concrete block forming part of the main structure of the house. The inside of the tank has a plaster and bituminous paint finish. A number of measures are taken to preserve the quality of the water over the fairly long storage periods. The placement of the tank in the centre of the house and the materials from which it is made will ensure that a cool and even water temperature is maintained, also the tank is covered to exclude dirt particles and sunlight.

The alternative solution of a cylindrical g.c.i, tank was considered and is in fact suggested in some of the alternative plans. The advantage of this type of tank is its ready availability and its somewhat lower cost. On the other hand the cylindrical form is more difficult to integrate within the house plan. and also the increased water temperature in an un-insulated tank can have a deleterious effect on the purity of the water.

water purity

There is some question as to what further precautions are required to preserve the potability of rainwater stored for several months especially bearing in mind that people have been drinking such water for many years without apparent harmful effects. Apart from the measures described above, it is proposed that chlorine be added to the water in the tank by means of a clay pot diffuser. In addition, if the prototypes are built, experiments will be carried out on simple filters, a device which would allow the first shower falling on a dirty roof to run off and a solar still purification system.

water use

As the supply of water obtainable from rainwater collection is never inexhaustable, the consumption of water is limited by having only one water outlet on the plot discharging over a splash area; from there water is carried to the kitchen and bathroom (the toilet requiring no water) which are fitted with a drained sink and shower waste respectively which lead to soak-aways. On larger plots the 'grey' water from the sink and shower waste could be used for irrigation purposes. Future installation of mains could be undertaken without changing the drainage system.

rationing

Several devices for rationing water during dry periods were investigated but were considered too restrictive and liable to failure. Instead a clear plastic tube, showing the inside water level, will be fixed to the outside of the tank in the expectation that as the level drops the users will exercise greater restraint. In areas with very high rainfall for part of the year, an additional tap would be provided to discharge over the kitchen sink. The outlet for this tap would be placed near the top of the tank so that it would only be usable in times of abundance.

waste disposal

The disposal of human excrement and kitchen waste is dealt with on the plot by the installation of a composting 'multrum' type latrine. The chief advantages of this type of toilet are that it uses no water, it is independent of a sewerage system and it avoids the risk of pollution of ground water through seepage or the production of contaminated effluent.

composting latrine

In principle the continuous type composting latrine or 'multrum' toilet consists of a larger chamber with three inter-connected compartments each with a lidded opening, one for excreta, one for kitchen refuse and one for removing the end product. Thus within the container excreta, urine, paper and organic kitchen refuse are mixed together. Before being used, the floor of the chamber is covered with a layer of soil and grass or leaves. The micro-organisms in this layer, together with those in the faeces, decompose the input into fertilized humus. The water vapour and CO_2 produced are ventilated away through an insect screened vent pipe. The sloping floor of the chamber ensures that, as decomposition proceeds, the material moves slowly from the input to the output end. During this process the volume of waste is decreased by 90%. The end product is scooped out once a year and is theoretically free from pathogenic organisms and odours and could be either buried or used directly as a fertilizer.

