

**CONSTRAINTS TO THE DISSEMINATION AND  
UTILIZATION OF FIBRE CONCRETE ROOFING TILE  
AND STABILIZED SOIL BLOCK TECHNOLOGIES IN KENYA**

BY

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**DECLARATION**

This Thesis is my original work and has not been presented for a degree in any other University.

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## ABSTRACT

The shortage of decent housing is a problem that many Kenyans, especially the low income households in both the rural and urban areas, are confronted with. The research in and development of appropriate building materials that are cheaper than conventional building materials is one of the ways in which governments have tried to provide more housing at prices that are affordable to the majority of those who need these houses.

So far the development of appropriate building materials like fibre concrete roofing tiles and stabilized soil blocks that are relatively cheaper than concrete blocks, concrete tiles, burnt clay bricks and tiles, among others has been successfully carried out. This research and development has been carried out by local institutions and organisations in conjunction with international donor and research agencies.

Despite these successes in the research and development of appropriate building materials, the dissemination of these materials to the general public and those who need better housing at reasonable costs has not been successful. Appropriate building materials are not being produced and utilized on a scale comparable to that of the relatively more expensive conventional building materials.

This study is aimed at finding out the constraints to the widespread dissemination, production and use of stabilized soil blocks and fibre concrete roofing tiles in Kenya and how such obstacles can be overcome. In order to identify these constraints the researcher interviewed officials of various organisations and individuals who are directly or indirectly concerned with the popularisation, production and use of FCR tiles and stabilised soil blocks.

This was done through the use of questionnaires and face to face discussions. Those interviewed include the following

- i) Organisations or institutions involved in the promotion and popularisation of FCR tiles and stabilised soil blocks. This was carried out in order to identify what constraints hinder the effective dissemination of FCR tile and stabilised soil block technologies.
- ii) Developers of housing or sponsors of community facilities like schools and churches which have been built using FCR tiles and stabilised soil blocks.
- iii) Small scale producers of FCR tiles and stabilised soil blocks and small scale producers of concrete blocks and concrete tiles.
- iv) A few architects and "fundis" or builders were interviewed by the researcher in order to shed more light on specific problems which may occur during the construction of a building when using FCR tiles and/or stabilised soil blocks.
- v) The Chief Architect in the Ministry of Public Works and Housing and the Principal Standards Officer in the Kenya Bureau of Standards were interviewed in order to find out the official government position with respect to the use of FCR tiles and stabilised soil blocks and the preparation of standards and specifications for the same.
- vi) Occupants of housing which has been constructed using FCR tiles and/or stabilised soil blocks in Nyahururu, Riruta and Komarock in Nairobi. This user reaction survey aimed at assessing how acceptable FCR tiles and stabilised soil blocks were to the users and potential users.

In addition to these interviews, the researcher visited and surveyed 7 different building projects where FCR tiles and stabilised soil blocks have been used. This aimed at recording

the physical condition of the FCR tile roofs and stabilised soil block walls since this is a good indicator of how durable the building materials are.

The constraints to the dissemination and use of FCR tiles and stabilised soil blocks that were identified by this study include the following;

- a) Lack of adequate funds for the organisations promoting the use of FCR tiles and stabilised soil blocks to effectively do so and the fact that so many organisations are involved in promoting the use of these two building materials without proper co-ordination of these efforts.
- b) Lack of widespread demand and ready markets for the finished FCR tiles and stabilised soil blocks; hence small scale producers of these two building materials have little hope for growth and expansion. This problem is compounded by the fact that small scale producers of FCR tiles and stabilised soil blocks have limited access to credit facilities from financial institutions.
- c) Lack of adequate skills on the part of artisans who are involved in the construction of buildings using FCR tiles and stabilised soil blocks. Their ignorance of the basic differences between FCR tiles and stabilised soil blocks on the one hand and the conventional concrete blocks and concrete tiles often leads to failures of buildings which are blamed on the materials rather than the faulty workmanship.
- d) Lack of widespread awareness by the general public of the properties and advantages of FCR tiles and stabilised soil blocks when compared to conventional building materials. Total acceptability of FCR tiles and stabilised soil blocks by many Kenyans

has yet to be achieved because of personal tastes and preferences which are in favour of conventional building materials.

- e) For potential users, questions about the durability of these two materials still linger especially since some of the demonstration projects where these building materials have been used have not helped sensitise the general public to fully accept FCR tiles and stabilised soil blocks.

The study is divided into five chapters. The first chapter contains the problem statement, objectives of the study, hypothesis, scope and limitations of study and the methodology. The second chapter is devoted to a detailed description of fibre concrete roofing tile and stabilized soil block technologies and their advantages and disadvantages when compared to conventional building materials. This chapter also contains a review of related literature on what problems are faced in the promotion of appropriate building materials in countries like Kenya and how such problems could be overcome to promote widespread use of newly developed appropriate building materials given their advantages over conventional building materials.

The third chapter focuses mainly on the historical development and spread of stabilized soil block and fibre concrete roofing tile technologies in Kenya. This chapter also contains a detailed account of the main organisations and institutions that are involved in the research, development and dissemination of stabilized soil block and fibre concrete roofing tile technologies.

The fourth chapter contains the findings of the study. This can basically be referred to as the constraints to the dissemination and utilization of stabilized soil blocks and fibre

concrete roofing tiles in Kenya. These constraints that were identified can be put into the following groups;

- i) Problems encountered by the organisations that promote the use of stabilised soil blocks and FCR tiles.
- ii) Factors that hinder the widespread commercial production of FCR tiles and stabilised soil blocks.
- iii) Difficulties that are encountered when constructing buildings using FCR tiles and/or stabilised soil blocks.
- iv) Problems that are inherent in these building materials themselves, ie, doubts about their durability.
- v) Lack of social acceptability, ie, FCR tiles and stabilised soil blocks are still not popular building materials.

The fifth and final chapter contains the conclusions and recommendations of the study.

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## LIST OF ABBREVIATIONS

AAK	Action Aid Kenya
AHF	African Housing Fund
ARSO	African Regional Organisation for Standardisation
BRE	Building Research Establishment
CIDA	Canadian International Development Agency
CSC	Commonwealth Science Council
DANIDA	Danish Agency for International Development
EEC	European Economic Community
FAO	Food and Agricultural Organisations
FCR tile	Fibre Concrete Roofing tile
GATE	German Appropriate Technology Exchange
gci	Galvanised corrugated iron sheets
GDP	Gross Domestic Product
GTZ	German Agency for Technical Co-operation
HRDU	Housing Research and Development Unit
ILO	International Labour Organisations
IDRC	International Development and Research Centre
IRT	Improved Rural Technology
ITIG	Intermediate Technology Development Group
ITW	Intermediate Technology Workshops
KBS	Kenya Bureau of Standards



KENGO	Kenya Energy Non-Governmental Organisation
KIE	Kenya Industrial Estates
KU	Kenyatta University
MP	Member of Parliament
NACHU	National Co-operative Housing Union
NCCK	National Council of Churches of Kenya
NHC	National Housing Corporation
ODA	Overseas Development Agency
R&D	Research and Development
R&T	Research and Training
RHP	Rural Housing Programme
SCAMS	Schools Construction and Maintenance Programmes
SEFCO	Small Enterprise Finance Company
SIDA	Swedish International Development Agency
SSB	Stabilised soil block
U.o.N	University of Nairobi
U.S.A.I.D	United States Agency for International Development
UN	United Nations
UNCHS	United Nations Centre for Human Settlements (Habitat)
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNICEF	United Nations Children's Educational Fund

- UNIDO United Nations Industrial Development Organisation
- VIP Ventilated Improved Pit
- WECO Western College of Arts and Applied Sciences

## CHAPTER ONE

### 1.1.0 INTRODUCTION

The building material and construction industry constitutes one of the most important sectors of the economy.

"The building materials and construction industries are the basic means for the implementation, expansion, improvement and maintenance of all civil engineering and human settlement projects".<sup>1</sup>

The construction industry is an essential contributor to the national development process. The output from construction forms about half of the gross fixed capital formation.

In African countries the construction sector accounts for between 3% and 8% of the Gross Domestic Product. Between 1965 and 1977, the construction sector accounted for 4%-6% of the GDP in Kenya.<sup>2</sup>

Between 1985 and 1988, the construction sector accounted for an average of 3.3% of the GDP.<sup>3</sup>

Table 1.1: The contribution of the Building and Construction Sector to the Gross Fixed Capital Formation in K£ Million.

YEARS	Building and Construction Sector	GFCF Total in K£ Millions
1984	119.42	593.56
1985	121.54	597.16
1986	128.71	668.08
1987	118.63	707.95
1988	140.02	769.29
1989	138.77	781.34

SOURCE : Statistical Abstract,  
Central Bureau of Statistics, 1990, Pg 45.

Apart from its substantial contribution to GDP and gross fixed capital formation (see Table 1.1) the construction sector provides jobs for a substantial portion of the population of Kenya. According to the Economic Survey 1990,<sup>4</sup> employment in the construction industry rose by 7.7%; from 62,600 people in 1988 to 67,400 people in 1989.

The building materials industry in African countries has several characteristics that are undesirable. These range from the high import content of the products; under-utilisation of installed capacities in many of the factories and requirement of

specialized skills in order to produce these materials. Yet these same countries are characterised by a shortage of capital, abundance of unskilled labour and lack of skilled and competent managerial manpower. This situation often leads to shortage of building materials. Some of these factories are expensive to maintain because they require imported spare parts.

The supply of some building materials is limited by these constraints mentioned above. In most cases, these materials are so expensive that there is no effective demand for them, although the need for them still exists. Building materials costs are the most expensive components of the total cost of construction. Where such materials are expensive the effective demand for them is limited to the few people who can afford.

The construction industry in developing countries is characterised by scarcity, frequent non-availability and prohibitive costs of imported building materials and the tendency of indigenous productions to be inadequate in capacity and often of low quality.

In order to help reduce the effect of these constraints, it will be necessary to set up a truly indigenous building materials production which will overcome these constraints, and in addition provide benefits of improved skills and income generation and stimulates other sectors. <sup>6</sup>

Labour, particularly unskilled labour, is in abundant supply in most developing nations. Labour costs do not constitute the largest component of the total construction costs. Therefore if total costs are to be significantly lowered the costs of the most expensive input (building materials) has to be reduced.

Building materials costs account for 76% and 86% of the total cost of non-residential and residential buildings respectively. <sup>7</sup>

Labour, technology and other overheads contribute the rest of the costs in construction.

The need to make more effort in the development of cheaper building materials is now more urgent than ever. This is so because, to the majority of Kenyans, both in the urban and rural areas who are not decently housed, the cost of building or buying a house is the single most important barrier to their satisfying this need.

Only 30% of urban households have sufficient income to afford minimum cost conventional housing. <sup>8</sup>

Developing cheaper building materials ensures that emphasis is placed on the component of construction which will have the greatest impact on the construction costs. Appropriate building materials have a greater likelihood of achieving lower construction costs than conventional materials. Appropriate building materials can be produced by small scale labour-intensive production. This kind of production is suitable for a country like Kenya with abundant unskilled labour, and the prevalence of low incomes among the population. This is in sharp contrast to the kind of capital-intensive technology required to produce most conventional building materials, ultimately making them unaffordable to the majority.

The basic resources that are vital for an indigenous building materials production sector include, raw materials (e.g. clay, soil, stone, fibre and limestone, labour, machinery and energy. Kenya is well endowed with most of these basic resources with the exception of sophisticated machinery. The potential for the production of a variety of innovative building materials exists. It has yet to be fully exploited.

Conventional building materials are those which satisfy the material specifications in the Building Code. They include the following:-

- a) Concrete: this can be mass concrete or reinforced concrete, concrete blocks, concrete tiles for roofing and floors.

- b) Stone: whether it is conventional or appropriate depends on the mode of production. If it is capital intensive and employs a lot of heavy machinery, it is conventional.
- c) Sawn or processed timber.
- d) Plastics.
- e) Burnt clay bricks can be both appropriate or conventional depending on the mode of production. Factory produced bricks are conventional building materials.
- f) Galvanized corrugated iron sheets (gci).

Appropriate building materials on the other hand are those that are based on local resources and take into account the prevailing climatic, economic and socio-cultural conditions.

Appropriate building materials include the following:-

Stabilized soil blocks, fibre concrete tiles, ferrocement or mortarmesh, natural stone, grasses or leaves (makuti) pozzolanas, sulphur concrete, sun dried or adobe blocks and rammed earth. Bricks produced at household or artisan level could be appropriate but brick production consumes a lot of energy during the firing.

On the whole, appropriate building materials are relatively cheap, readily available and easy to use when compared with conventional building materials. The production of appropriate building materials can be done at household or artisan level using improved local skills. This includes the stabilization and compaction of soil blocks using lime, asphalt cement, bitumen, ash, sand, or stone dust; or the use of fibre in the production of fibre concrete products e.g. roofing tiles; and the use of rice husk ash as a cement extender.

The relative ease of undertaking small-scale production of appropriate building materials implies that production on site is possible, transportation cost are greatly reduced. Ultimately the final product is cheaper than a conventionally produced alternative. The move towards a more intensive use of appropriate building materials and labour intensive techniques is at an early stage of development in Kenya. More efforts should be made to ensure widespread use of appropriate building technology so as to help solve the housing problems and provide vital buildings like schools and hospitals etc. This may be achieved by including some of the proven appropriate building materials in the building code and standardising them.

### **1.2.0. PROBLEM STATEMENT**

Despite the efforts already made in Kenya in the research and development of appropriate materials they are not being produced on a commercial scale comparable to that of the conventional materials.

The uptake and translation of concluded research findings and wide scale application of the already appropriate building materials made of locally available raw materials has been very slow.<sup>10</sup>

When compared to conventional materials for building construction, appropriate building materials have several advantages that have been realized where such materials have been used. These advantages are:-

- a) Maximum use of local resources and minimal use of imported inputs for production. Small deposits of natural resources such as limestone and clay can be used.
- b) Labour intensive production is possible.



- c) Appropriate materials are relatively low cost.
- d) Production of appropriate materials can easily be decentralized and done on small-scale basis.
- e) Appropriate technology allows for the exploitation of the full potential of the community. Community based organizations like women groups, schools, churches and other social groups are used in the pilot or demonstration projects so they can help replicate this technology.

The efforts made in Kenya in the research, development and dissemination of appropriate materials revolve around several institutions (public and private, international and local). These institutions have carried out research into the production of alternative materials and through pilot projects have been trying to disseminate appropriate building technology throughout the country. The demonstration projects aim at introducing appropriate materials into the community. The community is then expected to replicate the projects by continuing to produce these appropriate materials for use in similar projects or for sale to other people wishing to use these materials.

The dissemination of appropriate technology from promoters like Housing Research and Development Unit (HRDU) among others and the utilization of appropriate materials have faced several problems. The results of demonstration projects have not been replicated and very few housing projects within the local authority areas have employed the use of appropriate building materials. In the housing projects where some of these appropriate materials have been used, there have been conflicts among the various parties involved in the projects, resulting in

costly delays to the start of the scheme. The Kayole North Housing Project (Komarock) and the Nyahururu Tenant Purchase scheme are examples.

In the case of the Nyahururu project, there was the Nyahururu Urban Council on one hand trying to enforce the Grade I By-laws and Public Health Act requirements, and United States Agency for International Development (U.S.A.I.D.) insisting that FCR tiles and stabilized soil blocks were acceptable building materials.

In the case of the Kayole North Housing Project, because of delays in project approval the selling price of the houses rose from KShs. 200,000/= to KShs. 460,000/=. Yet the maximum price of these houses was originally meant to be Kshs.135,000/= for the biggest of the units available. <sup>11</sup>

Such conflicts and resultant delays in project commencement would have been avoided if the recommendations of the Kenya Low Cost Housing By-law Study had been implemented. The Kenya Low Cost Housing By-laws Study <sup>12</sup> was on the use of relaxed building standards that allow for the use of non-conventional building materials. The failure to implement these recommendations in full, as soon as the study was completed, is a major blow to the promotion of the use of appropriate building materials.

Standards and specifications are basic regulatory instruments for the promotion of acceptable products on the market; and in the context of building materials, they ensure economy, durability, safety and health in construction. Moreover standards and specifications can be used as instruments to promote import substitution and cost efficiency in construction; if standards for indigenous and low cost materials are formulated and incorporated in regulations.<sup>13</sup>

Apart from standards and building regulations, which are technical by nature, there are other constraints to the wide-scale utilization of appropriate building materials. Such

constraints, could be institutional, cultural, financial or simply the lack of trained personnel. Trained personnel are required to disseminate information on appropriate technology and train the potential users on correct production procedures and construction techniques.

Institutional constraints are policy related and this could include the capacity of implementing agencies that are responsible for approval of proposed building plans. This may be the main reason why most appropriate materials have officially remained unacceptable in most local authority areas in Kenya.

Cultural constraints on the other hand, may include the conservative nature of the building industry, hence its unwillingness to accept the use of appropriate materials. There is also the issue of the social-acceptability of appropriate materials among the potential users. Some of these appropriate materials may be looked upon as inferior because the public are not fully aware of the nature and properties of these materials. It is therefore important to find out the reasons for this negative attitude towards appropriate materials; ultimately what can be done to make such attitudes more positive.

The lack of access to conventional credit and financial services by potential producers and users of appropriate materials may be as a result of the fact that materials are still officially unacceptable. It is important to find out whether these are the only constraints to wide-scale production and use of appropriate materials or other reasons exist. Apart from the need to find out the extent of these constraints, it is necessary to find out how they can be removed so as to promote and popularise the use of appropriate technology.

### **1.3.0. OBJECTIVES OF THE STUDY**

- a) Identify what appropriate building materials and construction technologies exist in Kenya.
- b) Identify the constraints that are faced in the dissemination and utilization of appropriate building materials and construction technologies so identified.
- c) Suggest ways in which these constraints can be removed, if possible, in order to encourage the use of appropriate building materials for the great majority of Kenyans.

### **1.4.0. HYPOTHESIS**

The chief constraints to the widespread dissemination and utilisation of FCR tile and stabilised soil block technologies in Kenya are the lack of public awareness of the advantages of these building materials and the inability of the promoters to do so effectively.

The inability of promoters to effectively promote and popularise the use of FCR tiles and stabilised soil blocks and create greater public awareness of the advantages of FCR tiles and stabilised soil blocks may be due to the following;

- i) Lack of adequate funds for these organisations to employ enough qualified staff, and to set up the necessary physical facilities like libraries, laboratories, workshops and on-site testing facilities.
- ii) The general public's or potential users' preferences, personal tastes and attitudes that tend to favour the use of conventional building materials rather than stabilised soil block and FCR tiles. Non-acceptability of FCR tiles and stabilised soil blocks by the general

public will tend to limit the demand and market for these two building materials. As a result of this, there is little hope for the growth and expansion of production by the private commercial sector. Limited production of FCR tiles and stabilised soil blocks on a commercial scale means limited use of these two building materials by the potential users.

The lack of effective promotion and popularisation of FCR tiles and stabilised soil blocks by the promoters and the general public's preference for conventional building materials are not the only constraints to the widespread dissemination and utilisation of FCR tiles and stabilised soil blocks. Other constraints exist. These are basically to do with questions about the durability of FCR tiles and stabilised soil blocks and problems arising from their inherent properties and how these materials are handled during the actual construction of a building.

#### **1.5.0. METHODOLOGY**

##### **1.5.1. Operational Definitions**

- a) **Appropriate materials:** These are materials that are affordable, reasonably durable based on local resources, and their production takes into account existing conditions both climatic and socio-economic.
- b) **Technology** according to Stewart (1978) <sup>9</sup> is a set of techniques (skills knowledge and procedures for making and doing useful things. Appropriate technology is therefore the utilization of these (skills, knowledge and procedures) to satisfy the basic needs of a particular group of people within their environment while taking into account the

climatic conditions of the place and socio-economic and cultural characteristics of the people for whom it is meant.

- c) **Soil stabilization:** This is the process of adding a stabilizing agent like cement, ash, stone dust, bitumen, lime and sand etc, and compacting the soil after adding water to it so as to make the soil more suitable as a construction material. There are basically three main ways in which the quality of soil can be improved and made more suitable for construction purposes.
- i. By application of high compressive force on soil blocks in a block press. This may be referred to as mechanical stabilisation.
  - ii. By application of protective measures against the effects of rain.
  - iii. By application of stabilisers where the stabilisers bond with the soil particles after a chemical reaction; this could be referred to as chemical stabilisation.
- d) **Promoter** of appropriate building technology - any organisation, group, institution or individuals that are involved in the research on appropriate building materials or in trying to encourage the use of these materials.
- e) **Developers** - those who build housing for sale or rental purposes. In this case, it is the developers of housing constructed with FCR tiles or stabilised soil blocks.
- f) **Potential Users** - these are the general public who might be interested in using these appropriate building materials.
- g) **Users** - the people actually living in housing constructed using FCR tiles or stabilised soil blocks.

- h) **Disseminate** - to propagate or spread; in this study, the dissemination of appropriate building technologies is the transferring of these technologies from the initiators to the general public.

### 1.5.2. Procedures and Sources of Data

Constraints to the widespread adoption and use of FCR tiles and stabilised soil blocks in Kenya today occur right from the stage of dissemination to the stage where they are utilized for the construction of buildings.

In order to identify these constraints, the researcher interviewed officials of organisations and individuals who are directly and indirectly involved in the promotion, production and use of FCR tiles and stabilised soil blocks. These are

- a) institutions promoting the use of FCR tiles and stabilised soil blocks.
- b) Developers of some of the buildings and housing estates where FCR tiles and/or stabilised soil blocks have been used.
- c) Small scale producers of FCR tiles and stabilised soil blocks.
- d) A few small scale producers of concrete blocks and concrete tiles.
- e) A few architects within Nairobi.
- f) Builders or fundis on site where construction with FCR tiles and stabilised soil blocks was still going on in Nairobi.
- g) Government officials from the Kenya Bureau of Standards and the Chief Architect, Ministry of Public Works and Housing.

- h) Users of residential houses constructed using FCR tiles and/or stabilised soil blocks.

Secondly, the researcher also surveyed 7 different building projects where FCR tiles and stabilised soil blocks have been used. These were either community facilities like churches schools and dispensaries or residential houses. These are;

- a) The Nyahururu Tenant Purchase Housing Scheme in Nyahururu Town.
- b) Komarock Estate in Nairobi.
- c) Privately built rental houses in Riruta, Nairobi.
- d) Kariobangi Co-operative Housing Society's houses in Kariobangi, Nairobi.
- e) St. Joseph the Worker Parish in Kangemi, Nairobi.
- f) Ngunyumu Primary School in Kariobangi, Nairobi.
- g) Korogocho Primary School in Kariobangi, Nairobi.

Information on the organisations that are actively involved in promoting the use of FCR tiles and stabilised soil blocks was obtained through interviews with heads of these organisations or officials directly involved with the promotion of these two building materials. These organisations were evaluated in terms of money, physical facilities and staff that are available to them and whether these resources were adequate for their requirements. A sample of the questionnaire used for interviews with the officials of these organisations is provided in Appendix I. These organisations are;

- a. Housing Research and Development Unit (HRDU).
- b. Action Aid Kenya.
- c. Intermediate Technology Development Group (ITDG)



- d. Appropriate Technology Centre for Education and Research, Kenyatta University.
- e. Centre for Research and Training, Karen (Ministry of Applied Technology and Technical Training).
- f. National Council of Churches of Kenya (NCCK).
- g. National Co-operative Housing Union (NACHU).
- h. African Housing Fund of Shelter Afrique.
- i. Undugu Society of Kenya.