ref: 10

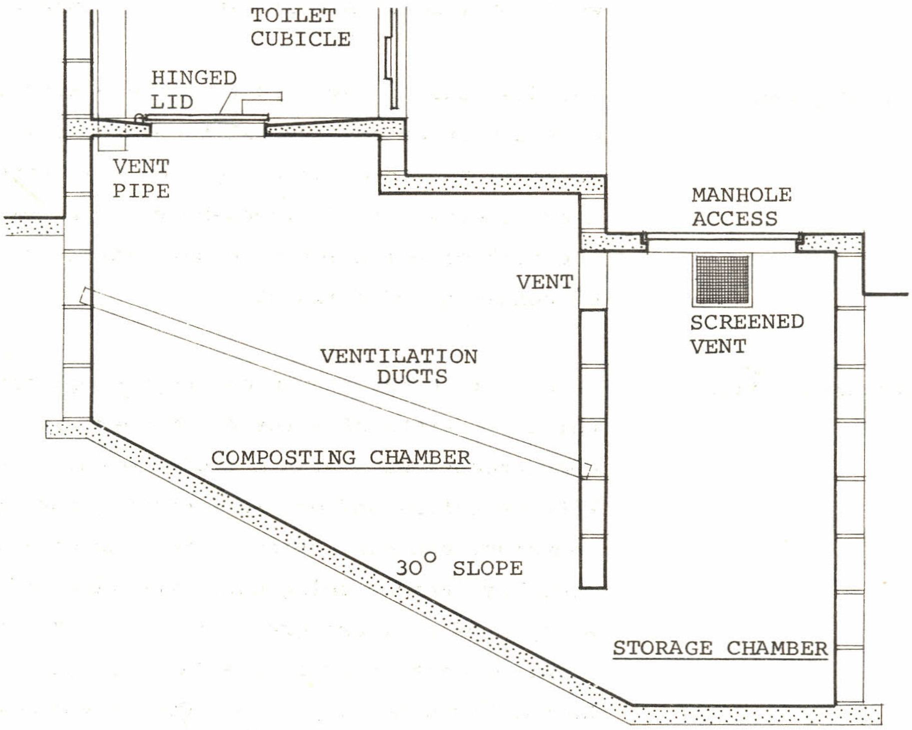
toilet design

The composting toilet design suggested for this prototype is based on the work of Mr. Uno Winblad who has been carrying out extensive research in Tanzania involving the construction and monitoring of 60 latrines. In this design there are two chambers (see fig.10) a main composting chamber and a smaller chamber from where the end product is removed. The system is completely sealed, with a hinged lid over the toilet opening and a cast iron manhole cover over the opening for the removal of the composted material. Also the ventilation openings are screened against insects. As one of the main problems with the composting latrine is excess liquid entering the chamber the toilet room itself is kept to a minimum size to deter its use as a washing room. It should be noted that Mr. Winblad's research is not yet completed and therefore it can be anticipated that when the final results are available some modifications may be made to the design. A working paper on composting toilets has been produced by

ref: 12 the H.R.D.U. for limited circulation.

FIGURE 10

section through composting latrine



SECTION FIVE - COSTS

The cost, to the occupant, of his house is usually made up of three items. A price for a contractor built element, a sum for the purchase of building materials to complete the house and an amount for hired labour needed for completion of the house. For a particular house design, the amount of each of these costs is related to a number of variable factors. The quality or standard of building, the extent of the contractor built element and the amount of building work done by self-help as opposed to hired labour. The costs related to land and financing through loans are dealt with in section six.

building standards

The quality or standard of building has a direct bearing on the contractor and material costs and indirectly on the direct labour costs. The range of materials considered appropriate for the prototype is given in Section Three and a detailed sample specification with costs is given in appendix one.

Apart from the previously mentioned criteria such as cost and availability the underlying guideline for the selection of materials has been the concept of improvable, acceptable standards. That is to say that all the materials used are acceptable for the life of the building but nevertheless the structure allows for the substitution or addition of higher grade materials should the occupants wish to improve their house.

upgradability

A more extensive application of the concept of upgradability was considered whereby, in order to cut initial costs, sub-standard materials such as rammed earth floors would be installed. This can however be considered to some extent a false economy in that it would virtually force the owner to carry out improvements at a later date when, due to inflation they would inevitably be more expensive. This is particularly critical bearing in mind that the price of building materials is rising more rapidly than the income of poorer people except perhaps for the income from letting which increases more rapidly due to the inflation of rent levels.

contractor vs self-help

With reference to the proportion of contractor built to self-help work, it is obvious that the contractor built element should be kept to a minimum for two reasons. Firstly the general rule of thumb is that a contractor's price is made up of the material costs plus 100% for labour, overheads and profit, whereas if direct labour is used (with the occupant acting in effect as his own contractor) the price will be only material costs plus 30 - 40% for labour. Secondly, an increased self-help component means that even if direct (hired) labour is used it does not add to the burden of loan repayment but can be paid for as and when the owner can afford it. Also of course at least some of the work can be done by the owner himself or by family and friends on voluntary basis.

In this project, it is proposed that only the shell of the core (i.e. all but secondary elements such as some doors, windows and some of the finishes) should be contractor built (The precise extent of contractor built work is shown in fig 12, appendix one). It is most important that this part be well built in that it contains the water tank and multrum chamber and also provides the main structural element of the house. It will also provide an enclosed shelter in which to store building materials. This does not mean that, in the right circumstances, this element could not be built by direct labour thus affecting considerable savings.

costs

To illustrate the above the following costs are given, based upon the specification for the fully developed (4 room) prototype:-

Total cost if contractor built	KShs.29,600/-
Total cost if partially contractor built and completed by hired labour	KShs.24,400/-
(contractor built core - KShs.11,400/-)	
(materials for remaider - KShs. 9,500/-)	
(labour for remainder - KShs. 3,500/-)	
Total cost if partially contractor built and completed entirely by self-help	KShs.20,900/-

SECTION SIX - AFFORDABILITY

Affordability, that is to say the ability of the occupant to pay for his dwelling, has proven the most intractable problem in housing provision for low income families. The question of cost is dealt with in the previous section, the other components of affordability namely the method of financing and income are covered below.

financing

It is planned that the financing of the house would fall within the same financial framework as a site and service scheme. The arrangement is similar to a tenant purchase agreement the loan being based upon an interest rate of 6.5% repayable over 20 years with a minimum deposit of KShs.700/- . The total repayment rate is 13% per annum which includes loan servicing, maintenance, insurance,

ref: 1

land rent, administration, bad debts and rates. It is proposed however that the 2% maintenance element could be omitted in this case in that it applies to maintenance costs of the infrastructure which, in the case of an autonomous house, would be insignificant provided that the road standards are modest.

land

Land is made available by the government for site and service schemes at a land rent of 3% of the value of the land (for the first 10 years, 5% thereafter) which in turn is currently assessed at KShs.2,000/- per plot. This amounts to approximately 0.3% of the cost of the house and is included as 'land rent' in the overall repayment rate of 13% given above.