Interviews with developers of housing estates and sponsors of community facilities and dispensaries where FCR tiles and stabilised soil blocks were done through the use of questionnaires (see Appendix II and IV) which were administered by the researcher. The objective of interviewing these developers was to identify those constraints to the widespread production and use of FCR tiles and stabilised soil blocks that are specifically related to the actual construction and how the initial construction costs and the maintenance costs of these buildings compare with buildings constructed using conventional building materials. The developers of residential estates who were interviewed are;

- a) The Kenya Building Society who are the developers of Komarock Estate.
- b) The Nyahururu Municipal Council and the National Housing Corporation (NHIC) together with the United States Agency for International Development who were the developers of the Nyahururu Tenant Purchase Housing Scheme in Nyahururu.
- c) A private individual developer in Riruta in Nairobi (Mr. Wanyee)

- d) Officials of the Kariobangi Co-operative Housing Society.
- e) Sponsors of St. Joseph the Worker Parish, Ngunyumu and Korogosho Primary Schools provided information on the school buildings, church and dispensary constructed using FCR tiles and stabilised soil blocks (see Appendix IV).

Private small scale producers of FCR tiles and stabilised soil blocks were interviewed in order to identify the problems they faced in the following areas

- a) Setting up the production unit
- b) The actual production of FCR tiles and stabilised soil blocks
- c) The marketing of the FCR tiles and stabilised soil blocks

Five (5) of these small scale producers of FCR tiles are found within Nairobi and were therefore easily accessible to the researcher who interviewed all the proprietors.

A few small scale producers of concrete tiles and concrete blocks who are located in the vicinity of building projects where FCR tiles and/or stabilised soil blocks have been used were interviewed. Those producing conventional roofing tiles and building blocks can be considered as the potential producers of FCR tiles and stabilised soil blocks since they are already in the building materials industry. It would be easier for those already in the building materials industry to establish production units for FCR tiles and stabilised soil blocks than for fresh entrepreneurs who have neither the benefit of long established contracts with suppliers of raw materials like sand and cement nor the experience in the building materials industry.

Interviewing the proprietors of small scale producers of concrete tiles and blocks aimed at identifying the problems that the potential producers of FCR tiles and stabilised soil blocks

face and the reasons for the lack of widespread interest in the production of FCR tiles and stabilised soil blocks by the private commercial sector.

A few architects were also interviewed since architects are specifiers of building materials that are used on the buildings they have designed.

Builders or "fundis" provided information on the problems encountered during actual construction of buildings using FCR tiles and/or stabilised soil blocks. These builders were drawn from projects where construction using FCR tiles and stabilised soil blocks are still going on.

Personal interviews with the Chief Architect in the Ministry of Public Works and Housing and the Principal Standards Officer in the Kenya Bureau of Standards (KBS) were carried out by the researcher. This was meant to find out the official government position with respect to the use of FCR tiles and stabilised soil blocks and the preparation of standards and specifications for these two building materials.

A user reaction survey was also carried out in Nyahururu, Riruta and Komarock Estate through the use of a questionnaire administered to the head of the household or spouse (see Appendix III). This survey aimed at assessing how acceptable FCR tiles and stabilised soil blocks were to the users, ie, occupants of housing built using FCR tiles and stabilised soil blocks when compared to conventional roofing and walling materials.

In Nyahururu, 26 houses are built using FCR tiles and stabilised soil blocks and in Riruta, 14 houses are built using stabilised soil blocks, hence total populations were considered. In the case of Komarock, a total of 1750 houses are roofed using FCR tiles and a random

sample of 10% of this figure, ie, 175 houses, were actually surveyed and occupants interviewed.

The sampling was carried out in the following way. There are a total of 1976 houses in Komarock Estate. Out of these, a total of 1750 houses are roofed using FCR tiles and 226 are roofed using asbestos roofing sheets. All the 226 houses which are roofed with asbestos sheets are in Sector I which has a total of 765 houses numbered from 1 to 765. Asbestos sheets have been used for roofing only the double storeyed houses. This made it easy to identify the house numbers for the houses roofed with asbestos from the layout plan. Therefore there are 531 houses roofed with FCR tiles in Sector I. Sectors II and IIIA numbered from 1 to 228 in Sector II and 229 to 807 in Sector IIIA. The last sector, Sector IIIB, has 396 houses numbered 1 to 396.

Starting from Sector I through Sectors II, IIIA and IIIB, each house was allocated a number from 1 to 1750. The house numbers of the houses roofed with asbestos sheets were identified from a layout plan which indicates the type of house on each plot and were excluded from being assigned a number. Using a table of random numbers, 175 numbers were picked. For each number picked between 1 and 1750 (inclusive), the corresponding house number and sector was recorded.

The projects where buildings have been constructed using FCR tiles and stabilised soil blocks are scattered all over the country. These projects range from single residential buildings and community facilities like churches, schools and dispensaries to bid residential estates like Komarock Estate in Nairobi. Most of the buildings constructed using FCR tiles and stabilised soil blocks were built mainly for demonstration or experimental purposes. Out of those 7

projects which were visited, 6 are located in and around Nairobi hence could be easily be reached by the researcher. The Nyahururu Tenant Purchase Housing Scheme in Nyahururu could not be excluded since it is one of the biggest projects in Kenya where both FCR tiles and stabilised soil blocks have been used for construction of residential houses.

The aim of visiting and surveying the 7 different was to obtain the information on:

- i) Construction problems when using FCR tiles and/or stabilised soil blocks from the developers.
- ii) Durability of FCR tiles and stabilised soil blocks through observation of the condition of the roofs and walls of these buildings.
- iii) The acceptability of FCR tiles and stabilised soil blocks to the users of buildings constructed using these building materials.

This was limited to the projects where FCR tiles and stabilised soil blocks have been used to build residential buildings where a direct user is easy to identify.

### 1.5.3. Methods of Data Collection

Information was obtained from actual field surveys and interviews with the various parties that have been mentioned earlier on. Other information was obtained from documents and publications obtained in the various libraries and in the records of the promoters and developers interviewed. More information was also obtained through observation of the houses built using FCR tiles and stabilized soil blocks.

#### 1.5.4. Data Analysis and Presentation

The analysis of data in this study basically involved the use of proportions and percentages to indicate the magnitude and prevalence of the constraints to the widespread production and use of stabilized soil blocks and FCR tiles. For instance, the proportion of organisations that had enough funds, staff and physical facilities to effectively promote the use of stabilized soil blocks and FCR tiles as a percentage of the total number of organisations that are involved in promoting the use of these appropriate building materials. Thus the proportion is an indication of how effectively these materials are disseminated.

In the area of small scale commercial production of FCR tiles and stabilized soil blocks, the proportion of those small scale producers who experience a specific problem which is identified as a percentage of the total number of small scale producers of FCR tiles and stabilized soil blocks who were interviewed, is a pointer to the extent and prevalence of the problem throughout the country.

In the analysis of data on defects in houses that have been built using stabilized soil blocks and/or FCR tiles, roofing defects are separated from walling defects, hence the number of houses having a particular roofing defect is taken as a percentage of the total number of houses roofed with FCR tiles. Defects in houses built with stabilized soil blocks are also presented as a percentage of the total number of houses walled with these blocks. These percentages indicate whether or not serious problems exist with respect to the durability of FCR tiles and stabilized soil blocks as building materials.

Analysis of data on acceptability of FCR tiles and stabilized soil blocks among the users and potential users of houses built using these materials involved the use of frequency tables and percentages.

The data has been presented in the form of tables, photographs and a write-up on the various constraints that were identified.

#### **1.6.0. SIGNIFICANCE, SCOPE AND LIMITATIONS OF STUDY**

The appropriate building materials covered in this study are those that are actively promoted. These are stabilized soil blocks and FCR tiles. This is because other materials that might be considered appropriate eg. thatch, adobe (sun dried mud) blocks, dried clay bricks, ferrocement (mortarmesh) and natural stone have several disadvantages. Thatch (grass, makuti) although easily available in some places, is not durable; it requires frequent repairs and replacements and is a fire risk. It is also not readily available due to pressures on land as population increases. In addition, thatch is not suitable for rain-water harvesting. The use of thatch is not actively promoted, although it remains the most widely used roofing material in the rural areas.

Sun dried mud blocks or adobe blocks have the main disadvantage of not being durable; their use is not actively promoted and is only used in certain parts of Machakos and Kitui districts.

Ferrocement or 'mortarmesh' is a relatively new material in the field of appropriate building technology. Ferrocement has yet to be used in projects on a scale equal to stabilized

soil blocks and FCR tiles. The long term performance and durability of state-of-the-art ferrocement is still not fully known.

Natural stone on the other hand may be an appropriate material where it is readily available. Where localized small-scale production is not possible, natural stone may be expensive if the quarrying is highly mechanised and the stone has to be transported from far. In most cases quarrying and even the dressing of the stone is manual.

Burnt clay bricks although actively promoted by the Lake Basin Development Authority, may not be appropriate because of the high energy consumption that occurs during production.

The Kenya Bureau of Standards has formulated standards for FCR tiles and soil cement blocks, thus draft standards for both these materials exist.

The projects covered in this study are those in which FCR tiles and soil-cement blocks have been used either separately or together. It does not matter whether it is only one element of a building that has been constructed using either of these materials.

Because some of the projects to be sampled may be small, they may not be representative of the general population in Kenya, it is therefore necessary to cover as many projects as possible within that sample, involving various beneficiaries. The beneficiaries could be individual households, or social groups like in the cases of schools, church, clinics and women's groups. The study focuses on projects involving more than one building because of reasons like accessibility and ease of obtaining information. Individual dwellings constructed of appropriate materials are not covered because it is impractical to try and visit all the single houses scattered all round the country.



These projects in which appropriate materials have been used are relatively young. The time period may not be long enough to obtain durability of the materials. This necessitates looking more at the social acceptability of these appropriate materials by incorporating potential users' views and attitudes towards appropriate materials. There will also be need to look at scientific or laboratory results about the materials as these form the basis for standardisation.

There is a lot of literature available on the properties and advantages of appropriate building materials. This includes literature on the cost effectiveness of appropriate materials and their great adaptability to decentralized small scale production. Not much has been done to find out why these materials, despite their apparent advantages over conventionally produced materials, are not being produced and used on a scale comparable to that of conventional materials. There is need to find out how acceptable these appropriate materials are to the potential users.

There have been studies focusing on the use of particular appropriate materials in particular areas, but none has covered the use of these materials in most of the country. Currently there is little information available on the problems associated with introducing appropriate technology and some of the methods used to overcome these problems. This study aims at identifying the problems associated with using appropriate building technology and how these problems can be overcome.

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## CHAPTER TWO

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Appropriateness of a material involves several both technical and socio-economic considerations. There are several factors that determine the appropriateness

- 1) Is the material produced locally, or is it partially or entirely imported?
- 2) Is it cheap, abundantly available, and/or easily renewable?
- 3) Has it been produced in a factory far away (transportation costs); does it require special machines and equipment or can it be produced at lower costs on the building site?
- 4) Does its production and use require a high energy input, and cause air-pollution and pollution? Is there an acceptable alternative material which alleviates these problems?
- 5) Is the material and construction technique climatically acceptable?
- 6) Does the material and construction technique provide sufficient safety against common natural hazards?
- 7) Can the material and technology be used and understood by the local workers, or are special skills and experience required?

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1.0 INTRODUCTION**

Appropriateness of a material revolves around both technical and socio-economic aspects of that particular material. There are several factors that determine the appropriateness of a material.

- 1) Is the material produced locally, or is it partially or entirely imported?
- 2) Is it cheap, abundantly available, and/or easily renewable?
- 3) Has it been produced in a factory far away (transportation costs); does it require special machines and equipment or can it be produced at lower costs on the building site?
- 4) Does its production and use require a high energy input, and cause wastage and pollution? Is there an acceptable alternative material which eliminates these problems?
- 5) Is the material and construction technique climatically acceptable?
- 6) Does the material and construction technique provide sufficient safety against common natural hazards?
- 7) Can the material and technology be used and understood by the local workers; or are special skills and experience required?

- 8) Are repairs and replacements possible with local means?
- 9) Is the material socially acceptable ? Is it considered of low standard or does it offend religious belief? <sup>1</sup>

There are several materials that satisfy some of these conditions, but for various reasons are not actively promoted by building research institutions. Among these appropriate materials, Fibre concrete roofing (FCR) tiles and stabilized soil blocks are the most widely promoted and have been used in several projects both community based, eg churches, schools, etc. and private housing. The literature review therefore revolves around the technical, economic and social acceptability aspects of FCR tiles and stabilised soil blocks.

To a certain extent the use of FCR tiles and stabilised soil blocks have taken off unlike other appropriate building materials that are still in the initial stages of research and development. Other materials that may be considered appropriate are mortarmesh, rammed earth, and adobe blocks.

The use of mortarmesh or ferrocement is still confined to very few demonstrations for experimental purposes that are being carried out by building materials research institutions. These projects would not be of much help when studying the problems of dissemination of the material and its acceptability by the potential users because its use is very limited.

Adobe block and rammed earth construction are limited to certain areas in Kenya where they have been traditionally used and are not the result of active dissemination by institutions that are promoting the use of FCR tiles and stabilized soil blocks.

The use of FCR tiles and stabilised soil blocks is actively promoted by several organisations in Kenya. There has been some considerable work done with respect to the

research into the properties of these materials and conditions in which they are best used. Consequently, there is a considerable amount of literature available on FCR tiles and stabilised soil blocks when compared to other appropriate building materials that exist.

Building materials like adobe and thatch that have been traditionally used were appropriate for the kind of housing that was built then and within that rural setting. Today, these materials cannot be used in high density areas like towns even if they were easily available.

In rural areas where these materials may still be suitable for construction purposes, they are not easily available. For instance, it is expensive to use thatch in Kisii because it is not easily available, one has to buy thatch, just like buying corrugated iron sheets. Formerly, anyone who needed to use thatch obtained it from his land.

### **2.2.0 STABILISED SOIL BLOCKS**

Soil has been used for shelter construction for many centuries. It is also one of the most widely used building materials today especially in the rural areas and unplanned parts of the urban centres. Soil is the cheapest and most readily available construction material; it is easy to work with and requires less skills so it can be handled by unskilled people. Despite all these, the major weakness of soil is its lack of compressive strength and low resistance to erosion by the elements. Hence the need to make soil more suitable for construction and officially acceptable as an alternative to the more expensive conventional materials.

There are three main methods of improving the quality of soil to make it more suitable for construction purposes. They include:

- a) Application of protective measures against moisture penetration is done by rendering the external wall surfaces with materials that protect against effects of rain. Protection against moisture penetration can be achieved through the design and construction of wide overhangs to protect the walls.
- b) Application of high compaction and compressive pressure to soil blocks is achieved by use of a block press. The compaction increases the strength of the soil block to a much higher level than adobe blocks but the soil blocks have to be kept dry. If a soil block is properly compacted during the production stage, and properly cured, it can have a strength of up to  $2 \text{ N/mm}^2$  without any stabilization depending on the type of soil.
- c) The use of stabilizers and compaction produces soil blocks of higher strength than just compaction alone. The use of stabilizers like cement, lime and bitumen among others can help in eliminating or reducing various soil weaknesses. The optimum content of stabilizer is that one which is economical and achieves the minimum required compressive strength which in the case of Kenya is  $2.8 \text{ N/mm}^2$ . According to the Building Code, all building blocks for walling must have a minimum crushing strength of  $2.8 \text{ N/mm}^2$ .

- i) Soil Stabilization with Cement.

The cement reacts with water and forms an insoluble concrete matrix that surrounds the soil particles and binds them together. The soils that are suitable for stabilization using cement are those with small amounts of clay namely murrum and sandy soils. The clay may be an aid to compaction but too much



clay is a disadvantage because clay swells and shrinks depending on the amount of moisture present. The strength of a soil cement block is affected by the following;

- The type of soil used
- The density of the soil-cement mixture
- The amount of cement used
- The methods of mixing and any delay between mixing and the onset of compaction.

#### ii) Soil Stabilization with Lime.

Lime does not contain cement so it does not stabilize soil in the same way as cement. Lime stabilization is best suited for soils with fine particles. Quicklime is preferable to hydrated lime, because it dries out the soil.

#### iii) Soil Stabilization with Bitumen.

The main function of bitumen, when mixed with soil, is to help act as a water repellent. The blocks are resistant to the effects of rain since they do not absorb moisture. Bitumen is best suited to stabilizing granular soils.

### 2.2.1 The Production of Stabilized Soil-Cement Blocks

The raw materials required for the production of stabilized soil-cement blocks are soil, cement and water. More often than not, the soil is not homogenous; it may contain stones, lumps, etc. The soil used must be free of stones and lumps or any other foreign substance because these have different shrinkage rates from the main body of the soil-cement mix. The

differences in shrinkage rates will lead to stresses in the blocks during the process of drying and this may spoil the appearance and weaken the blocks.

- i) The soil to be used for the production of soil-cement blocks must be crushed so that it can pass through a 5-6 mm sieve.
- ii) The water to be used must be of drinking quality; sea water should never be used; salt interferes with the bonding between cement particles and soil particles.
- iii) The cement should be fresh and free of lumps.

The soil and cement must be thoroughly mixed before water is added. Proper mixing of the dry ingredients ensures that the stabilizer is evenly distributed throughout the soil. This will increase the effectiveness of the chemical reactions and cementing action of the cement stabilizer once the water is added to the mixture.

Once the mixing has been done, it is important to start compaction immediately. This is because, once water has been added to the soil-cement mix, the setting begins and continues until hydration is complete. Therefore, the longer the delay between the mixing and compaction, the greater the cement bond, and the more the compactive effort needed to produce good quality blocks.

The production process of stabilized soil blocks can be seen in figures 2.1 to 2.6.

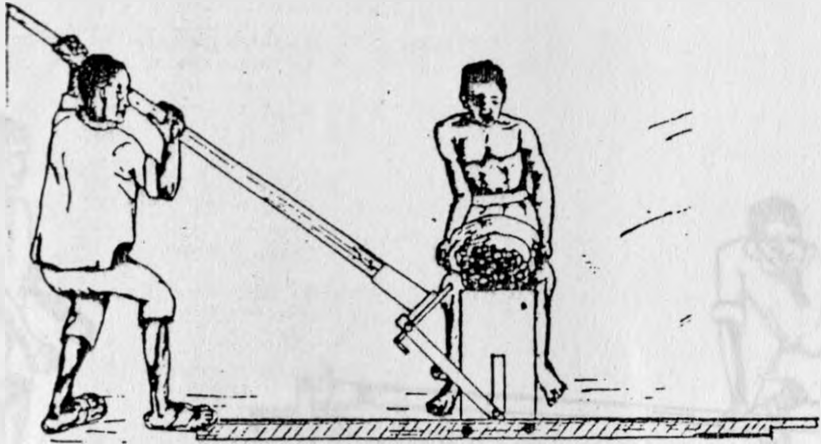


Fig 2.1: The Block Press mould is filled with the soil-cement mixture.

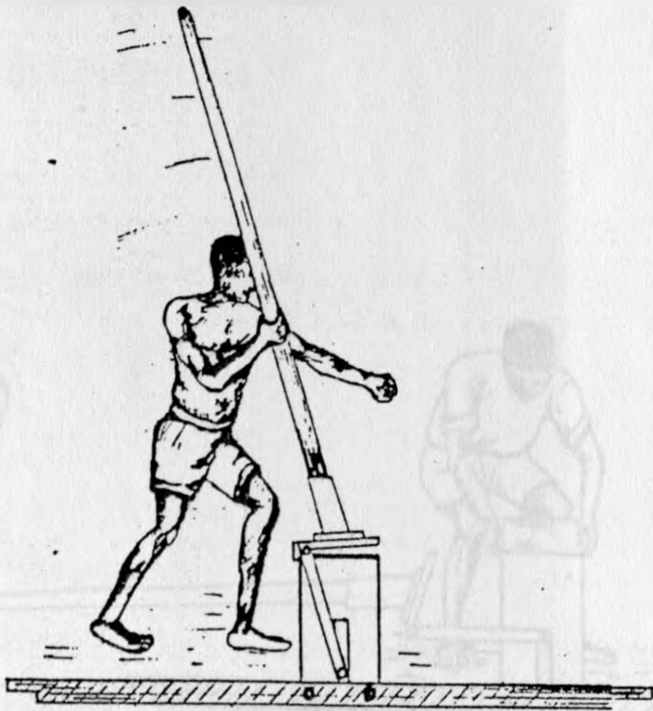


Fig 2.2: The handle of the press is swung quickly to the other side.

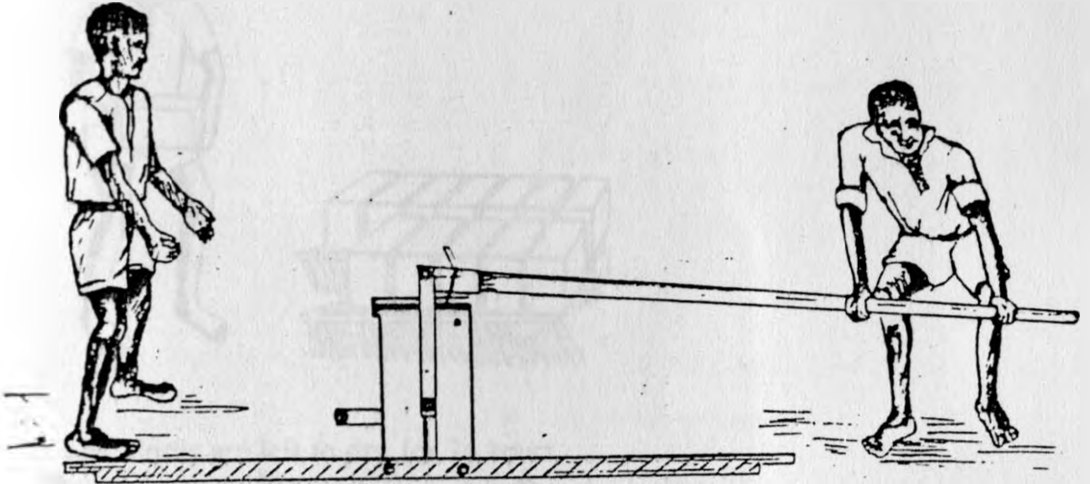


Fig 2.3: The block is compacted or pressed

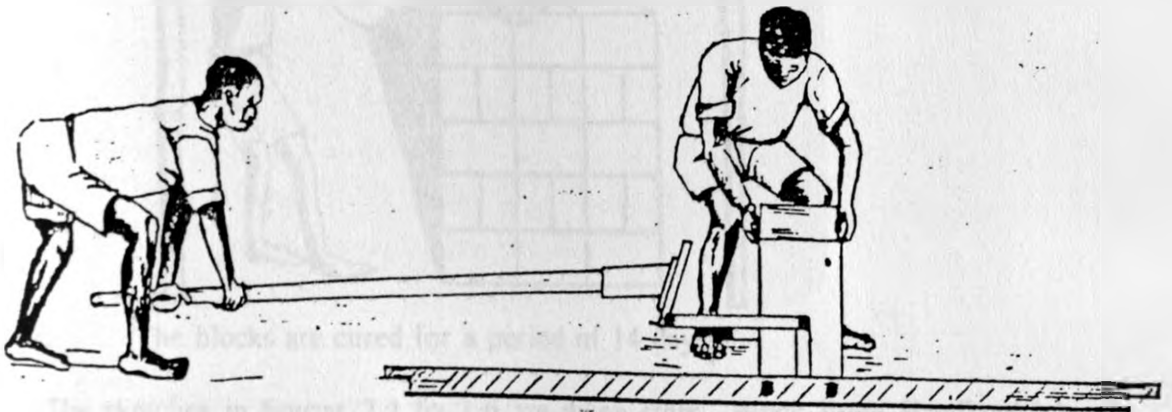


Fig 2.4: The compacted block is raised out of the mould

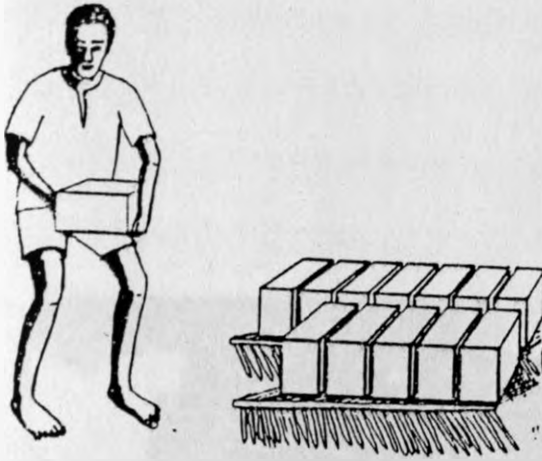


Fig 2.5: The blocks are left to dry for 24 hours.

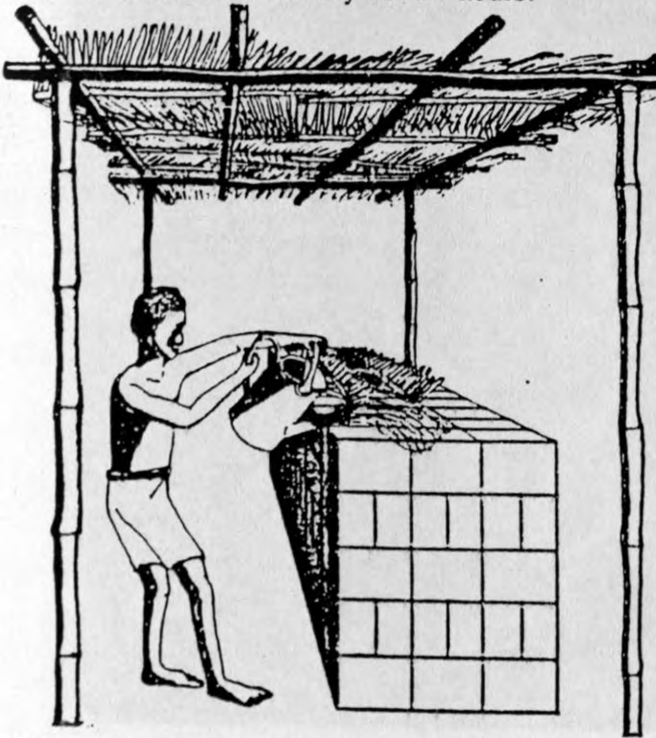


Fig 2.6: The blocks are cured for a period of 14 days.

The sketches in figures 2.1 to 2.6 are taken from "Block Press Handbook" by the Department of Housing and Planning Research, The University of Science and Technology, Kumasi, Ghana, pages 16 and 18. Kumasi, 1987.



**PLATE 2.1 STABILISED SOIL BLOCKS**

After 14 days of curing the blocks are left to dry completely, and are now ready to use.

Compaction of the blocks is achieved by use of a block press and there are several available in the market. The choice of block press is determined by the users' needs and financial capability. The CINVA-ram block press is one of the cheapest block presses available. The common dimensions of blocks are 240x140x90 mm. After compaction, blocks have to be cured so that they gain maximum strength. Like all cement-based materials, soil-cement blocks need a period of damp curing. After 2-3 days, the primary curing period is over and the blocks are removed and stacked. They are ready to use after about 21-28 days. It is important that soil-cement blocks are adequately cured. This is because they have to be capable of supporting the various loads which a building structure is subjected to. On the other hand, these blocks should not be left exposed or unused for a long time because they will deteriorate.

### 2.2.2 Properties and Advantages of Stabilized Soil-Cement Blocks

i) Compressive strength, durability, thermal conductivity, density, and permeability are important properties of a building material that make it more suitable or less suitable for construction purposes. The compressive strength of soil-cement blocks (ie, the amount of pressure per unit area these blocks can withstand without being deformed) depends on the following factors;

- the type of soil
- the amount of stabilizer
- the compactive effort
- the level of curing

- the delay between the mixing of ingredients and the compaction of the mixture.

The wet compressive strength of soil-cement blocks may be less than  $4 \text{ N/mm}^2$  (see Table 2.2). This is adequate for most single storey residential buildings. The Building Code requirements specify that any building block/unit must have a minimum strength of  $2.8 \text{ N/mm}^2$ . Therefore, these soil blocks compare favourably with the requirements of the building code, although soil-cement is not among the specified materials.

### ii) Moisture Movement

Moisture movement in building materials is particularly important where materials with different moisture movement characteristics are juxtaposed. Differential movements lead to stresses which may be big enough to break the bonding between the juxtaposed materials. Well compacted soil-cement blocks, which are based on soils that have no tendencies to expand or contract, have good resistance to adverse effects of moisture, unless under conditions of severe exposure.

### iii) Density and Thermal Properties

Soil-cement blocks are generally denser than a number of concrete based building materials; for instance the aerated and lightweight concrete blocks. The high density of cement stabilized blocks makes them more suitable for construction in the tropics when compared to some lightweight concrete products, because of their superior thermal capacity, hence their ability to provide a suitable internal environment without being affected by extremes of temperatures, both seasonal and diurnal temperature variations.



iv) Durability, Maintenance and Appearance of Soil-Cement Blocks

The appearance of the blocks is determined by soil colours, particle size and the amount of stabilizer. It is possible to manufacture blocks of good shape, consistent size and high quality finish. These can be built into fair-faced walling. Whitewashing can be done on stabilized soil block walling to reduce heat gain. These soil-cement blocks are quite durable. In Ghana, houses constructed in 1947-1949 using soil-cement blocks are still existing. There are no records of extensive replacements, as would be necessary in the event of collapse or serious failure, at the Asawasi Housing Estate in Kumasi since its construction in 1947.<sup>2</sup> Soil-cement blocks are quite durable in areas of moderate exposure.

v) Energy Consumption

"The use of soil in stabilized soil-cement blocks represents a 35 % to 68 % reduction in energy consumption when compared to burnt clay bricks."<sup>3</sup>

With rising energy costs, soil-cement blocks are a welcome alternative to conventional construction materials that involve high energy consumption in their production.

Table 2.1 compares the range of properties of stabilized blocks and alternative walling materials. Stabilised soil blocks compare favourably with other building blocks namely fired clay bricks and dense concrete blocks in terms of wet compressive strength density and thermal conductivity. Under conditions of severe natural exposure, stabilised soil blocks are not very durable. Stabilised soil blocks can achieve greater compressive strength when compared to lightweight concrete blocks.



**Table 2.2: Comparative Costs and Strength of Different Building Blocks.**

Type of block	Size in mm	Av. bearing capacity N/mm <sup>2</sup>	Av. cost per m <sup>2</sup> in Kshs	Remarks
Mud (adobe) blocks	150x150x300	0.9	33.5	below min. b/c of 3N/mm <sup>2</sup>
Unstabilized machine-made soil blocks	125x140x292	1.8	36.0	still below 3N/mm <sup>2</sup>
Stabilized "Cinva-Ram" soil blocks	125x140x292	3.2	54.0	min. b/c attained
Stabilized "Brepak" made soil blocks	100x140x292	3.4	50.0	min. b/c attained
Interlocking burnt clay blocks	110x140x292	2.4	76.0	below min b/c
Exaggerated standard burnt clay bricks	90x140x292	3.2	90.0	min. b/c attained
Standard burnt clay bricks	80x100x220	7.5	135.0	unnecessarily strong blocks and walls for L.C.H.
Concrete blocks	180x140x290	7 to 9	110.0	unnecessarily strong blocks and walls for L.C.H.
Building stone blocks	190x140x390	8 to 10	125.0	unnecessarily strong blocks and walls for L. C. H.

Key: Min. b/c - minimum bearing capacity

L.C.H. - Low-cost housing

Source: Improvement and Use of earth construction products for low-cost housing by J. K. Kateregga (1983 prices).

Prices of concrete blocks vary according to the sizes. See

Table 2.3.

Table 2.3: Comparative costs of building blocks.

Material	Price per unit in Kshs	Number of blocks in a square metre	Cost per square metre in Kshs
Concrete Blocks	25	13	335
Stabilized Soil	4.50	26	119.6
Stone blocks 6"	22.5 per metre run		150
Stone blocks 9"	30.0 per metre run		133

Source: Field Survey, 1992.

### 2.2.3 Disadvantages of soil-cement blocks.

The cost and availability of equipment used for block manufacture is quite a problem, especially to those individuals who are poor. The cheapest of these blocks presses - the CINVA-ram was costing about US \$230 (approximately Kshs 5,400) in January 1988.<sup>4</sup> There are locally fabricated machines which are cheaper than the imported ones, but are still beyond the means of an individual among the majority of Kenyans. This disadvantage could be offset by individuals forming a self-help group and buying the block press. Other block presses like the BRE-pak hydraulic block press, despite giving a superior quality of soil-cement blocks with less stabilizer and a faster production rate, is several times the price of CINVA-Ram. In

January 1988, the BRE-pak block press was selling for an equivalent of US \$1,217; approximately KShs 24,000.<sup>5</sup>

Another disadvantage of the stabilized soil technology is the fact that not all soil is suitable for stabilization. The soil that is most suitable for stabilization using cement is that soil with the proportion of 50-80% sand, 20-30% clay and less than 30% silt particles<sup>6</sup>. Soil with this kind of composition is not available everywhere. This is a limitation on the appropriateness of stabilized soil blocks. The anticipated reduction in cost may be negated by the amount of stabilizer required if the soil is not suitable for stabilization.

The tests that need to be done on soils to find out the type of soil and consequently determine the optimum amount of stabilizer are not easy to understand and carry out. Some of these tests require equipment and facilities that are not readily available throughout the country. This is a limitation on the appropriateness of stabilized soil technology.

#### 2.2.4 Construction and design considerations when using soil cement blocks.

Quality control measures should be carried out right from the selection of the optimum cement content to proper and adequate curing of compacted soil-cement blocks. The production of quality blocks does not guarantee that a structurally sound and easy to maintain building will be constructed. Stabilised soil block walls have a lower compressive strength than dense concrete blocks or natural stone, and are therefore more susceptible to damage through

- (a) erosion and moisture attack

(b) moisture movement and resultant dimensional changes as the wet and dry seasons alternate.

Soil-cement blocks should not be used in the ground i.e. for foundations or immediately above the ground, unless it is in very dry areas.

The design and construction of buildings to be built of stabilised soil blocks must provide for wide overhangs and damp-proof courses must be used. The size of openings should be limited and long uninterrupted wall spans should be avoided as they tend to crack very easily. Mortars used in the construction of a soil-cement block wall should be of a strength similar to that of the blocks.

In regions which are prone to a lot of seismic activity, it is necessary to install pillars, ring beams, and wall plates with adequate reinforcement. This is because the soil-cement block walling may not adequately absorb the tensile stresses created by earthquakes.

A sound understanding of the properties and nature of soil-cement blocks is important for the construction of safe and durable buildings. More often than not, such materials have been blamed where the workmanship was faulty. People have the belief that appropriate technology is so simple that no training is necessary for anyone constructing a house using innovative materials. Appropriate technology is indeed simple but basic construction skills are a prerequisite for quality workmanship.

### **2.3.0 FIBRE CONCRETE ROOFING TILES (FCR).**

Fibre concrete is basically made of sand, cement, fibres and water. There are various types and characteristics of fibre concrete depending on the quantity and quality of each of the

components, the methods of mixing, production and curing. Adequate training, supervision and quality control determine the quality of fibre concrete products.

Asbestos cement was until recently the most well-known and widely used fibre reinforced concrete. But there are serious side-effects on health associated with the mining of asbestos, the production and use of the asbestos products.

Fibres for reinforcing concrete can be natural or artificial. The main purpose of reinforcing concrete is to improve its tensile strength and inhibit cracking. In Kenya, fibre concrete production involves the use of short fibres which are randomly distributed in the cement-sand mix. The effect of these short fibres is to provide cracking resistance in all directions, especially during production of tiles.

Fibre concrete tiles have less problems than fibre concrete roofing sheets, both at production and roofing stages. The FCR tiles are made 6mm thick while the FCR sheets are made 10mm thick, hence the tiles are lighter, easy to handle and to cure in water tanks. FCR tiles are less susceptible to breakage while in transportation.

### 2.3.1 The Production Of FCR Tiles

The equipment and tools required for setting up a small FCR tile production unit are given in Table 2.4.

**Table 2.4: Equipment and tools required for a small tile production unit:**

1	Screeding machine (vibrator)
200	Tile moulds
20	Ridge tile moulds
1	Workbench
2	Curing tanks (approximately 1m x 2m)
1	Steel float
220	Polythene interface sheets
1	Kitchen scales
1	Panga
1	Sieve
	Sand/Cement batching boxes

**SOURCE:** Agevi E.; *Appropriate Building Materials, Production and Use for Low Cost Housing in Kenya*. A report from a seminar for Youth Polytechnic Instructors at Karen, Nairobi on 6-31 October 1986, Page 58.

Materials required in FCR production are;

- a) Ordinary portland cement, which should be dry and free of lumps.
- b) Sand should be well graded and fine, i.e., the sand particles should be angular and range between 0.06 and 2.0mm in size. The sand should not be salty, and fine particles of silt and clay should be reduced as much as possible. Silt and clay interfere with the cement matrix reducing the bond between cement and sand.



- c) Fibre: Fibre can be artificial or natural. In Kenya, sisal fibre is used. The fibre is normally chopped to approximately 12.5 mm lengths.
- d) Water used in the fibre concrete mixture should be of drinking quality.<sup>7</sup>

Cement and sand are mixed in ratios of 1:3 and chopped fibre of 12.5 mm length is added to the mixture. It is important that the dry ingredients are thoroughly mixed before the water is added. This is to ensure even distribution of the fibres. The proportion of the fibre should not exceed 1% by weight of the mixture, and not by volume, since fibre densities vary greatly.

Production of FCR tiles begins with the positioning of the polythene interface sheet on the screeding machine, after which the hinged frame is locked in position. The wet mixture is then trowelled onto the polythene interface sheet on the screeding machine while it is vibrating. The mixture is smoothed until it becomes level with the top of the steel frame. Before the tile is removed from the frame, a nib is formed at the top end of the tile and a wire loop is placed in it. After this, the tile is removed from the frame and placed on the mould. The tile is left on the mould for the next 24 hours before being demoulded and placed in the curing tanks for a minimum of 10 days. After these 10 days, the tiles are removed and stacked for dry curing. They are ready for use after 10 days of dry curing.

The production process is shown in Plate 2.2 to Plate 2.9.



PLATE 2.2: FCR TILES

Polythene interface sheet is placed on the screeding machine and the frame is locked in position.



PLATE 2.3: FCR TILES

A measured amount of wet mixture is trowelled onto the polythene interface sheet.



PLATE 2.4: FCR TILES

As the machine vibrates, the mixture is smoothed until it is level with the top of the frame.



PLATE 2.5: FCR TILES

A wire loop is placed in the nib at the top end of the tile.



PLATE 2.6: FCR TILES

The tile is removed from the frame.



PLATE 2.7: FCR TILES

The tile is placed on a mould for 24 hours.



PLATE 2.8: FCR TILES

The demoulded tiles are placed in the curing tanks after the initial 24 hour period for at least 10 days.



PLATE 2.9: FCR TILES

The tiles are removed from the curing tanks after a period of 10 days and stacked to dry for another 10 days.



**PLATE 2.10: FCR TILES**

The above picture shows Ridge tiles on moulds.



The production of ridge tiles requires a different steel frame and different setting moulds (see plate 2.10 on page 55), but the materials are the same. The moulding and curing process is the same as for the pan-tiles but the nibs and wire loops are fitted when the tile has been placed on the setting mould.

### 2.3.2 Properties And Advantages Of FCR Tiles

FCR tiles can be the cheapest and most durable locally made roofing material. Fibre reinforced cement tiles are thinner in section and easier to handle during installation than unreinforced concrete tiles which are heavier due to their thickness. The production of FCR tiles is adaptable to any level of production, hence decentralization of FCR tile production is possible.

i) Durability. FCR tiles have high fire resistance, superior thermal and acoustical performance when compared to the galvanised corrugated iron sheets (G.C.I.). Kenya Bureau of Standards (KBS) standards require that one FCR tile should support a minimum weight of 25 kg and that the tile should not crack when a 250g steel ball is dropped onto it from a height of 0.5 metres. This is to ensure that the tiles do not break or crack from the impact of dropping fruits, overhanging branches or hailstones. The percentage of fibre in the fibre concrete tile is not more than 1% by weight. The fibres add very little to the final strength of the tile which is properly manufactured and adequately cured. The main function of the fibres in the wet sand and cement mix is to prevent the formation of cracks during manufacture and curing. Cracks lessen the tiles resistance to impact damage.



ii) Permeability. FCR tiles compare quite favourably with alternatives like concrete and burnt clay tiles. The KBS standard with respect to permeability states:

The level of water should not drop more than 13mm in 24 hrs when a vertical tube is sealed to the top side of the tile and filled with water to a height of 250mm. And no drops of water should form on the underside of the tile.

iii) Thermal Insulation. The thermal insulation of a material is measured in terms of the "R" factor. The "R" factor is a measure of a materials resistance to heat transmission and it is expressed in " $\text{mm}^2\text{ }^\circ\text{K/Watt}$ ". A material with a high "R" value keeps a building cool when it is hot outside. When it is cold outside, the building remains warm.

Below are the insulation values for different roofing materials.

Table 2.5: Thermal Properties of selected Building Materials

Material	Approx. "R" values ( $\text{mm}^2\text{ }^\circ\text{K/Watt}$ )
G.C.I. sheets	
30 gauge	5.0
20 gauge	12.0
FCR Tiles (6mm thick)	2700.0
Asbestos Cement Sheets (6mm thick)	3100.0
Concrete Tiles (12mm thick)	5400.0
Clay Tiles (10mm thick)	12000.0

SOURCE: Agevi E., Alternative Construction Technologies FCR Tiles and Stabilized Soil Blocks. A paper presented at HRDU Seminar held on 31<sup>st</sup> March, 1987 at Silver Springs Hotel, Nairobi.

### 2.3.3 Disadvantages Of FCR Tiles.

The main disadvantage of FCR tiles is the availability and cost of equipment that is required for production. These are the screeding machine or vibrator and the setting moulds. Locally fabricated concrete moulds are much cheaper than imported plastic moulds, and locally manufactured fibreglass moulds (using imported components). For a viable small FCR tile production unit, at least 200 moulds are required. In 1988, imported plastic moulds cost KShs 350 per mould, fibreglass moulds cost KShs 156 per mould while concrete moulds cost KShs 22. The screeding machine/vibrator varies in cost depending on the manufacturer. The IIRDIU manually operated vibrator costing KShs 2,500 is the cheapest while those imported through John Parry and Associates are the most expensive.<sup>8</sup>

Apart from the cost and availability of equipment, there is also the limited availability and high price of cement. Cement is an important component of FCR tiles, and also for the making of the moulds. In cases where cement is expensive, FCR tiles may not be a viable alternative to other locally produced roofing materials. See table 2.6 on comparative costs of roofing materials.

**Table 2.6: Comparative Costs of Roofing Materials**

Material	Price per Unit	No. of tiles /m <sup>2</sup> in Kshs	Cost per m <sup>2</sup> in Kshs
Concrete tiles	15.60	10.00	156.00
Clay tiles	9.32	16.00	149.12
Asbestos roofing sheets of varying lengths(m) - 1.0, 1.5, 2.0, 2.5, 3.0			237.80
Corrugated iron sheets - varying lengths(m) - 2.0, 2.5, 3.0			
- gauge 30	59.16		130.50
- gauge 32	45.25		99.80
Fibre concrete roofing tiles	7.50	14.50	108.75

Source: Field Survey 1992

A further drawback to the spread of fibre concrete technology is the fact that the durability and strength of FCR tiles are directly dependent on the quality of workmanship during production, curing and storage. Apart from the skills of the workers, there must be adequate and regular quality control measures. Poor handling during transportation and installation of FCR tiles may lead to the breaking, cracking or loss of strength of the tiles before beginning their service life. Faulty workmanship in production and installation of FCR tiles may lead to the fibre concrete technology being referred to as substandard technology. Newly introduced materials face a lot of mistrust before they get to the stage where they are widely accepted and used.

Table 2.7 shows the comparative advantages of appropriate building materials in terms of cost reduction in the construction cost of each element in a building.

**Table 2.7: Cost Reduction when Alternative Materials are used for building**

	Element of Building	Relative cost %	Conventional Materials	Alternative Materials	Cost Reduction %	Relative Cost Reduction %
1	Foundation	3	Concrete or Reinforced Concrete	Concrete only	0.15	0 - 0.45
2	Floor Slab	10	Concrete or Reinforced Concrete	Stabilized Earth and Cement Screed	30	3.00
3	Walling	30	Concrete Blocks	Soil-Cement Blocks	10-45	3 - 13.50
4	Doors and Windows	10	Steel	Timber	0-10	0-1.00
5	Roofing	5	Steel/Timber trusses Asbestos or GCI Sheets	Timber trusses or FCR tiles	20-50	1 - 2.50
6	Plastering	6.5	No change	No change	N/A	N/A
7	Painting	15	PVA oil or water paints	Zamox colour wash/limewash	25	3.75
8	Glazing	4	Glass	Timber	30	1.20
9	Electrical Wiring	10	No change	No change	N/A	N/A
10	Plumbing	6.5	No change	No change	N/A	N/A
TOTAL REDUCTION					11.95 - 25.4 %	

**SOURCE:** National Housing Authority "Impact of Building Costs and Hindrances in the use of Local Building Materials in Zambia" in proceedings of the Symposium on Development and Use of Local Building Materials for Low-cost Housing in Africa, Shelter Afrique, 1989.

#### **2.4.0 TRANSFER AND DISSEMINATION OF APPROPRIATE BUILDING TECHNOLOGY.**

The research, development and dissemination of appropriate building technologies and materials the world over is characterised by the involvement of many organizations; international, local, quasi-governmental and non-governmental bodies; the common objective of these organizations being to develop and disseminate building technologies and materials that will result in the construction of affordable housing. In Kenya, the situation is the same.