monthly payments

ref: 4

Assuming that, as recommended, the core only is contractor built and the house is completed by self-help the total cost would be KShs.20,900/- . Subtracting the KShs.700/- deposit a loan of KShs.20,200 would have to be obtained which at a repayment rate of 11% per annum would require a monthly repayment of 185/- . Assuming that as set down in the site and service guidelines, an occupant can afford to pay 20% of his earnings on housing, this would require an income of KShs.925/- a month which puts him clearly outside the target population (KShs.300/- to 800/-) except in the unlikely case that he has considerable savings.

phasing and letting

Two possibilities present themselves for bringing the house within the economic reach of the target population. The first is by phasing the development to reduce the initial costs and consequentially the size of the loan, the second is by the owner subsidising his income through partial letting. As these two factors interact upon one another they can be taken together.

affordability

The table in figure 11 shows the relationship between the cost (in terms of capital and loan repayment) for each of three phases: the core only, the two roomed house and the four roomed house. These are related to the income required by the owner first without letting and then assuming that in phase 2 one room would be let and in phase 3 that two rooms would be let. This relationship is then shown for a range of rental rates per room.

core only

Thus it can be seen that for the core alone, which provides no accommodation for the owner nor capacity for letting, a monthly income of KShs.500/- is required which excludes a considerable proportion, of the target population. Therefore the core house as such provides no solution to the housing problem for the lowest income groups.

phase 2

If phase 2 is built with the owner occupying one room and letting the other, the owners ability to pay is increased considerably in that he can put all of the rent income towards loan repayment (as opposed to 20% of his earned income). Thus once a rent per room of KShs.50/- is charged the house becomes affordable to that same upper part of the target population (i.e. those earning over KShs.500/-), whereas a rental rate of KShs.90/- per month would be required to make the house affordable to the entire target population. This amount of rent is probably unobtainable in the kind of area for which the prototype is intended. Also it would create an unreasonable situation whereby while the tenant was paying KShs.90/- the owner

ref: 13 would be paying only KShs.60/-.

FIGURE 11

cost and affordability table

BUILDING ELEMENT	CORE ONLY (Phase I)	2 ROOM HOUSE (Phase 2)	4 ROOM HOUSE (Phase 3)
BUILDING METHOD	CONTRACTOR BUILT	CONTRACTOR + SELF-HELP	CONTRACTOR + SELF-HELP
COST	11,400	17,100	20,900
DEPOSIT	700	700	700
LOAN	10,700	16,400	20,200
REPAYMENTS*	100	150	185
RENT/ROOM	EARNED INCOME REQUIRED TO AFFORD REPAYMENTS		
0 (NO LETTING	500	750	925
10		700	825
20		650	725
30		600	625
40		550	525
50	TARGET POPULATION	500	425
60		450	325
70		400	225
80		350	125
90		300	-
100		250	-
110		200	-

N.B. All figures are in KShs.

* Repayments are rounded monthly payments.

A precise description of each phase can be found in appendix one.

phase 3

If phase 3 is built with the owner occupying 2 rooms and letting 2 rooms his ability to pay is even greater and his living conditions are considerably enhanced. In this situation a rent per room of KShs.40/- brings the house within the upper part of the target population and a rental of only KShs.60/- per room makes the house affordable to the whole group. Although the obtainable rent depends very much upon location, employment opportunities, wage levels and housing shortage, surveys show that rent levels of up to KShs.60/- may not be unrealistic in provincial towns or in the peripherial areas of larger municipalities.

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savings

One factor that could throw affordability calculations into disarray is that of savings. However within the income levels of the target population, savings are unlikely to be substantial. Furthermore, whatever savings are available will almost certainly not be applied towards paying a larger depost than is necessary (KShs.700/-) and therefore will not affect the size of the loan repayments It is far more likely that savings will instead be spent on the general expenses involved in establishing a new dwelling and paying the wages of fundis who will be hired to assist in completing the self-help portion of the house.

summary

Although the income from letting would vary according to location and preference, it is clear that the more accommodation built the more affordable the house becomes and the better the accommodation provided for the owner. This general trend arises primarily because the full income from letting can be applied to repayment and also because the non-income producing core is the most expensive item to build (60% of the total) whereas the addition of rooms is relatively cheap(10% of the total or approximately KShs.2,100/- per room).

conclusion

It is therefore proposed that the entire house be built at one time rather than in phases.The 15 month period of grace allowed for in the N.H.C. site and service guidelines would be sufficient for completion of the house before loan repayments begin. However it would mean that the maximum loan under the guidelines of KShs.14,000/- which at the moment effectively precludes the building of sufficient accommodation to allow letting, would have to be increased KShs.20,200/- to cover the full cost of the 4 roomed house.