Serious, capable and experienced people (engineers, scientists and managers) co-operating with base groups in the field of appropriate technology. Thousands of projects run by hundreds of organisations, institutes and groups worldwide. That is the picture of appropriate technology today.<sup>9</sup>

FCR tiles and stabilized block technologies are relatively new when compared to conventional building technology. Consequently, more challenges are faced when trying to disseminate a new technology.

The potential beneficiaries of appropriate technology are invariably drawn from the economically weak sections of society with very limited purchasing power. In conventional technology, beneficiaries are economically powerful and form a significant market for conventionally produced goods.<sup>10</sup>

Dissemination of conventional technology is done by commercial enterprises through the profit-seeking motive. Dissemination of appropriate technology, whether in the construction industry or any other sector, cannot be left to the market forces alone, since the purchasing power of the potential beneficiaries is very limited. The appropriate technology movement, especially in the area of shelter provision, has to come to terms with the following fact.

The control of western large-scale labour-saving technology places enormous political and economic power in the hands of the elites.<sup>11</sup>

It would not be in the interests of these elites and economically powerful sections of any society to change their attitude towards technologies and materials that are aimed at benefiting the poorer members of that society. For appropriate building technology to take root in any country, the politically powerful groups in that society must favour it or support it. It is therefore imperative that this technology receives adequate political backing.

On a global basis, wherever appropriate technology has started taking root, four main attitudes are identifiable.

- (i) Rejection of the concept
- (ii) Acceptance of the idea in principle
- iii) Active involvement in knowledge, mobilization and experimentation.
- iv) Willingness to apply the concept as a normal part of business administration and community activity.

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There is an urgent need for those involved in the research, development and dissemination of appropriate building technology to focus on the development of a political-economic climate that is conducive to the dissemination and acceptance of these technologies and products.

While the concept of appropriate technology has come of age, the national and international action required for its implementation is not yet commensurate with the magnitude of the task and challenge that it poses.<sup>13</sup>

A lot more effort is required to bring appropriate technology at par with conventional technology.

The appropriate technology effort as judged by the number of projects, the extent of funding and the development of manpower is quite inadequate compared to the enormous magnitude of the task and as indicated by the vast possibilities of appropriate technology.<sup>14</sup>

Appropriate technology, especially in the construction sector, has not been sufficiently institutionalised unlike conventional technology, whose dissemination has largely been effected through commercial organisations and the profit seeking mechanism. The dissemination of appropriate technology requires the provision of essential supporting services and political backing. There is insufficient emphasis on the development of the supporting services for intermediate technologies. This may be seen as a constraint which is internal to the process of dissemination of that technology. In the case of appropriate building technologies and materials production, supporting services include the fabrication and production of affordable equipment and the training of potential users of the materials in the production and use of such materials.

The provision of support services and infrastructure for the dissemination of appropriate technology should be the responsibility of the governments since it is only governments which are in a position to do so. Active political support from the government for the dissemination of technologies appropriate to the poor is a necessary and vital condition for the effective dissemination of such technologies.

The government is the only institution which can provide the catalytic effort and machinery required to disseminate appropriate technologies and products.<sup>15</sup>

Active participation and involvement of the target groups is a prerequisite condition to effective dissemination of appropriate technology especially in the area of housing production. Limited contact with the potential beneficiaries of the technologies (potential users of appropriate materials) is normally a limitation on the appropriateness of those technologies and products.

The main problems of appropriate technologies, be they in the building industry or any other sector, arise due to the lack of appropriate technology groups and institutions at all levels in society. These institutions should be at divisional, district, provincial and national levels. In those countries where such groups exist at these levels of administration, the main problem is that of co-ordinating their appropriate technology efforts and activities.<sup>16</sup>

In Kenya, there are several institutions and organisations that are involved in the research, development and promotion of appropriate technologies and products especially in the field of shelter provision. These organisations and groups are varied in origins; some are local, others are international, some are public bodies, others are non-governmental. These organisations include the following:

(i) Local Public Agencies

- Housing Research and Development Unit.
- Appropriate Technology Centre for Education and Research, Kenyatta University.
- Centre for Research and Training, Karen.

(ii) Non-governmental Organisations

- Undugu Society of Kenya.
- National Council of Churches of Kenya.



- National Co-operative Housing Union.
- Mazingira Institute.
- Action Aid.

**(iii) International Organisations**

- Building Research Establishment (BRE), U.K.
- German Agency for Technical Co-operation (GTZ).
- Intermediate Technology Development Group (ITDG)
- United States Agency for International Development (USAID).

**(iv) Commercial Enterprises**

- Intermediate Technology Workshop (ITW).

Some of these organisations like BRE and GTZ have been basically involved in the funding of some of the projects carried out by HRDU. They may also be involved in other aspects of appropriate building technology e.g. the design and fabrication of the tools and equipment that are required for the production of FCR tiles and stabilized soil blocks.

The dissemination of appropriate building materials in Kenya has mainly been done and continues to be done through the use of demonstration projects. In these demonstration projects, a target group is identified (this could be a womens' group, youth polytechnic, school or clinic). The group is then trained in the production and use of these innovative materials; in this case, FCR tiles and soil-cement blocks. These groups are then expected to carry out similar projects elsewhere within the community, hence replicating the technology. For these

appropriate building technology projects to be replicated, there must be a socio-political climate and economic structure that favours appropriate technology. The official government attitude towards appropriate materials in Kenya has changed over time.<sup>17</sup> The change in the Government's attitude towards appropriate building materials has been mainly due to the increase in the magnitude of the housing problem. Reducing the cost of construction of a building is one way in which housing could be made more affordable to the greater majority of Kenyans.

In the colonial days and just after independence, the government of Kenya was totally opposed to the use of innovative building materials. There was strict enforcement of the building code requirements with respect to the materials that could be used for building in areas covered by the building and planning by-laws. In the 1970s, the government's attitude towards appropriate building materials smacked of indifference, yet it was acknowledged that there was a major housing problem in Kenya.

In the last decade, the government's attitude towards appropriate building materials was more positive. This resulted in the Kenya Low-Cost Housing By-law study being carried out. The recommendations of this by-law study were meant to allow for the use of innovative building materials like FCR tiles and stabilised soil blocks. Up to now these recommendations have yet to be implemented. The Building Code is still much the same way it was in 1968. There is no legislation that allows for the use of appropriate building materials and technologies. This lack of regulations that allow for the use of appropriate building materials is the single most important constraint to the effective promotion of such materials.

Effective dissemination and promotion of any technology is important because it ensures that there are no gaps between the research stage and the widespread adoption of the developed products. In the case of appropriate building technologies and materials, serious gaps exist in the transfer of these materials to the potential beneficiaries. This is a situation that exists not only in Kenya itself, but also on a regional scale between the various countries in East, Central and West Africa. The main reason for this is lack of regional co-operation with respect to appropriate technologies and materials research and development.

There is hardly any mechanism for promoting technology transfer among African countries in the area of building materials production. Ghana, Kenya and Malawi have, for instance, made progress in equipment innovation for fibre concrete roofing yet countries such as Nigeria, Somalia, Uganda and Zambia are dependent on imported equipment.<sup>18</sup>

The lack of institutional mechanisms for the exchange of technologies among African countries is a major stumbling block to the exchange of experiences in the field of appropriate technology. These countries cannot freely exchange information, skills and experience on the research and development of appropriate building materials. The development of national and international policies that focus specifically on appropriate building technologies and materials would help in creating useful information flows and exchange of skills between various African states.

The successful dissemination and promotion of appropriate building technologies and materials will be determined to a large extent by the scale of production. It is therefore imperative that an appropriate scale of production is adopted in the production of appropriate building materials. Small-scale production of building materials is much more suitable for use in a country like Kenya, where there is abundant unskilled labour. Large-scale factories in

most developing countries (including Kenya) operate below installed capacities, thus the economies of scale are not realised and consequently, production costs are high. Small-scale production of building materials has several advantages including the possibility of decentralisation. With decentralised production, transportation costs of inputs and products are reduced, and the product is ultimately cheaper than an alternative produced in a faraway factory.

Effective promotion and widespread adoption of any building material is, to a large extent, dependent on the availability of requisite skills to use that material in construction.

Construction skills are important to the extent that they can improve the durability of low quality building materials. Conversely, where skills are inadequate or deficient, good quality and durable materials can be wrongly used in construction thereby making indigenous materials unattractive.<sup>19</sup>

Consequently, the dissemination and promotion of appropriate building materials must go hand in hand with the training of potential users and producers of those materials. Without requisite skills in the handling of newly introduced materials, there is the danger of inefficiency and wastage of these materials during construction, resulting in unnecessary expense.

#### 2.4.1 Constraints Limiting the Adoption of Appropriate

##### Building Technologies and Materials.

Despite the obvious advantages of using appropriate building technologies and materials, there are constraints that limit the widespread adoption of such technologies and materials. It is commonly assumed that the main obstacle to the acceptance of innovative building techniques and materials is simple conservatism and inertia on the part of the construction industry. This

is not necessarily the only constraint. There are several others, which are even more critical than the conservative nature of the building industry. These constraints revolve around the following issues:

- (a) Quality control building by-laws, and planning regulations.
- (b) The cost and availability of necessary equipment.
- (c) Access to credit facilities for both potential producers and users of appropriate building materials.
- (d) Demand and markets for appropriate building products.
- (e) Availability of support services, eg, trained personnel and institutional capacity to disseminate appropriate technologies and materials.

(i) Quality Control And Building By-laws.

There are two important and main explanations for the persistence of low quality problems in the appropriate building materials field. First, there is the prevalent lack of skills, consequently incorrect production procedures in this sector. Secondly, and more significant, is the lack of standards and specifications for these innovative building materials. Where these standards, specifications and testing procedures for innovative building materials have been formulated, they have not been officially adopted. This is the situation in Kenya, with respect to standards and specifications for FCR tiles and stabilised soil blocks.

Standards are the basic framework for promoting quality production, but they are only effective if properly enforced.<sup>20</sup>

The lack of quality control measures for innovative building materials is a major constraint to the widespread adoption of these materials. This is so because most developers do not use a building material that is not legal. The lack of standards and specifications for innovative materials is because they have not received official recognition by the existing authorities.

Standards, specifications and testing procedures should be formulated, documented and administered as part of government regulatory procedures.<sup>21</sup>

In the African region, it is only in Kenya and Ghana where draft standards for the production and use of stabilised soil blocks have actually been formulated. In Kenya, these standards are yet to be adopted officially. Draft standards for FCR tiles have been formulated in Kenya and Malawi. These draft standards have yet to be adopted by the respective regulatory institutions in either country.

The lack of legislation that allows the use of innovative materials is an important constraint to the popularisation of these materials in Kenya. The failure by the Government to implement the recommendations of the Housing By-law Study by Saad Yahya (1980) is a prime example of these legal constraints to the commercialisation of innovative building materials.

The Kenya Low Cost By-law Study of 1980 gave recommendations on how to formulate revised building standards that would allow the use of innovative building materials. It recommended that building and planning standards should be performance-oriented and a wider selection of building materials could be permissible. These performance standards would ensure that more building materials would meet the basic requirements

(i.e. carrying out a certain function adequately) than is possible under the current building code and other building regulations. The current Building Code specifies the materials that are considered permissible. A revised building code should take the form of performance specifications.

The current building by-laws and planning regulations in Kenya are so rigid and prohibitive that their continued application will accentuate the hopeless situation of unaffordability of shelter to the majority of urbanites.<sup>22</sup>

Building regulations and standards are only meant to operate as guidelines. What is crucial is how they are applied in practice. It is therefore necessary to ensure that standards are formulated in a manner that can easily be understood by the people expected to apply them and abide by them.

#### (ii) The Cost and Availability of Equipment.

The commercialisation of a newly introduced building technology is a complicated and resource-consuming process. Another important constraint to the achievement of total commercialisation of innovative building materials like FCR tiles and stabilised soil blocks is the cost and availability of the necessary tools and equipment. The reason for this is that in most cases, innovative building materials are introduced through demonstration or pilot projects.

The experience in Kenya is that there is need to make available tools and equipment (eg block presses, vibrating tables, moulds, etc) that are affordable by potential users and particularly since the technology aims at community based institutions. The equipment should be maintainable without the required specialised skills.<sup>23</sup>

The problem of availability and cost of equipment is compounded by the lack of access to credit facilities by most small-scale producers of innovative building materials. Equipment and tools which are imported tend to be very expensive. Local fabrication and production of such tools and equipment should be actively promoted if production of appropriate building materials is to be brought to a scale comparable to that of conventional building materials.

(iii) Access to Credit Facilities.

There are very few financial institutions that would be willing and ready to lend money to potential small scale producers of innovative materials. This is because of the greater costs which would be involved in the administration of small loans suitable to such small-scale entrepreneurs. But more importantly, innovative building materials and technologies are still officially unacceptable. It is therefore risky to lend money to potential producers of building materials that are still not permissible under the building regulations. Until statutes that allow the use of innovative materials like PCR tiles and stabilised soil blocks are enacted, potential producers of these materials will have no access to formal sources of capital. This lack of access to credit creates shortage of working capital for such small scale building material producers. This shortage of funds would obviously lead to problems in the purchasing of vital resources for those small-scale producers of innovative building materials already in production.

A shortage of capital means that producers are unable to finance the building up of stocks. Many of these producers can produce only in small quantities and are unable to expand their output rapidly in response to sudden increases in demand. This has serious repercussions on the prospects for successful marketing and the expansion of production in the long term.<sup>24</sup>



Successful promotion of innovative building materials requires that both potential producers and potential users of these materials have adequate access to credit.

(iv) Demand and Markets for Innovative Building Materials.

The widespread adoption of appropriate building materials and technologies is determined to a large extent by market conditions and the demand for these materials.

In fact, it can be argued that the constraints which limit the adoption of indigenous materials are related to the demand for these products rather than to their production or supply.<sup>25</sup>

The low income section of society forms the main market for indigenous and innovative building materials. Yet, most of these people look upon innovative materials as being of poorer quality than the conventional factory produced alternatives. It is time for the propagators of appropriate technologies and products to try and cultivate a positive image for their products.

People buy a product or use a specific technology because it is economically attractive, socially useful or technically appropriate. But they are also influenced by its symbolic value and by their perception of the product's modernity.<sup>26</sup>

(v) Availability of Trained Personnel and Institutional Support.

The effective dissemination and widespread adoption of appropriate technologies and materials is also constrained by the lack of requisite skills in the correct usage of innovative

building materials. It is crucial that people involved in using innovative building materials like FCR tiles and stabilised soil blocks have the necessary skills in handling these materials.

Some basic training in the production and use in construction of innovative building materials is vital, although these skills are relatively simple and easy to acquire. The safety of construction and durability of appropriate building materials is directly dependent on the skills and competence of the labour. Innovative building materials could be wrongly used ending in unsound and unsafe construction. This might be blamed on the material when the workmanship is faulty.

The failure by many governments in many developing countries (Kenya included) to use innovative building materials in public or government sponsored housing projects is also a constraint to the widespread adoption of such materials. Governments are normally the single largest and most important provider of housing eg, for civil servants, low income housing, etc. The failure of these governments to use innovative materials limits the popularity of such materials. The use by governments of such materials for public housing projects would help promote their dissemination and adoption of innovative building materials.

#### 2.4.2 Ways of Achieving Widespread Adoption of Appropriate Building Technologies and Materials.

Successful promotion of appropriate building materials like FCR tiles and stabilised soil blocks can only be achieved if the constraints that have been singled out are tackled. These constraints are intertwined and interrelated, hence they must be looked at together. The

removal of a single constraint on its own will not ensure successful promotion of innovative materials.

(i) **Formulation of Standards for Innovative Building Materials.**

First and foremost there is need to formulate standards for those appropriate building materials that have been developed. Where these standards have been formulated, it is necessary that these draft standards are adopted by the relevant standards institutions.

Standards formulation is an important basis for promoting quality production of indigenous buildings, materials and, thereby, promoting their widespread adoption. However standards formulation is only justifiable if stipulated standards can be enforced.<sup>27</sup>

The standards institutions in most developing countries are too rigid. Yet, flexibility is essential and necessary if newly developed innovative building materials are to find their way to the markets. It is not necessary to subject innovative building materials to stringent and extensive field tests which are too costly. Building materials for use in single storey buildings do not have to be of strength equal to that of materials to be used on multi-storey buildings. These standards for appropriate building materials should be formulated in a simple and easy to understand form given the background of the potential users who may not have the benefits of formal education.

(ii) **The Revision of Building and Planning Regulations**

Building regulations in Kenya and other developing countries are very restrictive in the type of building materials that they allow for use. Building regulations can be very useful for

promoting newly developed building materials if they are revised with the objective of including such innovative materials.

The introduction of a two tier regulatory system need have no adverse effects in safety but would enable new materials to make an impact on the desperate need for affordable housing and other forms of shelter.<sup>28</sup>

Building codes provide the required technical instructions for construction practice. The reformulation of building codes has, of necessity, to include technical details on design and construction requirements when using innovative building materials.

Together with the reformulation of building regulations, these regulations must be made enforceable. The government can play a leading role in the promotion of innovative building materials by using these materials in most government sponsored housing projects.

### (iii) . Availability of Trained Personnel and Institutional

#### Support.

The lack of clearcut national policies on technology is one of the reasons for the limited ability of most developing countries to promote appropriate building technology. The institutional capacity to promote appropriate building technology is severely limited by the lack of proper planning and policy formulation.

The large number of educational and technical institutions that are already established in many countries should participate directly in the development and dissemination of appropriate technologies.<sup>29</sup>

The institutions that have been referred to above, include Universities and Polytechnics. They have valuable infrastructure and technically skilled manpower that could be useful in the dissemination and promotion of innovative building materials.

On the other hand, it may not be so easy to incorporate most of these institutions into the processes of developing, disseminating and promoting appropriate building technology since most of these institutions have varied organisational structures and systems and may not be flexible enough to be geared towards the appropriate technology field if they are involved in other technologies. There is also the danger of having too many organisations involved in the same efforts and not co-ordinating their activities resulting in wasteful duplication of appropriate building technology activities.

In the light of this, it is necessary to have an organisation which co-ordinates all the research, development and dissemination efforts in appropriate building technology carried out in a particular country. In Kenya, there are several organisations that are involved in the development and dissemination of appropriate building technologies and materials, but there is no authority that co-ordinates these efforts. This role of co-ordinating appropriate building technology efforts and activities could be played by the Department of Housing in the Ministry of Lands and Housing.

Facilities should be provided for the training of personnel who are supposed to go and train the potential users of appropriate building during demonstration projects. This can be done through the provision of training centres run by technically qualified staff.

(iv) Provision of Access to Credit Facilities.

Access to credit from conventional financial institutions by small-scale entrepreneurs will still be difficult even after the adoption of standards for innovative building materials and enactment of the relevant revised building legislation. It is necessary that innovative or non-conventional sources of credit are established so as to benefit such small-scale entrepreneurs.

Loans could be provided to these small-scale entrepreneurs at preferential interest rates. In this respect, governments are best placed to address these issues of innovative financing schemes for small-scale entrepreneurs. These efforts should focus not only on the production of innovative building materials, but also to related fields like the fabrication and production of tools and equipment.

In Kenya, the equipment used for the production of innovative building materials like FCR tiles and stabilised soil blocks is expensive. This is particularly true of the imported equipment, but even the locally fabricated equipment is still beyond the economic means of ordinary Kenyans who are the majority.

Together with the above measures to remove those constraints that hinder the widespread adoption of appropriate building technologies and products, there needs to be a change of attitude towards these innovative building materials by ordinary people. Most people tend to look down upon products that are not produced in conventional large-scale factories. There needs to be a complete re-education of citizens of any country that wishes to effectively promote the use of appropriate building materials.

## **2.5.0 CONCLUSION**

The properties and advantages of stabilised soil blocks and FCR tile technologies vis-a-vis those conventional building materials have been discussed in detail in this chapter. These advantages include;

- i) Appropriate building materials like FCR tiles and stabilised soil blocks are relatively cheap when compared to most conventional building materials.

Stabilised soil blocks and FCR tiles can easily be produced on a small scale

business.

There is less energy consumption during their production when compared to conventional factory produced building materials.

FCR tiles and stabilised soil blocks have superior fire resistance and greater thermal insulation properties when compared some conventional building materials like corrugated iron sheets and aerated lightweight concrete blocks respectively.

Despite these advantages, FCR tiles and stabilised soil blocks are not being widely used in Kenya. These constraints have hindered the effective transfer and adoption of these technologies from research and development institutions to the target beneficiaries.

The objective of the research in discussing these constraints to the effective transfer of building technologies that have been identified globally is to find out whether these constraints exist in Kenya, their extent and whether these are the only constraints or there are others that are peculiar or specific to the Kenyan situation.

Without the active government support to efforts to promote and popularise the use of FCR tiles and stabilised soil blocks and FCR tiles. Beyond writing up papers and organising numerous seminars on the reformation of building by-laws and planning regulations to encourage the use of appropriate building materials, the Government of Kenya has yet to give the necessary financial and administrative support to the popularisation of FCR tiles and stabilised soil blocks in Kenya today. The Government of Kenya must demonstrate a

willingness to apply the concept of appropriate building technology as a normal part of administration and community activity. The Ministry of Works and Housing has yet to construct staff housing or government offices using FCR tiles and/or stabilised soil blocks in any part of Kenya. How then is the general public expected to know that such building materials exist?

Building by-laws and planning regulations in Kenya do not allow for the use of FCR tiles and stabilised soil blocks. FCR tiles and stabilised soil blocks are not among the building materials specified in the Building Code consequently many people may be reluctant to use them. Although Kenya has draft standards for FCR tiles and stabilised soil blocks, they have yet to be gazetted. This may be seen as a lack of total commitment on the part of the government to promote and popularise the use of FCR tiles and stabilised soil blocks in Kenya as quickly as possible.

The lack of demand and ready markets for FCR tiles and stabilised soil blocks in Kenya may have a lot to do with peoples personal preferences and tastes and their perceptions of these two building materials. The general public's awareness of these two building materials and their apparent advantages over similar materials that are conventionally produced in Kenya today is not that much. Greater public awareness of FCR tiles and stabilised soil blocks has to be created and natured if the constraint of lack of demand and ready markets for these two building materials is to be overcome.

Cost and availability of equipment and machinery and the issue of access to credit facilities by the potential producers and users of FCR tiles and stabilised soil blocks are closely intertwined. Some of these equipment and machinery used to produce these two building



materials especially the imported variety is very expensive. Even the machinery and equipment made/fabricated locally may be expensive to an individual but relatively cheap for co-operative groups and schools, etc, to purchase. In Kenya, there are few manufacturers of block presses and vibrating tables and these few are based mainly in Nairobi and a few other large towns.

It is important therefore to find out to what extent these constraints which have been discussed in this chapter apply to Kenya and if the suggested solutions to these problems are fully applicable in the Kenyan situation or if they may have to be modified to suit any peculiarities that are identified.

The following chapter gives the historical development of FCR tiles and stabilised soil block technologies in Kenya, the main organisations involved in promoting the use of these two materials and some of the projects where houses have been built using FCR tiles and or stabilised soil blocks.

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**HISTORICAL DEVELOPMENT OF ECR TECHNOLOGY IN KENYA.**

Research on the use of concrete technology was done at Nairobi by Leonard Njiru and the Director General for Housing Research. After this initial research in concrete and clay masonry technology was done in Ahmadu Bello, Kenya and Guyana, Concrete Roofing (ECR technology) was spread to various other countries as following:

- 1) Zambia
- 2) Zimbabwe
- 3) Malawi
- 4) Egypt
- 5) Columbia
- 6) Sudan
- 7) Bangladesh
- 8) Honduras
- 9) Sri Lanka
- 10) Indonesia
- 11) Fiji
- 12) The Dominican Republic
- 13) Gambia

## CHAPTER THREE

### THE DEVELOPMENT OF FIBRE CONCRETE ROOFING AND STABILISED SOIL TECHNOLOGIES IN KENYA

#### 3.1.0 THE HISTORICAL DEVELOPMENT OF FCR TECHNOLOGY IN KENYA.

Initial research on fibre concrete technology was done in Sweden by Lennart Nilson with funding from the Swedish Council for Building Research.<sup>1</sup> After this initial research in Sweden, further research in fibre concrete technology was done in United Kingdom, Kenya and Tanzania. So far, Fibre Concrete Roofing (FCR technology) has spread to several other countries which include the following:

- (i) Zambia
- (ii) Zimbabwe
- (iii) Malawi
- (iv) Egypt
- (v) Columbia
- (vi) Sudan
- (vii) Bangladesh
- (viii) Honduras
- (ix) Sri Lanka
- (x) Indonesia
- (xi) Fiji
- (xii) The Dominican Republic
- (xiii) Gambia

(xiv) El Salvador<sup>2</sup>

Malawi's experience in Fibre Concrete technology dates back to the 1970's. The Rural Housing Programme (RHP) in Malawi has been closely linked to the development of FCR Technology in that country. FCR technology was first introduced in Malawi by missionaries but they encountered several technical problems with respect to production and installation of the original ITDG FCR sheets. The Rural Housing Programme of Malawi investigated these problems, and drew up guidelines on the best methods of production. The RHP modified the original ITDG FCR sheets - reduced the weight and size and also changed the method of installation of these sheets on a roof structure. Workshops for the production of FCR sheets in Malawi were set up by the Malawi Housing Corporation.<sup>3</sup>

In Kenya, research in FCR Technology began at the Appropriate Technology Centre of Kenyatta University. This research in FCR technology was carried out by Dr. D. G. Swift and Prof. R. B. L. Smith; who started this work in 1976. This work at the Appropriate Technology Centre in Kenyatta University was carried out in conjunction with the Department of Civil Engineering, University of Nairobi.<sup>4</sup> Funds for the research were provided by the Swedish International Development Agency (SIDA) and the United Nations Food and Agricultural Organisation (FAO). Initially, Swift and Smith developed and tested a method of making FCR sheets. These FCR sheets were heavy and generally more expensive than the FCR tiles we see today. These FCR sheets were expensive and heavy because the mix had to be made in the 2:1 cement to sand ratio and the sheet had to be thick. The production process was manual, this made these



sheets even more expensive and the rate of production was very slow. The large size of these FCR sheets made installation on a roof structure very difficult. The weights of these FCR sheets meant that the roof structure was to be made carefully and strong enough to support these sheets without warping, twisting and cracking. FCR sheets have now been superseded by FCR tiles, but the initial research work and field testing of the FCR sheets by Smith and Swift led to the development of FCR tiles. The development of FCR tile technology owes much to the efforts of Swift and Smith and to the organisations that paid for this research work.

Intermediate Technology workshops (John Parry and Associates) started work on FCR tile production in Kenya in 1983. John Parry and Associates had started research work on FCR tiles in the United Kingdom with funding from the British Overseas Development Agency (ODA). In 1983 John Parry had developed the process of making tiles on a vibrating machine that was battery powered.

While the concept of vibrating concrete to compact the mix and add strength is quite old, as are the general forms of the profiles that Parry uses, Parry's innovation was in the application of these practices to fibre concrete.<sup>5</sup>

John Parry and Associates was the first firm to bring to Kenya a tile production kit which includes a vibrating machine and a set of plastic moulds. At the time John Parry and Associates were introducing this tile making kit into Kenya, a similar process had been developed in Malawi by Fred Jan Twigt, the vibrating machines were manually operated.

In 1984, Intermediate Technology Workshops (Kenya) the firm established in Kenya by John Parry and Associates to produce and market FCR tiles in Kenya had sold about seven tile making kits and had assisted five small-scale tile producing firms/individuals to start tile production.<sup>6</sup>

Apart from ITW (Kenya) which is a commercial enterprise, there are non-governmental organisations and public bodies that were involved in promoting the production and utilisation of fibre concrete roofing tiles. Action Aid Kenya is one of such non-governmental organisations that has undertaken several projects using fibre concrete roofing tiles and has helped design and fabricate equipment for tile making which is cheaper than ITW package.

Action Aid Kenya became closely involved in the promotion and dissemination of fibre concrete roofing tiles in 1983 after acquiring a John Parry tile production machine. By the end of 1984, four production units had been set up by Action Aid Kenya in Kiboswa in Kisumu District, Kibwezi in Machakos District, Webuye in Bungoma District and Kariobangi in Nairobi. The tiles produced by these units were used on Action Aid Kenya's demonstration projects which are mainly schools. Through these demonstration projects of Action Aid Kenya, local youth groups and local artisans were trained in the production and use of FCR tiles.

Housing Research and Development Unit (HRDU) is the principal public agency that has been involved in the promotion and dissemination of FCR tiles in Kenya. HRDU was particularly involved in designing of a hand-cranked vibrating machine. This machine was supposed to be a cheaper alternative to the expensive

imported Parry tile making package. This hand-cranked machine designed by HRDU and fabricated by Hartz and Bell (These are the manufacturers of machinery) was not very strong and all the machines that were field tested by Canadian Save The Children were no longer operational after minimal use, although in other areas the HRDU machines have done quite well.

The ITW tile production kit was costing a total of KShs 130,000/= . The package includes 200 imported plastic moulds (see table 3.1), batch boxes and miscellaneous equipment. The total cost of the tile making kit together with the cost of acquiring land and putting up a building and a water tank in 1989 was more than KShs 150,000/= . The capital cost of setting up a tile production unit using ITW equipment and machinery could be at least KShs 150,000/= (see table 3.1). Action Aid tile production kit with 200 locally made concrete moulds and miscellaneous equipment similar to that of ITW kit was costing about KShs 15,000/= in 1989. The additional cost of buying land, putting up a water tank and building made the start-up cost of a tile production unit to be KShs 35,000/= in 1989.<sup>7</sup>

Action Aid-designed tile making machines are fabricated by the Undugu Society's Metal Production Unit. There are three different types of Action-Aid tile vibrating machines;

- (i) . . . Pedal operated
- (ii) . . . Treadle operated
- (iii) . . . Electric FCR tile machine

**Table 3.1: Costs of various types of tile moulds. (1988/89 prices)**

Type of mould	Cost per unit KShs	Cost of 200 moulds	Origin/Source
Plastic moulds	350/=	70,000/=	Imported from Britain through ITW Kenya
Fibre glass moulds	180/=	36,000/=	Produced under licence in Nairobi by Sai Raj
Concrete moulds	25/=	5,000/=	Can be locally produced

**SOURCE:** Agevi E.

Country Paper on status of some promising local building materials in Kenya Workshop in Nairobi. 31st May - 3rd June 1989, Page

The Action Aid tile making machines are cheaper than those of ITW. By 1988, ITW had sold 43 tile making kits as compared to 68 tile vibrators sold by Undugu Society. By March 1989, Undugu Society had already sold 24 tile production machines.<sup>8</sup>

Currently, it is estimated that there are about 50 small scale tile production units in Kenya. Theoretically, these tile production units have the capacity to produce 2 million tiles annually.<sup>9</sup> In Nairobi there are two individual small scale producers making tiles, two women's groups are also producing tiles for sale and for use for their houses. Shelter Works - a tile making unit in Dagoretti Corner in Nairobi has the capacity to produce an average of 700 tiles per day. The other private firm in Nairobi producing tiles is Shelter Sure which has a capacity to produce 500 tiles per day. The tile production units owned by Kayole and Mihango Muungano Women's group in Kayole, Nairobi produces about 400 tile per day. Both this group and the other group in Komarock, ie, Humama Women's group were financed by African Housing Fund. Humama Women's group tile production unit with 9 screeding machines had the capacity to produce 4200 tiles per day.

The activities of both HRDU, and Action Aid Kenya have significantly increased peoples' awareness about FCR tiles in Kenya but there have been several limitations to the widespread manufacturing and utilisation of these tiles. First and foremost, these organisations, eg, youth groups, youth polytechnics, women's groups, Teachers/Parents associations and similar organisations in the target community which are being used as entry points for FCR technology dissemination and promotion do not have the financial capacity to manage the tile making business properly. For instance, most youth polytechnics in Kenya do not have the money to effectively train their students, year in year out in FCR tile production and use. This therefore limits potential use of FCR tiles. The youth groups trained by

Kenya cannot manage their FCR tile production units independent of financial and management support from Action Aid Kenya.

Training of these community groups is intermittent - this is done as the demonstration project is being started. Training should be because of the dynamic nature of the building material industry. There need to be various modes of teaching these community groups because of their characteristics. For example, training a women's group to manage a production unit should be different from the training of students of a youth centre.

Though FCR tiles have been utilised on several projects, that are being used on demonstration projects for purposes of disseminating this technology throughout Kenya, they have yet to gain acceptance as an alternative roofing material that is cheap and yet quite durable.

## THE HISTORICAL DEVELOPMENT OF STABILISED SOIL BLOCK TECHNOLOGY IN KENYA.

Mud has been used as a building material for many centuries throughout the world and this is particularly true for North Africa and the Middle East areas. Some of the buildings constructed using mud many years ago still stand. Mud is still being used by majority of people within the rural areas and the settlements in the urban areas of most, if not all, Third World countries.

Today, more than a Thousand Million people live (or survive) in dwellings made of adobe, puddled clay or earth blocks. <sup>10</sup>

In Kenya, Zambia, Turkey and Egypt, more than 50% of the rural populations live in housing built using mud or soil.<sup>11</sup> In Tanzania, the proportion of housing built using mud is about 60%. Soil construction is the most common form of house construction in rural Ghana.<sup>12</sup> Unfortunately, the method of construction in these rural Ghana houses does not present a positive image of soil as a building material. These houses which are built using wattle and daub or adobe blocks are not durable. The walls of these houses are subject to destruction by rain water and the foundations of these houses are normally destroyed by insects. Consequently, soil as a building material is not popular in Ghana; even in the remotest rural areas, concrete and iron sheets are chosen as a material for building a house for those who can afford.

There are several methods of using earth as a construction material for houses. The following are the most common;

- (i) Wattle and daub.
- (ii) Adobe or sun dried mud blocks.
- (iii) Rammed earth (Pise).
- (iv) Stabilised soil blocks.

(a) Wattle and daub construction.

This method of building the walls of a house is extensively used in rural areas and in some slum areas of towns. Wattle and daub is made by the initial

erection of a framework of vertical posts and thin horizontal poles. After the framework is complete, the house is roofed, then the mud is 'daubed' on to this framework externally and internally. The main disadvantage of the wattle and daub method, is that shrinkage cracks occur. These walls can be plastered using sand-cement mortar, cowdung or mud plaster. This plastering with cowdung or mud has to be repeated frequently because of the effect of rain on such walls.

(b) Adobe construction.

Adobe blocks are sun-dried mud blocks. These blocks are made by placing moist soil in moulds or are moulded by hand. The moulds are removed after a short while, after which these blocks are cured in the sun for between two to four weeks. Sun-dried blocks or adobe blocks are common in the rural areas of Kitui, Machakos, Meru and Kakamega Districts. The main disadvantage of these adobe blocks is that they have very uneven surfaces because they are not evenly compacted. Adobe blocks also tend to break easily, particularly at the edges. Because these kind of blocks are not even in sizes, a lot of mortar is required when constructing a wall. Adobe blocks have a low compressive strength of not more than  $1.37 \text{ N/mm}^2$ .<sup>13</sup>

(c) Rammed earth construction.

In this method of using earth for building a wall, the moist soil is rammed manually between two shutterings on both sides of the wall under construction. After one layer is complete, The framework/shuttering is raised. This ramming is done in layers which are 300mm high and the wall may have a thickness of between



150mm and 200mm. Rammed earth construction is common in Kisii District but not on a scale comparable to that of Wattle and daub. A few houses were built in Kileleshwa and South 'B', Nairobi, after the Second World War. These houses were plastered internally and externally to protect them from the elements.

The main disadvantage of rammed earth construction is that a lot of wood is required for the shuttering. Secondly, to be able to produce good quality walls, it needs higher construction skills than the two methods which have been discussed earlier. Rammed earth construction remains a method of construction that is not common in many parts of Kenya, and Africa in general. In Thika, 64 rammed earth houses were built in 1982. So far, this remains the biggest project of house construction using rammed earth.

(d) Stabilised soil blocks.

When soil blocks are compressed without adding a stabilising agent, eg, cement, lime, bitumen and rock dust to the soil, the walling made of such blocks is very susceptible to erosion by water. Adding a stabiliser to the soil and then compressing the blocks mechanically makes these soil blocks much stronger than adobe blocks.

In Kenya, active research in stabilised soil block technology has a history dating back to 1981. In Tanzania, stabilised soil blocks have not as yet had the desired impact on the construction market. In Uganda, some projects have introduced the use of stabilised soil blocks but these have yet to be taken as "open market" building materials. The cases of Uganda and Tanzania are not isolated;

Ghana and Nigeria are in the same position with respect to the status of stabilised soil blocks in the building industry. Ghana has a history of using stabilised soil blocks since the end of the Second World War in parts of Kumasi yet stabilised soil blocks remain a marginal building material. The reasons for this state of affairs are;

- (i) The unwillingness of the public sector in Ghana to amply and effectively demonstrate this technology in public construction projects.
- (ii) The very few examples of housing constructed using stabilised soil blocks are not enough to help popularise the technology. <sup>14</sup>

As already mentioned, active research in and development of the stabilised soil block technology dates back to 1981 when HRDU and the overseas division of Building Research Establishment (BRE) signed a memorandum of understanding to cooperate in the area of research in stabilised soil block technology on the behalf of their respective governments. The broad objectives of this agreement was to solve the problem of shortage of housing.

The following are the issues that particularly concerned this joint research;

The identification and testing of soils.

Soil stabilisation using cement.

- (iii) Production of these stabilised soil blocks and subsequent testing of dry and wet compressive strength, moisture penetration and shrinkage ratios.
- (iv) Field testing of the "Bre-Pak" block press and clay crusher donated by BRE.
- (v) Laboratory experiments and demonstration talks at the Faculty of ADD by expert from BRE.
- (vi) Field demonstration projects by HRDU technical staff with technical support from BRE expert.
- (vii) Production of stabilised soil blocks on site and construction of 50m<sup>2</sup> Kabiro Clinic demonstration structure at a cost of KShs 700/= per m<sup>2</sup> (Kabiro Clinic is in the Kawangware area of Nairobi).
- (viii) Monitoring, recording and evaluation of the performance of the structure at Kabiro clinic and reactions of users." <sup>15</sup>

HRDU and BRE joint research and development of stabilised soil block technology also extended to the dissemination of the same through the U.S.A.I.D. sponsored projects in the Improved Rural Technology (IRT) programme for low cost housing.

Apart from this joint research with BRE, HRDU had sought co-operation with the German Agency for Technical Co-operation (GTZ) in 1977. In 1983, an agreement was signed between Kenya and the (then) Federal Republic of Germany. This agreement saw the beginning of the HRDU/GTZ low cost housing technologies project. The main aim of this project was to develop, test and demonstrate low cost construction technologies in the various climatic zones of Kenya. These

technologies were to be based on local resources and simple enough for easy use by ordinary Kenyans. This project is still on-going after the initial soil identification and testing and construction of demonstration houses in the four main climatic zones of Kenya. The aim of these demonstration projects is to help disseminate stabilised soil block technology and to test and improve the designs of equipment used in stabilised soil block production.

Imported block presses are very expensive, for instance, the Bre-Pak block press that was initially used by HRDU. This block press has a hydraulic component that frequently breaks down and is very expensive to replace. Although the Bre-Pak produces good quality soil-cement blocks, it is expensive to maintain, thus it is better to buy locally made block presses. Most locally made block presses, on the other hand do not produce good quality soil-cement blocks because their compacting force is low. The best block press is therefore one which is relatively cheap to buy and maintain and produces relatively strong soil blocks.

Apart from public institutions like HRDU, there are non-governmental organisations that have been closely involved in the development of stabilised soil block technology in Kenya, particularly in the design and fabrication of quality block presses. Action Aid Kenya is one such organisation. The Action-Pak was designed by Action Aid engineers after they re-evaluated the original Action Aid block presses designed by Bonner, ie, the Bonner-Pak. The Action-Pak block presses cost about KShs 11,000/= at the beginning of 1991.<sup>16</sup> Currently, Action Aid Kenya is designing a block tester. A block tester would ensure that only good

Quality soil blocks were used for wall construction. Bad quality construction as a result of poorly made stabilised soil blocks would work against the popularisation of this technology in Kenya and elsewhere.

Both Action Aid Kenya and HRDU have used and continue to use demonstration projects to disseminate stabilised soil block technology. Action Aid Kenya works through its Schools Construction and Maintenance (SCAMS) programmes. HRDU has worked through youth polytechnics, training both the staff and students in this technology through the construction of staff houses using stabilised soil blocks and FCR tiles.

## **10 THE DISSEMINATION OF STABILISED SOIL BLOCK AND FIBRE CONCRETE ROOFING TECHNOLOGIES IN KENYA.**

A variety of institutions and organisations are involved in the development and dissemination of stabilised soil block and FCR tile technologies in Kenya. There are international organisations which are primarily involved in funding the local agencies that disseminate the use of these two appropriate building materials.

International donor agencies include the following;

- i) Building Research Establishment
- ii) United States Agency for International Development (USAID)
- iii) German Centre for Technical Co-operation (GTZ)
- iv) The Ford Foundation

v) The United Nations Centre for Human Settlements (UNCHS - Habitat)

The above five international, bilateral and multilateral organisations are the main funding agencies for most local organisations involved in the development and dissemination of appropriate building technologies.

Besides the above five agencies, there are several others that are involved to a lesser extent in financing research in appropriate building materials by local organisations. These include;

- (a) United Nations Development Programme (UNDP)
- (b) International Development and Research Centre (IDRC)
- (c) United Nations Children Educational Fund (UNICEF)
- (d) Danish Agency for International Development (DANIDA)
- (e) Swedish Agency for International Development (SIDA)
- (f) Canadian Save The Children
- (g) Overseas Development Authority (ODA)
- (h) European Economic Community (EEC)
- (i) United Nations Food and Agricultural Organisation (FAO)
- (j) Canadian International Development Agency

The organisations and institutions that are actively involved in the research and promotion of both stabilised soil block technology and FCR tile technology are varied in origin. Some like HRDU are public institutions, others like Intermediate Technology Development Group are international charity organisations which aim to promote intermediate technologies. The list of organisations that were surveyed

is not exhaustive. These organisations which have been listed are basically the main organisations in Kenya which are well known and are directly involved in promoting the use of stabilised soil blocks and fibre concrete roofing tiles. Below is a list of these selected agencies that are promoting stabilised soil block and FCR tile technologies in Kenya.

- (a) International Non-governmental Organisations.
  - (i) Intermediate Technology Development Group
  - (ii) Action Aid Kenya
- (b) Local or National Non-governmental Organisations.
  - (i) Undugu Society of Kenya
  - (ii) National Co-operative Housing Union (NACHU)
  - (iii) National Council of Churches of Kenya (NCCK)
  - (iv) Mazingira Institute
- (c) Local Public Institutions
  - (i) The Appropriate Technology Centre for  
Education and Research, Kenyatta University
  - (ii) Centre for Research and Training, Karen
  - (iii) Housing Research and Development Unit (HRDU)
- (d) International Public Agencies
  - (i) African Housing Fund (AHF) - Shelter Afrique
- (e) Commercial Enterprises

- (i) Intermediate Technology Workshops (John Parry's and Associates)

### 3.3.1 Intermediate Technology Development Group (ITDG)

ITDG is a non-profit making, non-governmental organisation which was established in the United Kingdom with the aim of promoting intermediate technology. ITDG receives funds from the Overseas Development Authority (ODA) and the European Economic Community (EEC).

In Kenya, ITDG has focused on the dissemination of the FCR tile technology. This has been done through training potential entrepreneurs in the various aspects of tile production including technical and management issues. The potential producers of FCR tiles who were selected for training by ITDG could be individuals or groups. Between 1986 and 1988, ITDG had selected about 12 potential producers of FCR tiles for training on a pilot basis. ITDG, in this case, was to be responsible for the initial training in business or management and technical aspects of running a tile production unit. These potential entrepreneurs, after this training, were to obtain loans from Small Enterprises Finance Company (SEFCO) and Kenya Industrial Estates (KIE).

Apart from the training of possible entrepreneurs, ITDG has also emphasised dissemination of FCR tile technology through promotional seminars and workshops to train potential producers and users of FCR tiles. Participation in the major Agricultural Society of Kenya Shows has also been a forum through which ITDG



has tried to disseminate FCR tile technology. Currently ITDG has set aside about 80% of its budget annually for its activities in the promotion of FCR tile technology.<sup>17</sup>

ITDG works closely with other non-governmental bodies, both local and international, eg Action Aid Kenya and training institutions like HRDU. Training institutions provide facilities where ITDG trains potential producers and users of FCR tiles through workshops and seminars.

### 3.3.2 Action Aid Kenya

Action Aid Kenya is a non-governmental organisation that is actively involved in the development and dissemination of appropriate building technology. Action Aid Kenya was born from very small beginnings in the 1970's when "Action in Distress" first began operations in Kenya. Action Aid Kenya has since grown and supports community development programmes in agriculture, health, water and sanitation, adult literacy, income generation and small scale business development, and low-cost building technologies.

Action Aid Kenya raises the majority of its finances through the process of "child sponsorship". The system of "child sponsorship" means that a needy primary school child from a poor community in Kenya is identified and put into contact with a sponsor in Europe. This sponsor contributes a certain amount of money to Action Aid. The money is then used for projects that benefit the community in which the child lives.

Action Aid Kenya also raises money through funding for specific projects by organisations like ODA, EEC, UNICEF, and several others.

Action Aid Kenya has been one organisation that has been actively involved in the dissemination of FCR tile and stabilised soil block technology. The Appropriate Technology Unit is the division of Action Aid which deals with issues related to research in technology. The Appropriate Technology Unit has focused on the design and fabrication of good quality local tile vibrating machines and block presses, and the training of people in the production and use of these materials.