APPENDIX ONE - Cost Analysis

FIGURE 12

core shell cost analysis

AUTONOMOUS HOUSING PROTOTYPE P H A S E 1 CORE SHELL (Contractor built) C O S T B R E A K D O W N	Rainwater storage	Multrum chamber	Kitchen, toilet	TOTAL
EXCAVATOR				
Remove top soil	20.--	9.50	52.40	81.90
Trenches for foundations	41.--		62.80	103.80
Pit for Multrum chamber		63.90		63.90
Hardcore under floors	48.--		77.--	125.--
Shallow trenches in hardcore			11.20	11.20
EXCAVATOR TOTAL CARRIED TO SUMMARY K.Shs.	109.--	73.40	203.40	385.80
CONCRETOR				
Foundation strips	170.--		583.50	753.50
Concrete floors	75.--		475.--	550.--
Trowel smooth to floors			34.--	34.--
Base plate to Multrum chamber		70.--		70.--
Reinforced cover slabs to ditto		167.20		167.20
Kitchen work bench			181.60	181.60
Reinforced concrete lintols			200.--	200.--
CONCRETOR TOTAL CARRIED TO SUMMARY K.Shs.	245.--	237.20	1,474.10	1,956.30
MASON				
Concrete blockwork from foundation to DPC	327.60		306.90	634.50
Ditto , from DPC to roof	1,246.--		1,138.50	2,385.50
Ditto , to Multrum chamber		322.50		322.50
Ditto , to partitions and dwarf walls			318.50	318.50
MASON TOTAL CARRIED TO SUMMARY K.Shs.	1,573.60	322.50	1,764.90	3,661.--
CARPENTER				
Rafters , 4" diam.			75.--	75.--
Purlins , 3" diam.			120.--	120.--
CARPENTER TOTAL CARRIED TO SUMMARY K.Shs.	--	--	195.--	195.--
METALWORKER				
Galv. iron straps to rafters and purlins			78.--	78.--
Nails to above			6.--	6.--
Corr. galv. iron cover to r.w. tank	187.50			187.50
Mosquito-wired vent to wall Multrum		12.30		12.30
Extract hood and flue to kitchen			400.--	400.--
Burglar bars			91.20	91.20
METALWORKER TOTAL CARRIED TO SUMMARY K.Shs.	187.50	12.30	575.20	775.--
PLASTERER				
Cement-sand bagwash to external walls			148.50	148.50
Cement-sand plaster to int. walls toilet, bath			283.20	283.20
Cement-sand screed to floors toilet, bath			78.80	78.80
Cement-sand plaster to int. walls tank	164.30			164.30
Cement-sand plaster to floor tank	62.40			62.40
Cement-sand plaster and screed to splash area	34.60			34.60
PLASTERER TOTAL CARRIED TO SUMMARY K.Shs.	261.30	--	510.50	771.80
ROOFER				
28 s.w.g. corr. galv. iron sheeting			884.--	884.--
12" diam. half round galv. iron gutter	105.--			105.--
End closers to gutter	10.--			10.--
Down pipe to gutter with wire screen	15.--			15.--
ROOFER TOTAL CARRIED TO SUMMARY K.Shs.	130.--	--	884.--	1,014.--
PAINTER				
DPC	14.--		16.--	30.--
Bitumen emulsion to tank	282.--			282.--
Lime wash to external walls			150.--	150.--
Gloss paint to int. walls toilet, bath			163.20	163.20
PAINTER TOTAL CARRIED TO SUMMARY K.Shs.	296.--	--	329.20	625.20

FIGURE 12
continued

	Rainwater storage	Multrum chamber	Kitchen, toilet	TOTAL
PLUMBER AND SANITARY ENGINEER				
Fittings to water storage tank	142.50			142.50
Kitchen sink, complete			350.--	350.--
Sink waste to splash area	60.--			60.--
Ditto to bathroom			60.--	60.--
1½" galv. iron waste pipes to soak-away pits	250.--		500.--	750.--
Elbow joints to above	5.--		10.--	15.--
Soak-away pits , excavation			62.80	62.80
stone fill			94.20	94.20
paving over			50.--	50.--
Vent pipe to Multrum chamber		135.--		135.--
Manhole cover to ditto		200.--		200.--
Plastic air-guidance pipes to ditto		120.--		120.--
PLUMBER AND SAN. ENG. TOTAL TO SUMMARY K.Shs.	457.50	455.--	1,127.--	2,039.50
S U M M A R Y				
EXCAVATOR	109.--	73.40	203.40	385.80
CONCRETOR	245.--	237.20	1,474.10	1,956.30
MASON	1,573.60	322.50	1,764.90	3,661.--
CARPENTER	--	--	195.--	195.--
METALWORKER	187.50	12.30	575.20	775.--
PLASTERER	261.30	--	510.50	771.80
ROOFER	130.--	--	884.--	1,014.--
PAINTER	296.--	--	329.20	658.80
PLUMBER AND SANITARY ENGINEER	457.50	455.--	1,127.--	2,039.50
G R A N D T O T A L - P H A S E 1 K.Shs.	3,259.90	1,100.40	7,063.30	11,423.60
Percentage of total cost	28 % R.w.stor.	10 % Multrum	62 % Kitchen	100 % Total

FIGURE 13
phases 2 and 3
cost analysis

AUTONOMOUS HOUSING PROTOTYPE P H A S E S 2 & 3 COMPLETION (Self-help) C O S T B R E A K D O W N (materials only)	PHASE 2		PHASE 3	TOTAL
	Core completion	Living room Bedroom	Separate rooms	
EXCAVATOR				
Remove top soil		--	--	--
Pits for poles		--	--	--
Hardcore under floors		167.--	115.--	282.--
Shallow trenches in hard core		--	--	--
EXCAVATOR TOTAL CARRIED TO SUMMARY K.Shs.	--	167.--	115.--	282.--
CONCRETOR				
Pits for poles		85.50	81.--	166.50
Concrete floors incl. ribs		465.--	495.--	960.--
Trowel smooth to floors		--	--	--
CONCRETOR TOTAL CARRIED TO SUMMARY K.Shs.	--	550.50	576.--	1,126.50
CARPENTER AND JOINER				
Cedar poles 5" diam.		37.50	45.--	82.50
Ditto, 4" diam.		190.--	162.--	352.--
Rafters 4" diam.		62.--	50.--	112.--
Purlins 3" diam.		100.--	105.--	205.--
Doors	495.--	390.--	260.--	1,145.--
Window frames	40.--	110.--	50.--	200.--
Naco louvres	120.--	360.--	160.--	640.--
Timber panels over windows		178.--	71.--	249.--
Kitchen shelving	60.--			
CARPENTER AND JOINER TOTAL TO SUMMARY K.Shs.	715.--	1,427.50	903.--	3,045.50

FIGURE 13

continued

METALWORKER				
Galv. iron straps to poles, rafters, purlins		51.60	44.70	96.30
Nails to above		7.--	5.--	12.--
Angle shelf supports	105.--			105.--
Burglar bars to windows		122.50	57.60	180.10
METALWORKER TOTAL CARRIED TO SUMMARY K.Shs.	105.--	181.10	107.30	393.40
MUD AND WATTLE WALLS				
Vertical fitto's , 1½" - 2" diam.		42.--	38.--	80.--
Horizontal fitto's , 1" diam.		306.--	238.--	544.--
Mud filling		--	--	--
MUD AND WATTLE TOTAL TO SUMMARY K.Shs.	--	348.--	276.--	624.--
PLASTERER				
Cem. sand plaster to int. walls kitchen	95.--			95.--
Mud with bitumen emulsion to m.& w. walls		262.--	233.--	495.--
PLASTERER TOTAL CARRIED TO SUMMARY K.Shs.	95.--	262.--	233.--	590.--
ROOFER				
28 s.w.g. corr. galv. iron roof sheeting		1,014.--	758.--	1.772.--
Galv. roofing nails		15.--	10.--	25.--
ROOFER TOTAL CARRIED TO SUMMARY K.Shs.	--	1,029.--	768.--	1.797.--
PAINTER AND GLAZIER				
Bitumen emulsion to pole ends		12.90	13.60	26.50
Bitumen emulsion to plinth and skirting		37.60	29.80	67.40
Lime wash to external walls		81.--	62.50	143.50
Ditto to internal walls		160.50	105.50	266.--
PVA emulsion to int. walls kitchen	76.--			76.--
Painting to joinery	70.--	65.--	35.--	170.--
Oiling to panels over windows		14.--	6.--	20.--
Glazing to louvre windows	84.--	244.80	117.--	445.80
PAINTER AND GLAZIER TOTAL TO SUMMARY K.Shs.	230.--	615.80	369.40	1,215.20
FENCING				
Bamboo fencing to rear yard K.Shs.	--	--	380.--	380.--
S U M M A R Y				
EXCAVATOR	--	167.--	115.--	282.--
CONCRETOR	--	550.50	576.--	1,126.50
CARPENTER AND JOINER	715.--	1,427.50	903.--	3,045.50
METALWORKER	105.--	181.10	107.30	393.40
MUD AND WATTLE WALLS	--	348.--	276.--	624.--
PLASTERER	95.--	262.--	233.--	590.--
ROOFER	--	1,029.--	768.--	1,797.--
PAINTER AND GLAZIER	230.--	615.80	369.40	1,215.20
FENCING	--	--	380.--	380.--
GRAND TOTAL - PHASES 2 and 3 K.Shs.	1,145.--	4,580.90	3,727.70	9,453.60