Action Aid Kenya became involved in the promotion of stabilised soil block and FCR tile technology because of its schools improvement projects. The walls in these schools built by Action Aid Kenya are made of stabilised soil blocks and the roofing is done using FCR tiles. Both these materials are produced on site. The schools construction and improvements programme serves two main purposes: First and foremost, it provides better quality school buildings especially those in slum areas of Nairobi. Secondly, these schools serve as demonstration projects where stabilised soil blocks and FCR tiles are introduced to the community. They serve to arouse peoples awareness and interest in stabilised soil block and FCR tile technology. In these demonstration projects, Action Aid Kenya encourages community participation to help reduce labour costs of material production and construction of the buildings. Action Aid Kenya also trains the local artisans on the production and use of soil blocks and FCR tiles through these demonstration projects. So far, Action Aid Kenya has carried out demonstration projects in

he in Isiolo District, Ngunyumu, Korogocho and Baba Dogo Primary within Nairobi's sprawling slum settlement. Action Aid Kenya has also put demonstration projects in Funyula Primary school in Busia District in Province. These are some of the projects that Action Aid Kenya has put with the aim of improving school buildings disseminating appropriate building technologies.

Action Aid Kenya allocates about 6% of its annual budget to the development appropriate technology projects and only about 3% on projects that aim at the development of appropriate building technologies and materials.<sup>18</sup>

Action Aid Kenya, in its schools improvement programme, has faced several problems like the lack of enough qualified staff to train the selected local artisans making material production and use. Secondly, funds for carrying out these demonstration projects are not always adequate.

### Undugu Society of Kenya

The Undugu Society of Kenya is a local non-governmental organisation which was established in 1973. Undugu Society of Kenya is involved in more than low-cost shelter provision. Undugu Society's community development activities are primarily aimed at the slums of Nairobi although other urban areas of Kenya benefit from its projects. Undugu Society works with Action Aid Kenya, especially in the area of equipment and machine fabrication. Undugu Society's Metal Production

Unit has been producing both the tile vibrating machines and block presses that have been designed by Action Aid engineers.

Undugu Society of Kenya obtains funds from various sources, including its own income generating projects within Nairobi which include workshops for metal production, car repairing and furniture making. Other sources of funds which are project specific include the Ford Foundation, Norwegian Agency for International Development (NORAD), Intermediate Technology Development Group from the United Kingdom and many other international organisations.

Undugu Society spends about 7.5% of its annual budget on projects that promote low-cost shelter construction materials.<sup>19</sup> Undugu Society has been involved in the promotion of stabilised soil block and FCR tile technologies in Kenya for some time, especially in the field of fabrication of good quality but cheap local equipment and machines for block making and FCR tile production.

Undugu Society, in its community development project, works closely with other non-governmental organisations like Action Aid Kenya, National Co-operative Housing Union (NACHU), National Council of Churches of Kenya (NCCCK) and ITDG. This is especially true for the low cost shelter programme.

#### 3.3.4 National Council of Churches of Kenya (NCCCK).

The NCCCK represents about 40 different churches and private religious organisations in Kenya. It is one of the oldest and most active non-governmental organisation in the area of community improvement projects including low-cost

shelter provision. NCKK has been involved in programmes to assist both the rural and urban poor. NCKK has about 60 members of staff in its Urban Community Improvement Programme and it emphasises community participation in all their shelter provision projects within the selected communities.

The most well known shelter provision project carried out by NCKK is the Mji wa Huruma Resettlement Scheme. In this project, 500 squatter families were resettled in Mji wa Huruma. After being provided with a serviced site, they built houses with loans from NCKK. This is a project which was started in 1970 but the resettlement began in the middle of 1975.

NCKK is also involved in the promotion of innovative building materials like FCR tiles and stabilised soil blocks. To carry out its community improvement programme, NCKK receives finance from international donor agencies like IDRC, Ford Foundation, UNDP and UNCHS (Habitat).

NCKK's involvement in the dissemination of FCR tile and stabilised soil block technology is limited to three main demonstration projects which have been financed by IDRC and Ford Foundation. These demonstration projects are in the following places.

- (i) Kunati in Meru District.
- (ii) Chonyi in Kilifi District.
- (iii) Ruai on the outskirts of Nairobi.

In all these demonstration projects, single houses have been built using stabilised soil blocks and FCR tiles; the aim of the projects being to demonstrate

the use of these two building materials at the same time train the people in that area on how to produce and use the materials.

The Mathare-Huruma project which is being undertaken by NCKK as part of the Urban Shelter Improvement Programme will help demonstrate the use of FCR tiles. The project had not gone beyond the stage of allocating plots to allottees as at the beginning of 1991. Each allottee is expected to contribute KShs 3000/= towards the development of the plot. This is a project financed by the Ford Foundation, UNCHS (Habitat) and UNDP.

The Ford Foundation is providing US\$ 132,000/= for the purchase of equipment and material to be given on loan basis to the allottees. UNCHS is providing KShs 2 Million as seed capital for the revolving fund to enable NCKK to provide loans to the allottees. The UNDP is giving NCKK the equivalent of US\$ 38,500/= for training of the producers of the building materials and the builders, etc. The Mathare-Huruma project is not employing the use of stabilised soil blocks; NCKK opted to use hollow concrete blocks.<sup>20</sup>

NCKK does not set aside a particular percentage of its budget for projects to promote the use of appropriate building materials because the money it receives is project specific. The donors choose projects they wish to sponsor.

NCKK works closely with Undugu Society, Action Aid Kenya and HRDU. Currently, NCKK is in the process of trying to reach more people who need decent shelter through the various churches and religious organisations that are its members.

### 3.3.6 Mazingira Institute

Mazingira is a non-governmental organisation based in Nairobi and is involved in information exchange on various issues related to or about self-help settlements or housing projects in Africa. This is done through the Settlements Information Network Africa (SINA); Mazingira also publishes the SINA Newsletter. Apart from this Mazingira Institute also carries out extensive research on settlement issues, urban transport, women and shelter, urban food growing and urban housing improvements among other things. Mazingira institute is carrying out a rural housing improvement project in North and South Samia locations of Busia District. Demonstration houses have been built on the Mazingira office site in Funyula Market. They are supposed to demonstrate the use of stabilised soil blocks and FCR tiles. Mazingira has trained local artisans and women's groups on the production of FCR tiles and stabilised soil blocks. Currently two women groups have bought block presses and are producing blocks for sale.

### 3.3.7 The Appropriate Technology Centre for Education and Research, Kenyatta University (KU)

The Appropriate Technology Centre is a department within the faculty of Science in Kenyatta University. It is primarily involved in the research and development of appropriate technologies in the field of solar and wind energy, low-cost building materials, better methods of water storage, etc. The centre receives financing from the university since it is a department within it. Other funds come

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facilities where youth polytechnic instructors undergo training on how to produce and use stabilised soil blocks and FCR tiles among other things.

The first demonstration house showing the use of stabilised soil blocks and FCR tiles was constructed on this site by HRDU in conjunction with the centre. The Centre for Research and Training, Karen, is also involved in demonstrating the use of wind and solar energy equipment that is locally made and the production of ferrocement or mortarmesh water tanks for water storage.

The centre's projects are financed by the government, through the parent ministry - the Ministry of Technical Training and Applied Technology. The money allocated to the centre varies according to the economic conditions that are prevailing in the country. Sometimes very little money is set aside for the centre by the Treasury. In the Financial Year 1989/90, Kshs 4 Million<sup>22</sup> was available to finance the centre's training programmes for youth polytechnic instructors and to put up demonstration projects. In the 1990/91 financial year, very little money was available to the centre, so its activities have been limited.

The Centre for Research and Training, Karen has been actively involved in the dissemination of low cost building materials like FCR tiles and stabilised soil blocks. In conjunction with HRDU, the centre had helped train the people who built demonstration houses in various parts of Kenya. These demonstration houses have been built in youth polytechnics in Kangema, Mogotio, Maseno and Mazaras. The role played by the centre in these projects was that of training youth polytechnic instructors and students with the help of technical staff from HRDU.

The centre is plagued by a shortage of funds for carrying out more demonstration projects, workshops and seminars to help popularise the use of appropriate building technology.

### 3.3.9 Housing Research and Development Unit (HRDU)

The Housing Research and Development Unit (HRDU) is the principal Government agency that is actively involved in the development and dissemination of appropriate building technologies - the main building materials being stabilised soil blocks and FCR tiles.

HRDU was established in 1967 as a research unit within the Faculty of Architecture, Design and Development (ADD). HRDU was established so that it could undertake research in low-cost housing, community facilities and planning in both rural and urban environments. In 1990, it was proposed that HRDU be upgraded to the Housing and Building Research Institute (HABRI).

HRDU has disseminated FCR tile technology and stabilised soil block technology through the use of pilot projects throughout the country. Apart from the demonstration projects, HRDU also organises training programmes, workshops and seminars on the objectives of popularising the use of stabilised soil blocks and FCR tiles. The thrust of HRDU's appropriate building technology dissemination programme has been through youth polytechnics in various parts of the country.

Demonstration programmes have been carried out at various youth polytechnics where staff houses have been constructed using FCR tiles and stabilised soil blocks. These demonstration projects include the following;

- i) Two staff houses at Kangema completed in April 1988.
- ii) A single staff house at Mogotio Youth Polytechnic completed in July 1988.
- iii) Two staff houses at Maseno Youth Polytechnic completed in August 1988.
- iv) Two staff houses at Mazeras Youth Polytechnic completed in October 1988.

The aim of these demonstration projects at youth polytechnic is to train youth polytechnic graduates in the production and use of these innovative materials and to introduce the technology to target communities where these youth polytechnics are located. These youth polytechnics produce the local artisans like carpenters and masons who after training should be able to produce stabilised soil blocks and FCR tiles of similar quality and construct a building using these materials.

Apart from youth polytechnics, HRDU has also worked through primary schools so as to introduce stabilised soil blocks and FCR tile technologies to various communities. The Improved Rural Housing Technology (IRT) project in Western Kenya involved the design and construction of six staff houses in Busia District and four staff houses in Mbita in South Nyanza District. These were staff houses for primary schools in these two districts.

HRDU has worked closely and continues to work closely with several other agencies both local and international organisations. International organisations are mainly involved in funding the research in and development of these appropriate

building technologies. These organisations include GTZ, Ford Foundation, USAID, UNCHS (Habitat) among others.

Local agencies that work closely with HRDU include public institutions like the Department of Civil Engineering, University of Nairobi, The Centre for Research and Training, Karen and the Appropriate Technology Centre, Kenyatta University.

HRDU also co-operates with non-governmental organisations like Action Aid Kenya, NCKK, NACHU, and Undugu Society among others in its efforts to promote appropriate building technologies and materials.

### 3.3.10 The African Housing Fund (AHF)

The AHF was established in 1988 by Shelter Afrique, The African development Bank, The Reinsurance Corporation, The Commonwealth Development Corporation and 28 African States which are members of Shelter Afrique. Membership to AHF is open to all members of Shelter Afrique, other countries and non-governmental organisations. The AHF is financed by Shelter Afrique and several other bilateral aid organisations including SIDA, CIDA, DANIDA, ODA and USAID. Private foundations like the Ford Foundation also give money to AHF.

AHF aims at assisting the poor so that they can establish income generating activities and to improve their housing conditions. So far AHF has assisted two women groups in Nairobi to establish building material production units. AHF has

also assisted poor communities in Burundi, Zambia, Uganda and Guinea.

Assistance to these communities and groups consists of the following;

- a) Training
  - i) in building material production and construction of houses.
  - ii) in the management, financial control and accounting in these income-generating projects.
  - iii) quality control of the building materials produced and the marketing of these building materials.
- b) provision of loans to set up the building material production units
- c) Support to the groups operating the businesses which have been set up with loans from AHF to acquire land or access to secure land tenure among other things.

The two women groups that have been assisted by AHF to set up FCR tile production units in Kenya are

- (1) Humama Women's group from Mathare
- (2) Mihango-muongano Women's group in Kayole

With assistance from the AHF Humama Women's Group managed to get a KShs 3,100,000 contract from Intermediate Technology Workshop (ITW) to produce a total of 800,000 FCR tiles for Komarock Estate. This contract was signed in February 1989.<sup>23</sup> The estate which has now been completed is fully occupied. Currently the Humama Women's group produces FCR tiles on order to anyone who

wishes to buy tiles. They have yet to get a contract similar in magnitude to the one of providing FCR tiles for roofing about 1800 houses in Komarock.

The Mihango-Muongano Women's Group in Kayole is the second group to get assistance from AHF in setting up and managing a building material production unit. This group produces FCR tiles, hollow concrete blocks and floor tiles. The materials being produced by this group go into the construction of houses for the members. The houses are roofed using FCR tiles while the walling is done in hollow concrete block and the floors are tiled using concrete floor tiles.

AHF's role in the popularisation of FCR tile technology has been in helping establish small-scale FCR tile production units and helping secure markets for these tiles.

### 3.3.11 Intermediate Technology Workshops (ITW)

ITW is a commercial enterprise that is actively involved in the dissemination of FCR tile technology. ITW was established in Kenya in the early 1980's for purposes of selling FCR tile making equipment and machinery. The person behind ITW is John Parry and Associates of the United Kingdom.

Apart from FCR tile-making equipment, ITW sells machines for making concrete blocks and concrete floor tiles. The ITW factory in Karen produces all these for sale throughout Kenya, but most of the customers are drawn from Nairobi and it's surrounding areas.

ITW is not involved in research and development of FCR tiles but is a profit-making firm producing FCR tiles and FCR tile-making equipment and machines. ITW's role in the dissemination of FCR tile technology has been in importing and selling tile-making equipment in Kenya. Because of the import factor, most equipment and machinery sold by ITW has tended to be very expensive - this paved way for local designing and fabrication of alternative machines that are much cheaper than John Parry products. ITW is not involved in making equipment for stabilised soil blocks, the reason given for this being that the production of soil blocks is not commercially viable because the market for soil blocks is not assured.

#### 3.4.0. PROJECTS IN WHICH STABILISED SOIL BLOCKS AND FCR TILES HAVE BEEN USED.

The list of projects where FCR tiles and stabilised soil blocks have been used which were actually visited and have been described in detail here and those listed in Tables 3.3 and 3.4 is not exhaustive. The projects which were visited are those which were easily accessible or were relatively large projects where FCR tiles and stabilised soil blocks have been used hence could not be excluded as in the case of Nyahururu. Those projects which have been listed in Tables 3.3 and 3.4 are those where the main organisations were involved in promoting the use of FCR tiles and stabilised soil blocks or played a direct or indirect role in their development.

A total of 7 projects were actually visited and studied for the purposes of getting first hand information on the use of FCR tiles and stabilised soil blocks.

These projects are;

- a) The Nyahururu Tenant Purchase Housing Scheme in Nyahururu Town.
- b) Komarock Estate in Nairobi.
- c) Wanyee's houses in Riruta, Nairobi.
- d) Kariobangi Co-operative Housing Society's houses in Kariobangi, Nairobi.
- e) St. Joseph The Worker Parish in Kangemi, Nairobi.
- f) Ngunyumu Primary School in Kariobangi, Nairobi.
- g) Korogocho Primary School in Kariobangi, Nairobi.

In the Nyahururu Tenant Purchase Housing Scheme, there are a total of 26 houses built of FCR tiles and stabilised soil blocks. This was a demonstration project to show how local authorities could provide relatively cheap but decent houses for low income urban dwellers.

Komarock Estate in Nairobi is now the largest project in Kenya involving the use of FCR tiles. A total of 1750 houses have been roofed with red coloured FCR tiles although the walls are built using quarried stone and concrete blocks.

St. Joseph the Worker Parish in Kangemi is a big complex of various buildings constructed using both FCR tiles and stabilised soil blocks. It is a good example where both these materials have been successfully used without major problems.



Information on other projects where FCR tiles and stabilised soil blocks have been utilised was obtained from the organisations that have been involved in disseminating the use of these building materials.

### 3.4.1 The Nyahururu Tenant Purchase Housing Scheme

The inception of the Nyahururu Tenant Purchase Housing Scheme in 1983 came at a time when the policy of housing the low income families was changing from the provision of serviced plots and materials loans to the provision of core units on unserviced plots. This project involved the construction of 100 dwelling units in Maina Ward which had a high concentration of low income families. The financing for this project came through the National Housing Corporation (NHC) from the financiers U.S.A.I.D. After very lengthy deliberations between NHC, Nyahururu Municipal Council, the Public Health Officer for Nyandarua District and U.S.A.I.D., it was decided to make the project a mixed development.

The use of stabilized soil blocks for the walling, FCR tiles for roofing and ventilated improved pit latrines (V.I.P.s) were strongly supported by the financier of the project - U.S.A.I.D. This was the main point of contention between the various parties involved in the Nyahururu Tenant Purchase scheme. The Public Health Officer argued that the use of pit latrines in gazetted urban areas was against the requirements of the Public Health Act. U.S.A.I.D. strongly favoured the construction of V.I.P latrines so as to reduce the costs of servicing the land and therefore ultimately reducing the total cost of the whole housing project.

A total of 116 houses were constructed in this tenant purchase scheme in Nyahururu out of which;

- a) 26 houses were built using FCR tiles and stabilized soil blocks.
- b) 90 houses were built using corrugated iron sheets (g.c.i.) and quarried/natural stone.

The houses built using stone and g.c.i. sheets have two rooms, a flush toilet and a shower. The first 50 houses of this type, which were completed in 1986, cost Kshs 45,680 per unit. The next 40 houses of the same type, which were completed in 1987, were sold for Kshs 65,000 per unit. The reason for this large increase in price was the delay in construction and the increases in building material costs over the period of one year.<sup>24</sup>

The houses built using FCR tiles and stabilized soil blocks have three rooms with a separate VIP latrine and bathroom. These houses were designed to be upgraded gradually to waterborne sanitation and construction of two more rooms. Each of these houses cost about Kshs 31,880.<sup>25</sup>

The gross cost of this housing scheme was Kshs 4,372,100.<sup>26</sup> The projected cost of a three room core unit built using FCR tiles and stabilized soil blocks was Kshs 26,000 at the planning stage of this project. Due to delays in commencement of construction of these houses, the actual construction cost of each house was higher than this projected cost. The houses built of FCR tiles and stabilized soil blocks were built on unserviced plots so water is provided communally at a central point.

Apart from lower prices, the houses built of FCR tiles and stabilized soil blocks have an added advantage over those built conventionally. The FCR tile and stabilized soil block house has three rooms that are larger than those in a conventionally constructed house. The two-room house built of stone and g.c.i. sheets has rooms which are 9ft by 10ft compared to the 3 rooms of the houses built of FCR tiles and stabilized soil blocks which vary in size from 12ft by 10ft for the biggest room, 10ft by 10ft for the medium size room and 10ft by 8 ft for the smallest room<sup>27</sup> (see figure 3.1). Figure 3.2 shows the plan of the core unit and a sample of how the extension could be done.

Nyahururu Municipal Council faced several problems in the carrying out of this development given that FCR tiles and stabilized soil blocks were relatively new building materials which had not been used before on a project of a similar scale. These problems include the conflict with the Public Health Officer with respect to the application of the Public Health Act and the use of pit latrines within the gazetted boundaries of an urban area. Other problems which the Nyahururu Municipal Council also faced when implementing this tenant purchase housing scheme arose out of the fact that stabilized soil blocks and FCR tiles were new materials which had not been used on comparable projects in Kenya. In the case of FCR tiles, the council suffered a big loss initially because a stock of more than 300 tiles<sup>28</sup> were not suitable for use and had to be discarded. The tiles were too porous because of the type of sand used in the mixture and the solution was to use better quality sand obtained from a different source.

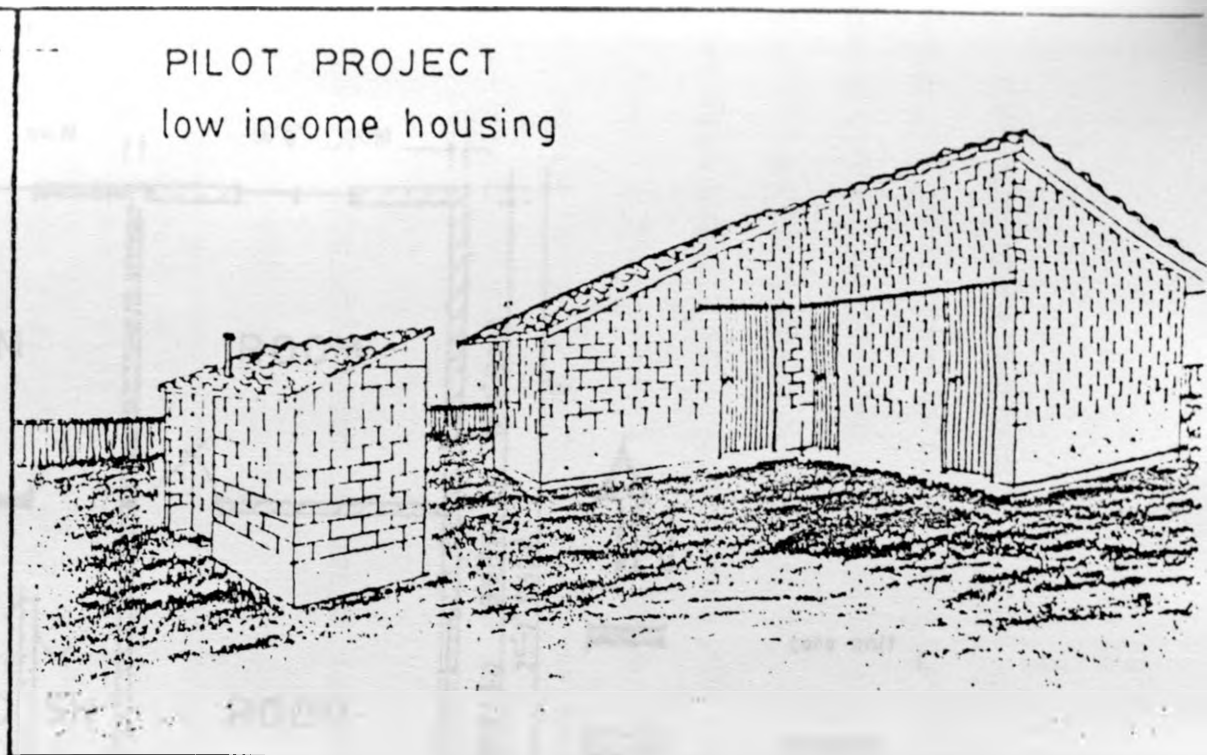
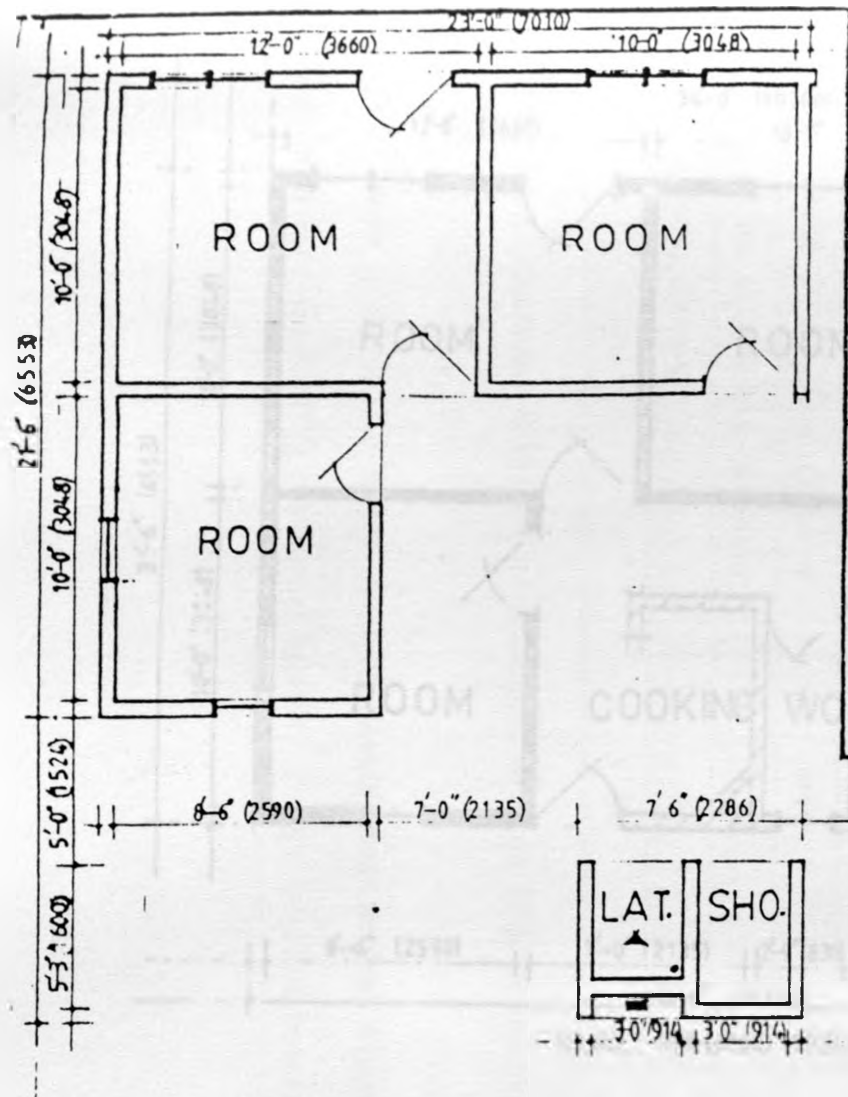
The stabilized soil blocks that were first made were too light, hence not suitable for constructing walls. These blocks had not been properly compacted and the block press that had been used for making them had to be exchanged for a better one before further production of the blocks was undertaken.