FIGURE 14

cost summary

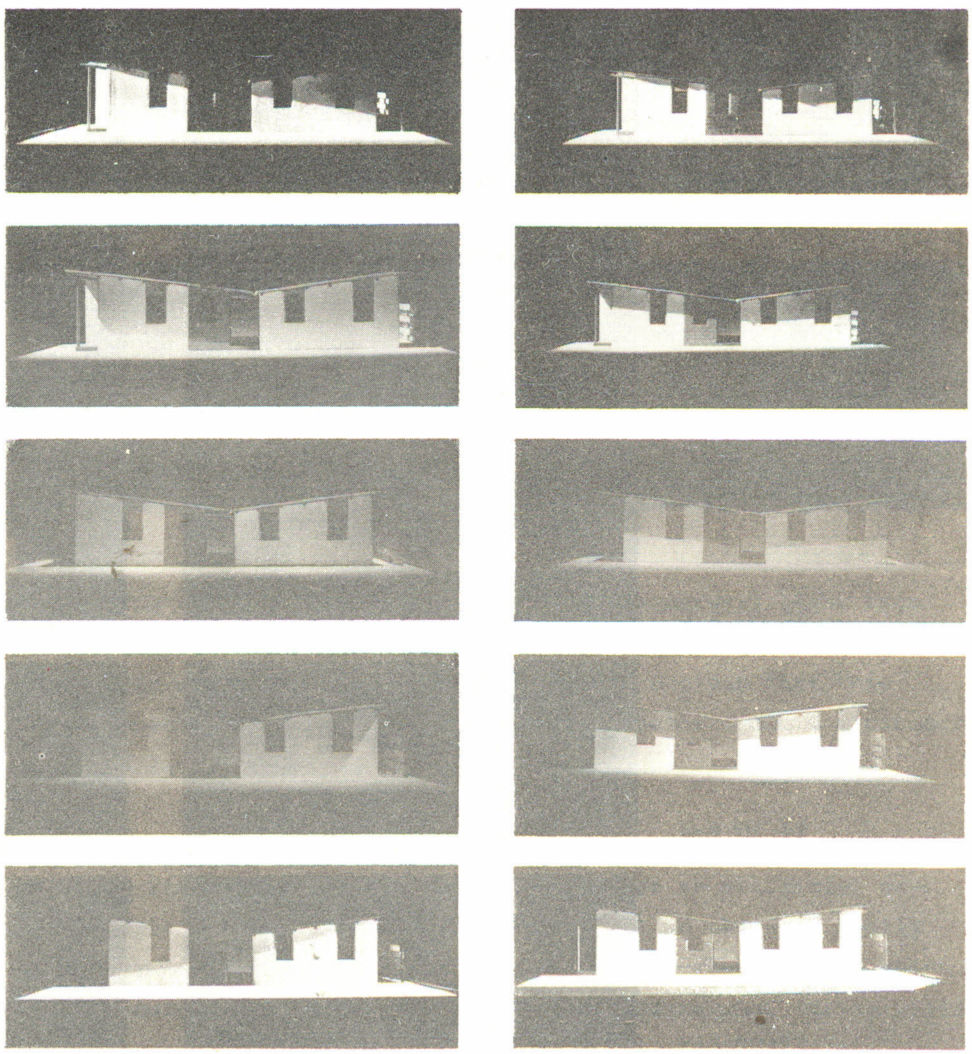
Core shell (Contractor built)	= KShs.11,423/-
Core (completed by self-help)	= KShs.12,568/-
2 room house (completed by self-help)	= KShs.17,148/-
4 room house (completed by self-help)	= KShs.20,875/-

A model of the prototype was examined in the Faculty of Architecture, Design and Development architectural science laboratories to ascertain the effect of the roof shape on insolation to walls and windows and also the quality of natural lighting within the rooms.

The critical feature as far as insolation is concerned is the amount of protection, particularly to windows, afforded by the roof overhang. Two elevations were studied, the north and the east (there being no windows in the west elevation and the single main window in the south elevation being similar to those in the north).

AUGUST/APRIL - 500 mm OVERHANG   JULY/MAY - 500 mm OVERHANG

FIGURE 15
north elevation
april may july august



7.00 hrs.

9.30 hrs.

12.00 hrs.

14.30 hrs.

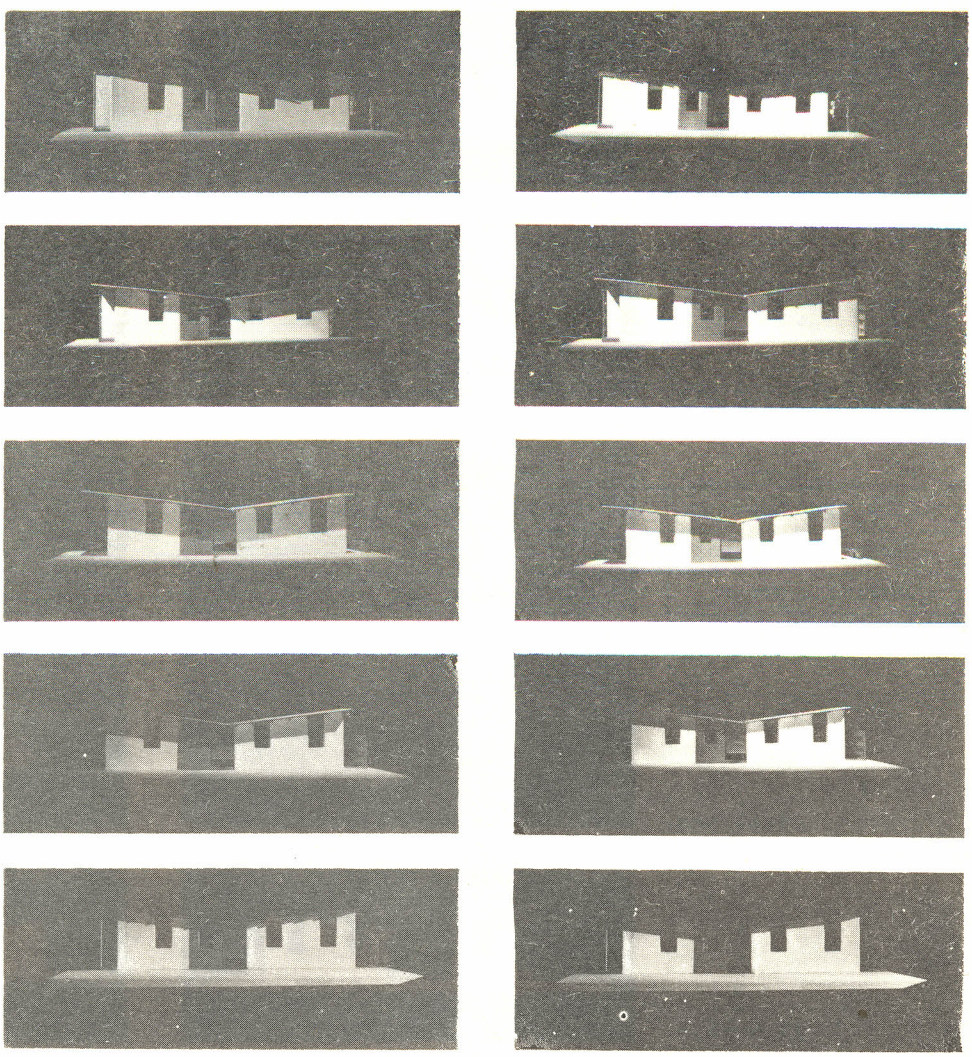
17.00 hrs.

The north elevation was studied for the months when the sun is in the northern hemisphere (April through August) and for five times of the day (7.00, 9.30, 12.00, 14.30 and 17.00 hrs.). Initially a roof overhang of 500 mm was tried and found to be adequate throughout the day for the months of April, May, July and August (see fig. 15).

In the critical month of June the morning and evening conditions were considered to be satisfactory due to the oblique angle of the sun. However, through the middle of the day less than 50% of the window area was shaded. The same tests were made for June) with a roof overhang of 750 mm and it was found that the situation was much improved in fact very similar to the July/May situation with a roof overhang (see fig.16).

FIGURE 16
north elevation
june

JUNE - 500 mm OVERHANG | JUNE - 750 mm OVERHANG



7.00 hrs.

9.30 hrs.

12.00 hrs.

14.30 hrs.

17.00 hrs.

Considering, however, that with a 500 mm roof overhang, the critical period for insolation is only a few hours per day for one month of the year (that month being during the cool season), the additional cost (about KShs.200/-) of increasing the overhang to 750 mm was considered unjustified.

The east elevation was studied for the morning hours of 7.00 and 9.30 hrs. (the time of year being inconsequential). Firstly a 500 mm roof overhang was tested and it was found that by 9.30 the living room window, which is shaded by the porch, was already in shade. The bedroom window, however, was still completely exposed to the sun. Next the roof overhang was increased to 1.000 m but this still did not give proper shading to the bedroom window (see fig.17).

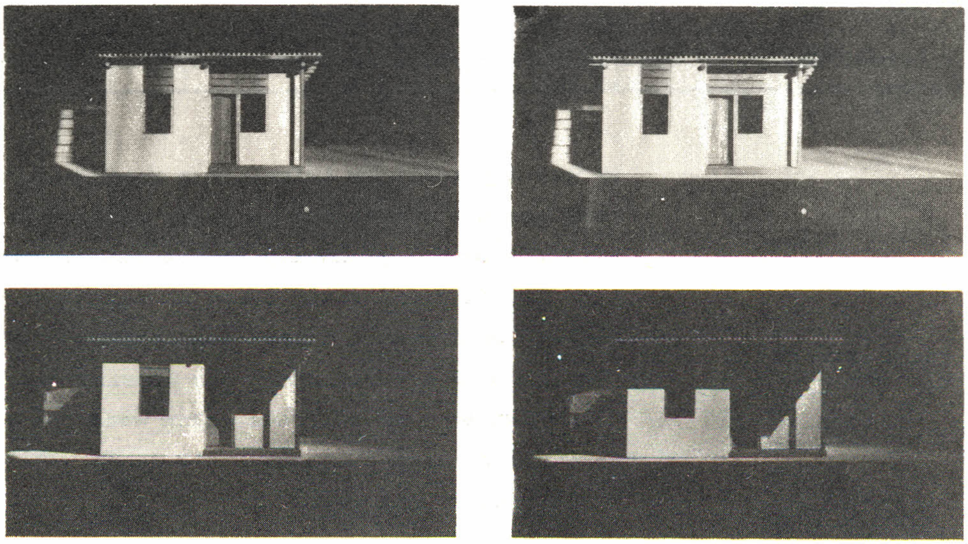
500 mm - OVERHANG 1.000 mm - OVERHANG

FIGURE 17

east elevation
7.00 and 9.30 hrs

7.00 hrs.

9.30 hrs.



Considering that the bedroom obtains adequate natural light from a window on the south elevation and that effective shading of the east facing window would be difficult it was decided that this window could be omitted in areas (genrally, below 1,800 m altitude) where insolation problems are serious.