Despite the obvious advantages in cost reduction that the use of FCR tiles and stabilized soil blocks had, the Nyahururu Municipal Council had to overcome several problems of inexperience in the production and use of these building materials in order to proceed with the construction of the rest of the housing scheme. The scheme was completed in 1987.

The houses in the Nyahururu Tenant Purchase Scheme using FCR tiles and stabilized soil blocks are already showing signs of wear and tear. Some of the defects that are very evident now could have been avoided during the design and construction stages of the project. The FCR tiles used for roofing these houses were 4mm thick<sup>29</sup>. The recommended thickness as found in the draft Kenya Standard for FCR tiles is 6mm thickness. Broken and cracked tiles are very visible on these houses (see plates 4.1 - 4.3). Most of these houses' owners are now replacing these tiles with g.c.i. sheets.

In the case of the stabilized soil block walls, the thin coat of cement or "bag wiping" is peeling off in big patches (see plates 4.7 and 4.8), especially with the heavy rains that Nyahururu receives. The problem of rain damaging walls could have been avoided if these houses had been designed and constructed with ample roof overhangs to protect the walls from driving rain. The FCR tiles would have been less liable to cracking and breaking if their thickness was at least 6mm rather than 4mm.

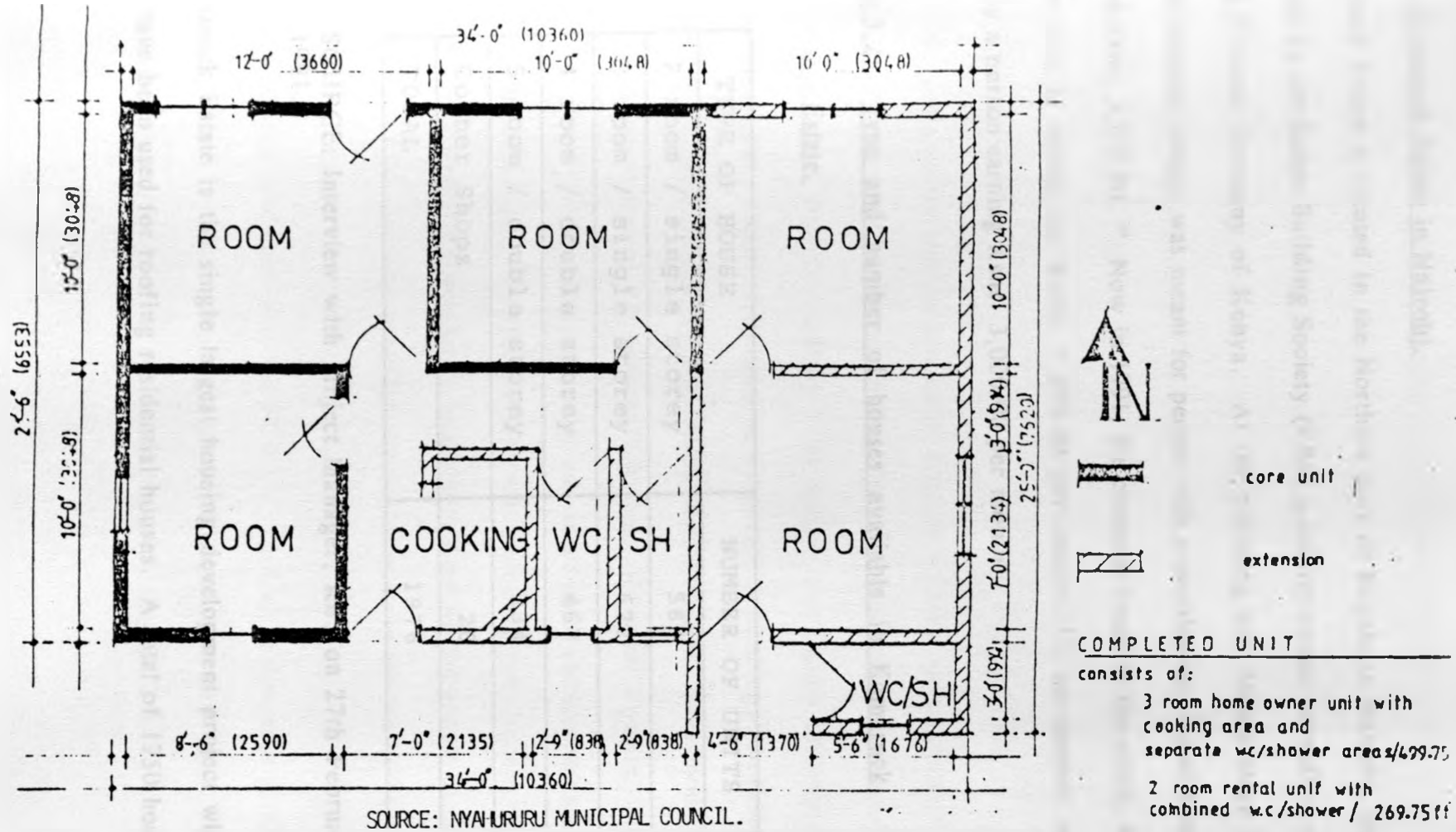
FIGURE 3.1: Plan of the core unit.



SPECIFICATIONS

FOOTING	6" thick mass concrete 1:3:6
FOUNDATION	3 courses 6x9 quarry stone mortar mix 1:6
D.P.C	6" wide bituminous felt laid on approx 1" thick mortar bed (mix 1:4)
TOTAL AREA	rooms 358.25 ft <sup>2</sup> . latrine/shower 39.375 ft <sup>2</sup>
WALLING	stabilized soil blocks
WALL PLATE	7'-6" high
ROOFING	fibre cement roofing tiles /span 10'-9" /rise 4'-2"
WINDOWS	timber shutters with security bars/ upgradable to louvred windows

FIGURE 3.2: Plan of the completed sample house.



### 3.4.2. Komarock Estate in Nairobi.

Komarock Estate is located in the Northern part of Kayole in Nairobi, and was developed by the Kenya Building Society (KBS) a wholly owned subsidiary of the Housing Finance Company of Kenya. At the planning and design stage in 1983/84, this housing scheme was meant for people with a monthly income of Kshs. 3,000.00 and Kshs. 3,200.00.<sup>30</sup> Now in 1991, the cheapest house in the estate, ie, a two room unit is rented for Kshs. 1,800.00 per month,<sup>31</sup> an amount not affordable by a person earning Kshs. 3,000.00 per month.

**Table 3.2: Type and number of houses available in Komarock Estate.**

TYPE OF HOUSE	NUMBER OF UNITS
2 room / single storey	583
3 room / single storey	672
4 room / double storey	467
5 room / double storey	234
Corner Shops	20
TOTAL	1976

**SOURCE:** Interview with Project Manager, KBS on 27th February, 1991.

Komarock Estate is the single largest housing development project where FCR tiles have been used for roofing residential houses. A total of 1750 houses

have been roofed using FCR tiles.<sup>32</sup> The rest of the houses have been roofed using Elgon Simbarite asbestos sheets.

The estimated costs of these houses were not supposed to exceed a maximum of Kshs. 135,000 for the largest house. The actual construction of these houses started much later than was anticipated during the inception stage of the scheme. Consequently, the smallest house in this scheme, ie, a two roomed single storey unit, costs not less than Kshs. 200,000<sup>33</sup> and a five room double storey unit costs about Kshs. 550,000.<sup>34</sup>

The FCR tiles used for roofing houses in Komarock Estate were produced by Humama Women's Group and two other small-scale individual entrepreneurs. The contract to produce FCR tiles for roofing 1750 houses was signed between the developers of Komarock Estate, KBS and Intermediate Technology Workshops (ITW) who subcontracted Humama Women's Group and two other individual FCR tile producers to supply a total of 1.2 million FCR tiles. Humama Womens' Group was to supply 800,000 FCR tiles while the other two small scale entrepreneurs were to produce 400,000 FCR tiles.<sup>35</sup> ITW sold the tile production equipment to the women's group and the other tile producers, and also trained all the people involved in the production of FCR tiles and provided the supervision in the area of quality control in tile production.

In 1989, the tile producers sold the FCR tiles to KBS at the price of Kshs. 3.60 per tile.<sup>36</sup> The Kenya Building Society used FCR tiles in Komarock Estate because examples seen elsewhere in Kenya had shown that FCR tiles were an



acceptable roofing material. Apart from this, the raw materials required for the FCR tile production were available locally and no interruption in the supply of FCR tiles was anticipated. Finally, according to the Project Manager of KBS, the production of FCR tiles offered an opportunity for Humama Women's Group to engage in an income generating activity, hence benefitting from such work. On price consideration, the KBS Project Manager said that FCR tiles had only marginal advantages over asbestos roofing sheets from Simbarite.<sup>37</sup> In the actual construction of the roofs in Komarock Estate, no particular problems that were specifically related to the FCR tiles shape or material of which it is made were encountered. In a user reaction survey carried out by the developers of the estate, the occupants of the initial phase of the estate were mainly dissatisfied with the lack of a ceiling. Consequently, KBS had to build a ceiling in the houses that were constructed later. Komarock Estate Phase One was completed in early 1990 and is now fully occupied, i.e. all houses have been sold by the developers.

The developers of Komarock Estate were of the opinion that it would not be easy to build approximately 200 houses using stabilized soil blocks. The reasons given were that stabilized soil blocks cannot be made as quickly as concrete blocks. It is easier to make many concrete blocks and meet the fairly strict quality control requirements outlined in the building code. Concrete blocks were preferred to stabilized soil blocks and the developers of Komarock Estate chose to use the new building materials selectively.

So far there is no other estate in Kenya where more than 1750 houses have been roofed using FCR tiles. The development of Komarock Estate will go a long way in helping popularise FCR tiles as a roofing material which is an acceptable alternative to g.c.i. sheets, asbestos sheets, concrete tiles and clay tiles.

#### 3.4.3. Wanyee's Houses in Riruta, Nairobi.

A private developer, Wanyee, has built 14 rental houses in Riruta in Nairobi using stabilized soil blocks and corrugated iron sheets. This developer chose to use stabilized soil blocks because they were cheaper than stone or concrete blocks. A two bedroom house built of stabilized soil blocks and corrugated iron sheets with a toilet-cum-shower cost approximately Kshs. 50,000.00 to construct in 1986.<sup>38</sup> The soil used for making the stabilized soil blocks for constructing these 14 rental houses was obtained from the site. The developer had to buy cement and stone dust.

According to Wanyee, approval of the building plans by the Nairobi City Commission was not necessary since buildings made of stabilized soil blocks are considered temporary. The actual construction of these houses did not encounter any problems that were specifically related to the use of stabilized soil blocks. The houses were built in 1986 and are still in good condition. The walls are plastered up to a height of about 0.75m from the ground to protect them from the effects of splashing water.

This private developer heard about stabilized soil blocks from Action Aid Kenya. In fact, he bought a block press from Action Aid Kenya. Although this developer had heard about FCR tiles, he preferred to use corrugated iron sheets for roofing these 14 houses. The reason he gave for this choice was that FCR tiles can easily be removed by burglars, thus according to this developer, a house roofed with corrugated iron sheets is more secure. Other people living in the Riruta area of Nairobi, especially within the same neighbourhood as Wanyee are beginning to use stabilized soil blocks by hiring the block press from him.

These houses built of stabilized soil blocks are let for rents equivalent to houses built of stone and concrete blocks. There are 4 two-bedroom houses and 10 one-bedroom houses. The two bedroom houses fetch a rent of about Kshs. 2,500.00 per month while the one-bedroom houses are let at Kshs. 1,500.00 to 1,800.00 per month. <sup>39</sup>

#### 3.4.4. Kariobangi Co-operative Housing Society Project.

The Kariobangi Co-operative Housing Society joined the National Co-operative Housing Union (N.A.C.H.U.) in 1978. Their main objective is to provide houses for the 526 members of this society.

The Kariobangi Co-operative Housing Society, with help from N.A.C.H.U. and U.S.A.I.D., has built 9 condominiums in Kia Maiko Village in the Kariobangi area of Nairobi. These houses are built of hollow concrete blocks for walling and FCR tiles for the roofing. FCR tiles were used because they were cheap and could

be produced on site where members could provide the labour. Technical assistance and supervision of the FCR tile making was provided by N.A.C.H.U. Consequently, no problems were encountered either in the tile production or actual construction of the roofs. There were no problems with respect to the approval of the plans for the condominiums. At the time of the interview with officials of the Kariobangi Co-operative Housing Society, only 4 of the 9 condominiums were occupied. The society had rented out these 4 condominiums to 12 separate tenants. Each tenant paid Kshs. 500.00 per room per month. <sup>40</sup>

The Kariobangi Co-operative Housing Society is hoping to build 207 condominiums for its members. These houses are to be built using FCR tiles and hollow concrete blocks. The funding for this project is from U.S.A.I.D. and is being channelled through N.A.C.H.U. A total of Kshs. 26 million has been set aside for this project. <sup>41</sup>

Although the Kariobangi Co-operative Housing Society had heard of stabilized soil blocks, they did not use them because the members felt that stabilized soil blocks were not as permanent as concrete blocks or stone. Secondly, they had reservations about using building blocks made of soil.

The construction of the 207 condominiums is being delayed by the fact that the construction site is occupied by other people who are not necessarily members of the Kariobangi Co-operative Housing Society although a few are. The people to be displaced by the construction of the 207 condominiums who are not members of the society are quite resistant to the planned demolition of their makeshift houses.

The 9 condominiums already built were completed in 1980 and are in good condition. The roofs are intact, and no major repairs have been carried out on the roofs since completion. The houses are rented out so as to provide income to the society.

### 3.4.5. Other Residential Housing Projects

Other projects where residential houses have been constructed using stabilized soil blocks and FCR tiles include the following.

**Table 3.3: Residential Housing: Projects where FCR tiles and stabilized soil blocks have been used.**

PROJECT	Number of houses	Materials used for		Developer or Promoter	REMARKS
		WALLS	ROOFS		
Demonstration houses in Ruai-Nairobi	1	SSB	FCR	N.C.C.K.	
Kunati-Meru	1	SSB	FCR		
Chonyi-Kilifi	1	SSB	FCR		
Mathare-Huruma	41 houses to be built	Hollow concrete blocks	FCR tiles	N.C.C.K.	Project is ongoing
Private houses in Nyandarua	8	Concrete blocks	FCR tiles	Private individuals	
Demonstration house in Lamu	1 Mpeketoni Scheme		FCR tiles		
Private houses in Meru	5		FCR tiles	Private individuals	
Demonstration house at Karen Centre for Research and Training	1	SSB	FCR tiles	HRDU/Karen Centre for R&T	Completed in 1986
Staff houses - Kangema Youth Polytechnic, Muranga	2	SSB	FCR tiles	HRDU	Completed April 1988

Table 3.3 contd...

PROJECT	Number of houses	Materials used for		Developer or Promoter	REMARKS
		WALLS	ROOFS		
Staff house - Mogotia Youth Polytechnic, Baringo	1	SSB	FCR tiles	HRDU	Completed July 1988
Staff houses - Maseno Youth Polytechnic, Kisumu	2	SSB	FCR tiles	HRDU	Completed August 1988
Staff houses - Mazeras Youth Polytechnic, Kilifi	2	SSB	FCR tiles	HRDU	Completed October 1988
Mihango-Kayole Muungano Women's Group housing in Kayole, Nairobi	61 units still being built	Hollow concrete blocks	FCR tiles	African Housing Fund of Shelter Afrique	Ongoing - no single house had been completed by Feb'91

SOURCE: Field Survey 1991.  
SSB represents Stabilized Soil Blocks

Apart from the residential houses, there were other projects where buildings like schools, churches and other community facilities are built using FCR tiles and stabilized soil blocks. Those that were actually visited and surveyed as part of the case studies include the following: St. Joseph The Worker Parish in Kangemi, Ngungumu Primary School and Korogocho Primary School.

frames rather than wood. The total cost of construction of the church was Kshs. 6 million and it was completed on 1st. May, 1989.



PLATE 3.1: KANGEMI, NAIROBI

The church at St. Joseph The worker Parish, Kangemi.

Both the FCR tiles and stabilized soil blocks were produced on site. Initially, with the FCR tiles, there were problems of quality because the production

was rushed in order to meet the deadline for the official opening of the church. During the making of the first batches of FCR tiles, too much water had been added to the fibre concrete mixture and this resulted in the tiles being very brittle and porous. Before further production was undertaken, the production of FCR tiles was closely supervised.

There were no quality problems in the production of stabilized soil blocks because strict supervision of the production process was undertaken.

During the actual construction of the buildings that are already finished at this parish, there were some problems. For instance, the roof using FCR tiles required people with experience of installing FCR tiles and there was some difficulty in getting artisans with such skills and experience. Construction of the walls using stabilized soil blocks presented no major problems although it took the fundis (artisans) some time to appreciate the differences between stabilized soil blocks and concrete or stone blocks. For example, the mortar required for constructing with stabilized soil blocks did not require as much cement as is the case when using concrete or stone blocks.

After completion of the church building, a nursery school of 4 classrooms was constructed. FCR tiles were used for the roof while the walls are made of stabilized soil blocks. The nursery school was completed at the end of 1989.





PLATE 3.2: KANGEMI, NAIROBI

The building in the background is the nursery school block at St. Joseph The Worker Parish, Kangemi.



PLATE 3.3: KANGEMI, NAIROBI

Residential quarters for the priest at St. Joseph The Worker Parish, Kangemi.



PLATE 3.4: KANGEMI, NAIROBI  
Parish offices, St. Joseph The Worker Parish, Kangemi.

The parish offices and residence for the priest were completed in 1989. There is also a Youth Training Centre adjoining the parish offices where there are 4 classrooms. This centre was completed in 1990. There is also a dispensary built using FCR tiles and stabilized soil blocks like all the other buildings at this parish. The dispensary consists of two buildings; one for the outpatient services, the other for Maternal Health and Child-care services. The total construction cost of the dispensary was about Kshs. 1.7 million. <sup>42</sup>

There is also a Primary School where so far 8 blocks of classrooms and toilet blocks have been completed. Further construction is still going on. Construction of the primary school started in 1987. The following plates show classrooms at the primary school.



PLATE 3.5: KANGEMI, NAIROBI  
Block of classrooms at St. Joseph The Worker Primary School.



PLATE 3.6: KANGEMI, NAIROBI  
Block of classrooms at St. Joseph The Worker Primary School.



PLATE 3.7: KANGEMI, NAIROBI  
Classrooms at St. Joseph The Worker Primary School.



PLATE 3.8: KANGEMI, NAIROBI  
Classroom under construction at St. Joseph The Worker Primary School.

The walls in all the buildings constructed using stabilized soil blocks have been plastered. The rendering provides protection against the effects of moisture. The rendering is brick coloured because of the cement colour added to the cement sand mixture prior to plastering.

The St. Joseph The Worker Parish Complex is an example of where both stabilized soil blocks and FCR tiles have been used to construct decent buildings at a relatively low cost. The labour used for making the tiles and blocks was from the church community, the soil used for blocks from a site in Riruta. All the buildings are in good condition; the roofs are intact and repairs of broken tiles are minimal. So far, only a few have been replaced on the roof of the church. There were no problems with approval of the plans for the buildings by the Nairobi City Commission because the buildings constructed using stabilized soil blocks were considered temporary. The parish only needed the City Commission's approval for the church which is built of stone and FCR tiles.

#### 3.4.7. Ngunyumu Primary School

Ngunyumu Primary School is located in the sprawling Kariobangi slum of Nairobi's Eastlands area. There is a large population of school children in this area. The school has a total of 1325 pupils and 24 teachers.

The decision to construct the classrooms using FCR tiles and stabilized soil blocks was as a result of the desire, on the part of Action Aid Kenya, to promote the use of these building materials and help develop poor communities.

Consequently, Ngunyumu Primary School is part of Action Aid Kenya's Schools Construction and Maintenance Scheme. A total of 22 classrooms were built using FCR tiles and stabilized soil blocks. Three more classrooms and a toilet block are still being constructed.

A classroom which is approximately 8m x 6.5m in size cost a total of Kshs. 80,000. The roofing cost about Kshs. 20,000 including a ceiling while the walling cost about Kshs. 20,000 excluding the cost of labour.<sup>43</sup>

All the tiles and blocks used for construction of these classrooms and toilet blocks were produced on site. The murrum for making the stabilized soil blocks is obtained from Njiru at the cost of Kshs. 700 a lorry load (an 8 tonne lorry).<sup>44</sup> No major problems were encountered either during the production of both the FCR tiles and stabilized soil blocks or during the actual construction of the building. Technical supervision during the production and actual construction stages was provided by Action Aid Officials. Action Aid Kenya also trained the people who were making both the FCR tiles and stabilized soil blocks.

The buildings are in good condition and more classroom blocks are under construction. There was no approval for the building plans before construction started at Ngunyumu because they felt that seeking approval from the Nairobi City Commission would take very long since FCR tiles and stabilized soil blocks were still officially unacceptable building materials. So far the Commission has not sought to demolish the buildings because of this lack of approval of the plans.