In order to assess the quality of natural light in the habitable rooms and kitchen the model was examined under an artificial sky. The sky factor was measured at work-top level in the most poorly lit corner of each room. The minimum sky factor found was 4% which, even allowing for preferential testing circumstances, (white walls, no furniture, curtains etc) is considered more than adequate.

APPENDIX THREE - Rainwater Collection and Use

Initially a study was made of the usefulness of collecting rainwater from the roof of the prototype assuming a location in the highly populated Central Province which falls into the highland climatic zone. The area of the roof of the completed house is 90 m^2 which gives 90 l of water for each 1 mm of rainfall. From the average monthly rainfall figures and an assumed maximum occupancy of 10 persons (say 6 adults and 4 children) the relationship between rainfall and the amount of water available per person per day can be derived (see fig.18).

FIGURE 18

rainfall and water collection

month	J	F	M	A	M	J	J	A	S	O	N	D	Ave
rainfall in mm	45	55	100	210	170	45	20	25	30	60	130	90	80
litres/P/day	13.5	16.5	30	63	51	15.5	6	7.5	9	18	39	29	24

It was difficult to establish a reasonable minimum consumption rate because statistics on areas without piped water are obviously affected by the proximity of the source and by family size etc. In a survey of rural communities in East Africa without piped water it was found that 61% used less than 10 l/person/day and 90% used less than 20 l/person/day. The Housing Research and Development Unit's own surveys of areas where water is bought from a kiosk show that approximately one debe (18 l) of water is used per adult family member per day.

Considering the above and also the need to keep the storage tank to a reasonable size, a minimum consumption rate during the dry season of 12 l/person/day was accepted. This means therefore that for Central Province there are three months (July, August, and September) when there is a short fall amounting to 4,050 l. Thus taking into account a loss of approximately 10% due to evaporation from the roof, a tank of 4,500 l capacity is provided so that at least 12 l will be available during the dry season and an average of 24 l/person/day will be available year round.

Applying the same methodology on a broader scale to the other climatic zones of Kenya it can be seen that an adequate water supply could be provided from roof collection in the Highland, Upper Highland, Lake and Coast zones which between them accommodate the vast majority of population. In the highest rainfall areas, economies can be made by reducing the tank size. For example in Kericho a tank of 2,250 l would be sufficient to ensure a minimum daily allowance of 20 l/person with a year round average of 36 l/ person/day.

For the remaining two zones, Savanah and Semi-Desert, the amount of water collectable can be said to be inadequate but nevertheless worth while. In the Savanah zone, although the rainfall averaged over the year would theoretically give 17 l/person/day, during the dry season (June through September) an amount of only 4 l/person would be available. In reality this would mean that the collected rainwater would be exhausted early in the dry period leaving no water for several months. In the semi-desert zone the picture is even more bleak, the average over the year being 7 l/person/day but the reality being that for at least half the year there would be no water available from rainwater collection.

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MATHARE VALLEY, A CASE STUDY OF UNCONTROLLED SETTLEMENT IN NAIROBI 50/-

David Etherton, September 1971, 96 pages.

A survey of the largest area of uncontrolled urban settlement in the outskirts of Nairobi.
The report describes two surveys, one conducted in June 1969 and one in July 1970.
The data collected covers the economic, physical, social and organisatoric aspects, which are described and illustrated in detail.
The summary and recommendations have formed the basis for the Nairobi City Council's improvement plans, implemented in the area.

SITE AND SERVICE SCHEMES, ANALYSIS AND REPORT 109/-

P. Houlberg, N.O. Jorgensen, R. Steele, May 1971, 109 pages

This analysis of 12 existing and planned site and service schemes in Kenya was carried out on request by the National Housing Corporation in order to develop recommendations for the planning and operation of the large number of new schemes programmed for the Development Period 1970-74.

ROOFS FOR LOW-COST STRUCTURES 40/-

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This publication combines a number of studies on technical and economical aspects of roofs for low-cost structures and comprises:

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b. Roof structures for low-cost housing (April 75)

Contains cost comparisons for a range of roof structures (support plus covering) for different locally manufactured covering materials.

c. Cost of metal roof sheeting for low-cost structures (Nov. 74)

Contains technical data and cost comparision for metal roofing materials manufactured in Kenya.

d. Roofing tiles for low-cost structures (Nov. 75)

Contains technical data and cost comparison for the range of roofing tiles manufactured in Kenya.

AN AUTONOMOUS HOUSING PROTOTYPE FOR LOW-INCOME FAMILIES 30/-

P.J. Mein, May 1977.

The report describes a prototypical housing unit developed at the request of the United Nations Habitat and Human Settlements Foundation. The prototype is designed to meet the housing needs of the lower income groups and is based upon the following principles:-

Autonomy - The prototype is intended to be independent of mains services (water supply and sewerage).

Conservation - Water is to be conserved by the collection of rainwater from the roof and by the installation of a 'dry' composting toilet.

Economic - The constructional design is such that inexpensive, indigenous materials and self-help methods can be used extensively.

Finance - The prototype is planned to provide partial letting by the owner which will in effect subsidize his means for loan repayment.

INSTITUTIONAL CONSTRAINTS IN THE DEVELOPMENT OF INFORMAL HOUSING AREAS 15/-

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