PLATE 3.9: KOROGOCHO, NAIROBI  
 Classroom under construction at Korogocho Primary School.  
 Note: The walls have been plastered.



PLATE 3.10: KOROGOCHO, NAIROBI  
 Completed classroom at Korogocho Primary School. Note the stabilized soil blocks stacked on the verandah for future use.



The construction of Korogocho Primary School using FCR tiles and stabilized soil blocks started in 1984. So far only minor repairs involving the replacement of broken tiles have been necessary. With respect to the walls, two blocks of classrooms had patches where plaster had peeled off. These were being repaired at the time of interviewing the school's officials. According to the artisan in charge of the construction at Korogocho Primary School, the rendering was peeling off because it was not properly done.

No particular problems were encountered in both the making of the tiles and the actual construction of the buildings. Action Aid Kenya provided the necessary training and supervision of the people involved in the various tasks of tile and block making and actual roof and wall construction. Murrum for making the stabilized soil blocks was obtained from Njiru at the cost of Kshs. 700 for an 8 tonne lorryload.<sup>48</sup> From a single bag of cement (50 kg), 120 soil blocks could be produced. A 50kg bag of cement could also yield an average of 125 FCR tiles of 6mm thickness.<sup>49</sup> The stabilized soil blocks produced at Korogocho Primary School were sometimes sold to help finance construction of more classrooms. In 1986, a stabilized soil block was sold at Kshs. 2.40. At the beginning of 1991, the price was Kshs. 3.50 per block.<sup>50</sup> A few people are actually buying blocks from the school for purposes of constructing houses.

The sponsors of Korogocho Primary School did not seek approval of the plans in 1983. This was because they felt the process would take too long and they had already been promised co-operation by the M.P. for that area at that time. They





Table 3.4. contd...

Action Aid Regional offices in Kisumu Kitui and Kapsokwony areas	Over 7 separate buildings	SSB	FCR tiles	Action Aid Kenya	Started in 1985, still ongoing. App. cost between Kshs 120 - 200 per sq. foot
Forest View Academy, Karen Nairobi	1	Stone	FCR tiles	Private individual	Roofing cost a ttl of Kshs 50,562 including labour costs

SOURCE: Field Survey 1991.  
SSB represents Stabilized Soil Blocks



PLATE 3.11: KAREN, NAIROBI  
Forest View Academy in Karen, Nairobi. The roof is built of FCR tiles.

### 3.5.0. CONCLUSION

The projects which have been discussed in detail or listed in the tables given do not provide a complete list of all buildings in Kenya which have been built using FCR tiles and stabilized soil blocks. These projects are only some of them, and they are mainly those in which organisations such as HRDU, Action Aid Kenya, and other similar organisations have had a direct or indirect involvement in their development. This could be either through the sale of equipment and machinery for tile and block making to individuals or groups who have then gone on to construct schools, churches, clinics or residential houses. Information on all these projects was obtained from organisations that are actively involved in the development and promotion of FCR tile and stabilized soil block technologies in Kenya.

This chapter has looked at the historical development and spread of both FCR tile and stabilized soil block technologies in Kenya. The various projects where buildings have been constructed using FCR tiles and stabilized soil blocks have been discussed. The next chapter will involve identifying and discussing the constraints to the utilisation of FCR tiles and stabilized soil blocks.

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## **CHAPTER FOUR**

### **DISSEMINATION AND UTILIZATION OF FCR TILES AND STABILISED SOIL BLOCKS.**

#### **4.1.0 INTRODUCTION**

The introduction of FCR tiles and stabilised soil blocks in Kenya has faced several problems that have hindered the widespread use of both these materials. The constraints to the widespread use of FCR tiles and stabilised soil blocks may be due to the methods used to disseminate the use of both these building materials or may be inherent in these technologies themselves. Thus these constraints range from the abilities of those organisations that are involved in promoting the use of FCR tiles and stabilised soil blocks to promote the use of these building materials to the potential user's perception of FCR tiles and stabilised soil blocks. The evaluation of these constraints is therefore structured in terms of;

- a) Constraints to the dissemination of information on FCR tiles and stabilised soil blocks.
- b) Problems of production of FCR tiles and stabilised soil blocks.
- c) Problems of using FCR tiles and stabilised soil blocks.
- d) Durability of FCR tiles and stabilised soil blocks.
- e) Acceptability of FCR tiles and stabilised soil blocks to the users.

In order to obtain information on the dissemination, production, use and durability of FCR tiles and stabilised soil blocks, there was a need to interview

people involved in the various aspects of FCR tiles and stabilised soil block technology development. This included evaluation of the following.

- i) Promoters of FCR tiles and stabilised soil block technologies. These promoters were mainly organisations or institutions involved in the research, development and dissemination of FCR tiles and stabilised soil blocks. The aim of evaluating these organisations was to find out their experiences and problems in their efforts to promote the use of FCR tiles and stabilised soil blocks.
- ii) The private small scale producers of FCR tiles and stabilised soil blocks. These were either individual entrepreneurs or self-help groups. This survey of private small scale producers of FCR tiles and stabilised soil blocks aimed at finding out the problems and difficulties such producers face. The problems faced by such producers could be an important pointer to the reasons for the lack of widespread interest in producing FCR tiles and stabilised soil blocks by the private sector. The private sector normally takes over from research and development institutions in the production of new products provided there is demand for these products.
- iii) The potential producers of FCR tiles and stabilised soil blocks. These were drawn from small scale producers of building materials who were in the vicinity of housing projects where FCR tiles and stabilised soil blocks have been used. The assumption here is that these producers of conventional building materials like concrete tiles and blocks might be interested in

producing FCR tiles and stabilised soil blocks since they are already in the building materials industry.

- iv) Architects. It was necessary to interview a few architects since they are specifiers of building materials that are to be used on buildings they design.
- v) Builders or fundis involved in the actual process of building with FCR tiles and stabilised soil blocks.
- vi) The users of houses constructed using stabilised soil blocks and FCR tiles. This survey of these users was to find out what they felt about FCR tiles and stabilised soil blocks as alternative building materials to those that are commonly used, eg. concrete blocks and tiles, asbestos sheets and corrugated iron sheets, etc. These users were drawn from 3 projects where FCR tiles and stabilised soil blocks were used for construction of residential houses. These projects include Komarock Estate in Nairobi, Nyahururu Tenant Purchase Housing Estate in Nyahururu and a privately built estate in Riruta, Nairobi.

In the case of Komarock Estate, there is a total of 1750 houses roofed with FCR tiles. A random sample of 10% of these houses was taken, hence a total of 175 households were surveyed. The respondents were asked questions that related to the FCR tile roof since the walls were built of stone and concrete blocks (see Appendix III).

In the case of Nyahururu, the occupants of the 26 houses built of stabilised soil blocks and roofed with FCR tiles were asked about both these materials.

With respect to the privately built estate in the Riruta area of Nairobi, occupants were asked about the stabilised soil block walls since these houses were roofed using corrugated iron sheets.

#### **4.2.0 DISSEMINATION OF STABILISED SOIL BLOCK AND FCR TILE TECHNOLOGIES.**

A total of 9 different organisations that are involved in promoting the use of FCR tiles and stabilised soil blocks were surveyed. Out of these, 3 organisations were public institutions while the rest were non-governmental organisations. These organisations have been discussed in detail in the foregoing chapter and they include;

- a) Action Aid Kenya
- b) Intermediate Technology Development Group (ITDG)
- c) National Co-operative Housing Union (NACHU)
- d) National Council of Churches of Kenya (NCCK)
- e) The Appropriate Technology Centre for Education and Research of Kenyatta University (ATC,KU)
- f) Centre for Research and Training, Karen
- g) Housing Research and Development Unit (H.R.D.U)
- h) African Housing Fund of Shelter Afrique
- i) Undugu Society of Kenya

Most of these organisations are involved in other activities apart from promoting the use of appropriate building materials. The scope of work of each organisation varies and each institution has its own main objectives. Organisations like Action Aid Kenya, Undugu Society of Kenya, the Appropriate Technology Centre for Education and Research of Kenyatta University and the Centre for Research and Training, Karen are involved in the research, development and dissemination of other appropriate technologies like innovations in renewable energy sources, simple water storage technologies and fabrication of simple agroprocessing implements and machines. Out of the 9 organisations surveyed, only 3 organisations focus their research and development efforts on appropriate building materials only.

Table 4.1. shows what building materials are being promoted by each of the organisations surveyed and the emphasis of each organisation's activities.

**Table 4.1: Organisations promoting the use of FCR tiles and stabilised soil blocks**

Name of Organisation	Material being Promoted	Emphasis or Thrust of Organisation's work
Action Aid Kenya	- FCR tiles - Stabilised soil blocks	Research-especially in the design and fabrication of machinery and equipment. Dissemination of these building materials through pilot projects in schools in Kenya.
I.T.D.G. (Kenya)	FCR tiles	Dissemination through seminars and workshops on FCR tiles.
Undugu Society of Kenya	- FCR tiles - Stabilised soil blocks	Dissemination through fabrication of machinery and equipment for the production of both these materials. Also carries out some demonstration projects using FCR tiles and stabilised soil blocks.

Table 4.1. contd...

N.A.C.H.U.	-FCR tiles -Stabilised soil blocks	Dissemination of these materials through the member co-operative societies.
N.C.C.K.	-FCR tiles -Stabilised soil blocks	Dissemination through its Urban Community Improvement Programme.
A.T.C. Kenyatta University	FCR tiles	Focuses mainly on research work but carries out a few demonstrations on how the technology works.
Centre for Research and Training, Karen	-FCR tiles -Stabilised soil blocks	Research and Dissemination especially through the training of potential producers and users of both these building materials through the Youth Polytechnics.
H.R.D.U.	-FCR tiles -Stabilised soil blocks	Research and dissemination. -Design and fabrication of equipment and machinery. -Carrying out of demonstrations on the use of FCR tiles and stabilised soil blocks.
African Housing Fund Shelter Afrique	FCR tiles	Dissemination through helping groups to set up small scale FCR tile production units.

SOURCE: Field Survey 1991

The majority of these organisations are involved in promoting the use of both stabilised soil blocks and FCR tiles. This is perhaps out of realisation of the fact that to achieve a real low cost building, both the roof and walls have to be made of low cost materials. Those organisations whose main emphasis is technology dissemination have close links with organisations that carry out research on building materials for purposes of testing the building materials and training potential producers and users of stabilised soil blocks and FCR tiles.

Dissemination of the use of FCR tiles and stabilised soil blocks has mainly been through the use of pilot projects. In these pilot projects, buildings have been constructed using these materials. Pilot projects where the use of FCR tiles and stabilised soil blocks is demonstrated are vital for purposes of evaluating how acceptable these building materials are to the potential users, and what problems those who are producing FCR tiles and stabilised soil blocks are experiencing. For instance, Action Aid Kenya has worked through its Schools Construction and Maintenance Scheme while H.R.D.U. has worked through the Youth Polytechnic Movement through which staff houses have been constructed using FCR tiles and stabilised soil blocks on selected Youth Polytechnic sites in various parts of Kenya.

Demonstration projects on the use of FCR tiles and stabilised soil blocks are scattered throughout Kenya but they have yet to create widespread interest in the use of both these relatively new building materials among the general public. This may be due to the constraints that have hindered the effectiveness of organisations that are promoting the use of FCR tiles and stabilised soil blocks. These constraints include the following;

- a) Lack of adequate funds to carry out more demonstration projects on the use of FCR tiles and stabilised soil blocks where more people could be trained in producing and using these building materials.
- b) Lack of enough professional staff both in the technical and non-technical aspects of technology dissemination. This is important especially where demonstration projects are the main method of technology dissemination.

c) Lack of adequate physical facilities like laboratories, workshops and libraries. Laboratories and workshops are vital for purposes of testing the building materials being developed and for demonstrating the production processes of stabilised soil blocks and FCR tiles to the potential users and producers of these materials. Libraries help create an information base for the benefit of the general public and members of staff of any organisation that is involved in promoting the use of appropriate building materials. It is important that records of projects carried out by an organisation that is promoting the use of appropriate building materials are kept so as to facilitate exchange of information with other organisations that are involved in similar work. Exchange of information on demonstration projects among organisations involved in the promotion of FCR tiles and stabilised soil block technologies will enable such organisations to learn from experiences of other organisations. Libraries are also vital for reference purposes; this benefits both the staff of the organisation and the potential users of the building materials being promoted by that organisation.

Finance is an important determinant of the effectiveness of an organisation's efforts in promoting the use of a new product. Money is vital for carrying out demonstration projects, for setting up physical facilities like workshops, laboratories and libraries, and equipping each of these facilities. Money is necessary for the day to day activities that are carried out in any organisation or



institution which is involved in research and development. Where the amount of money available to such an organisation is not enough to carry out all the activities necessary to promote the use of a new product, the effectiveness of such an organisation is severely limited.

Out of all the organisations that were surveyed, 66.67% of the organisations felt that the money available to them was not enough to satisfy all their requirements. A large proportion of these organisations depends on international donor agencies to finance their work. In most cases, funds from donor agencies are specifically meant for a particular project identified by the agency donating such money. Perhaps if more money was available to these organisations involved in promoting the use of FCR tiles and stabilised soil blocks, more demonstration projects could be carried out throughout Kenya, and this would have a more widespread impact than has happened with the demonstration projects that are concentrated in certain areas of the country.

The proportion of an organisation's income that is set aside for the development and dissemination of appropriate building material technologies is a good indicator of that organisation's commitment to promoting the use of these building materials. For instance, I.T.D.G., which is an international non-governmental agency, sets aside about 80% of its annual budget for the purposes of promoting the use of alternative building technologies. I.T.D.G.(Kenya) has focused mainly on the dissemination of FCR tile technology through organising seminars, workshops and promotional campaigns through the national agricultural

shows. I.T.D.G. felt that the amount of money available to them was adequate for carrying out their activities.

H.R.D.U. also sets aside about 80% of its annual budget for the purposes of promoting the use of appropriate building materials like stabilised soil blocks and FCR tiles. The amount of money available is not enough for all the activities the unit would like to undertake. The shortage of funds sometimes leads to delays in the completion of demonstration projects being undertaken by H.R.D.U. Funds are also necessary for purposes of carrying out continuous training programmes for the potential users, artisans and producers of stabilised soil blocks and FCR tiles. Thus if more funds were available to H.R.D.U., it would be able to carry out training programmes on a regular basis especially through the Youth Polytechnics.

In the case of the African Housing Fund of Shelter Afrique, 92.6% of its annual budget is set aside for the dissemination of appropriate building materials. African Housing Fund is involved in promoting the use of FCR tiles and other vibrated concrete products like floor tiles and hollow concrete blocks. African Housing Fund disseminates these technologies by assisting self help groups to set up small scale building materials production units. The main objective of this programme by African Housing Fund is to help such groups establish income generating activities and ultimately to improve their housing conditions. In order to support these groups until they are able to operate on their own, African Housing Fund requires money to finance their training in materials production, business management and marketing of the finished products among other things.

African Housing Fund is financed by the parent organisation, Shelter Afrique and other international donor agencies like the Ford Foundation, U.S.A.I.D., and DANIDA, etc. African Housing Fund would like to help many more self help groups to establish building materials production units especially in low income areas of towns but this will be determined by how much money is available to the fund.

The Centre for Research and Training, Karen, which is under the Ministry of Technical Training and Applied Technology sets aside about 60% of its annual budget for the purposes of developing and promoting the use of appropriate building materials. The amount of money that the centre receives from the Treasury varies from year to year. Sometimes there is enough money to finance the training of Youth Polytechnic instructors throughout the year; other times, the money is just enough for a few courses. There is a problem of finances at this centre. The centre is also understaffed, according to the Principal of the centre. This is because there is not enough money to employ more staff.

Action Aid Kenya sets aside about 3% of its annual budget for the development and dissemination of FCR tiles and stabilised soil blocks while Undugu Society sets aside about 7.5% of its annual budget for the same purpose. Both Action Aid Kenya and Undugu Society of Kenya are involved in other activities other than the promotion of low cost building technologies. Action Aid Kenya is involved in the design of equipment and machinery for the production of FCR tiles and stabilised soil blocks. The block presses and screeding tables designed by

Action Aid Kenya are fabricated by the Undugu Society of Kenya. Both these non-governmental organisations felt that the availability of more money would enable them to carry out more demonstration projects. Action Aid Kenya felt that they needed more money in order to employ more technical staff to help in the design and field testing of equipment and machinery, train the buyers of these machines and monitor the production of FCR tiles and stabilised soil blocks and the use of these materials in their Schools Construction and Maintenance Scheme.

The Appropriate Technology Centre for Education and Research of Kenyatta University, N.A.C.H.U. and N.C.C.K. all spend variable amounts of money on appropriate building technology projects. This is usually determined by the agency financing the research or demonstration projects.

Apart from financial constraints, there are other problems that have affected the effectiveness of organisations and institutions that are involved in promoting the use of appropriate building materials. For organisations that are involved in promoting the use of new building materials like FCR tiles and stabilised soil blocks, facilities like workshops, laboratories and libraries are essential. Laboratories and workshops are vital for those institutions that are involved in the research on building materials. They are necessary for purposes of performing scientific tests and carrying out of demonstrations of the production of these new building materials.

Libraries are necessary for purposes of providing information to everyone who is interested in producing and using materials like FCR tiles and stabilised soil blocks which are relatively new products. Potential users of newly developed building materials like FCR tiles and stabilised soil blocks would like to know where such materials have been used successfully. Information on houses and other buildings where FCR tiles and stabilised soil blocks have been used successfully, if easily available in libraries, would help popularise the use of these materials. Libraries are also necessary as sources of reference material for employees of any organisation which is involved in promoting the use of appropriate building materials. This is so that they can keep abreast of developments in this field that have taken place in other parts of the world.

Lack of facilities like workshops, libraries and laboratories in organisations that carry out research and dissemination of appropriate building materials is an obstacle to achieving the widespread use of such building materials.

Out of the total number of organisations that were involved in promoting the use of either stabilised soil blocks or FCR tiles or both these materials only 55.6% had workshops where they could demonstrate the use of the block press for making stabilised soil blocks and the screeding table for making FCR tiles. These organisations include H.R.D.U., Action Aid Kenya, the Centre for Research and Training, Karen, Undugu Society of Kenya and the Appropriate Technology Centre of Kenyatta University. In the case of H.R.D.U., the workshop is adequate for their requirements but there is need for more onsite testing facilities. Action Aid

Kenya needs more outdoor space where they could demonstrate the actual construction of walls using stabilised soil blocks and roofing with FCR tiles to the potential users of these two building materials.

Those organisations that did not have their own workshops work closely with H.R.D.U. and use the facilities that are available at H.R.D.U. This is inconvenient to potential users of these materials who go to organisations like N.C.C.K., N.A.C.H.U., African Housing Fund, and I.T.D.G. and then get referred to H.R.D.U. for purposes of seeing demonstrations of how FCR tiles and stabilised soil blocks are made.

With respect to libraries from which someone could actually borrow books or journals, only 33.3% of the organisations had such libraries. These are H.R.D.U. Appropriate Technology Centre of Kenyatta University and African Housing Fund. In the case of African Housing Fund, the library is part of the parent organisation - Shelter Afrique. This library is relatively small and requires more journals, bibliographies and microfiche facilities. The library at H.R.D.U. has a substantial number of publications but it requires more space, ie, a bigger building. The library at the Appropriate Technology Centre of Kenyatta University also requires more books and more space.

The fact that only 33.3% of the organisations which are actively promoting the use of appropriate building materials have libraries from which someone could actually borrow books or other materials implies that information on building materials like FCR tiles and stabilised soil blocks is not easy to obtain, especially

for those people who cannot easily get to the H.R.D.U. library. The other organisations ought to set up libraries for purposes of creating information bases. The Centre for Research and Training, Karen has planned to construct a library as from the beginning of 1992 but this is subject to the availability of money to finance the project. Libraries would also facilitate the exchange of information between the various organisations that are involved in the promotion of the same building materials.

Apart from money and facilities like laboratories, workshops and libraries, organisations promoting the use of appropriate building materials need staff who have the necessary skills and expertise to disseminate new technologies. The dissemination of FCR tiles and stabilised soil blocks requires the services of both technical and non-technical staff. Engineers, technicians and artisans among others provide the necessary technical skills needed in handling technical aspects of technology dissemination. This is particularly true in cases where pilot or demonstration projects are used as a method of disseminating the use of new building materials. These technical staff will do all the tests necessary prior to the production of FCR tiles or stabilised soil blocks, demonstrate the correct production procedures for these building materials, train and supervise the potential producers and users of these building materials.

The non-technical requirements of disseminating the use of stabilised soil blocks and FCR tiles should be provided by sociologists and social workers. These sociologists help define the needs of a target group or potential beneficiaries of

these appropriate building technologies. In cases where organisations that are promoting the use of new products present these products as the best solution to a particular group's problem without prior consultation with these potential beneficiaries, such a solution is rarely acceptable to those it is supposed to benefit. The services and skills of sociologists and social workers would help minimise any negative perception of relatively new building materials like FCR tiles and stabilised soil blocks. Sociologists would also help evaluate the impact of pilot projects - whether such projects are having the desired impact on the target group and ultimately the people around the area where the project is located.

In cases where the staff available to carry out both the technical and non-technical aspects of technology dissemination are not enough, the ability of such an organisation to promote such technologies is limited.

Only 33.3% of the organisations surveyed had enough technical and non-technical staff to handle the various tasks of disseminating the use of FCR tiles and stabilised soil blocks. This implies that the majority of the organisations that are involved in promoting the use of FCR tiles and stabilised soil blocks do not have enough staff with the relevant skills and expertise to effectively disseminate the use of these building materials and ensure their widespread use. In particular, more technical staff like artisans and technicians were required by these organisations. For instance, the Appropriate Technology Centre of Kenyatta University needs more staff like engineers to carry out the actual research work in the laboratories and workshops. The Centre for Research and Training, Karen requires more technical



staff in order to carry out its training programme more effectively and efficiently. This has largely been hindered by lack of funds to hire more staff.

The problems of lack of money, lack of adequate physical facilities like workshops, laboratories and libraries and the unavailability of enough staff with the requisite skills and knowledge to disseminate the use of FCR tiles and stabilised soil blocks are closely interrelated. The amount of money available to an organisation determines how much of the physical facilities and qualified staff will be available.

#### 4.3.0. **PRODUCTION OF FCR TILES AND STABILISED SOIL BLOCKS IN KENYA.**

Producers and potential producers of FCR tiles and stabilised soil blocks in Kenya face several problems which must be overcome before both these materials can be widely used. It is imperative that the private sector takes over from the research and development institutions like H.R.D.U. with respect to the production or manufacture of FCR tiles and stabilised soil blocks. So far, the private sector has barely become interested in the production of FCR tiles and stabilised soil blocks. This is due to constraints that range from inadequate knowledge of these building materials by the general public who make up the private sector to the uncertain market conditions for stabilised soil blocks and FCR tiles.

The potential producers of FCR tiles and stabilised soil blocks are those manufacturers of conventional building materials like concrete tiles and blocks, etc. These are potential producers of FCR tiles and stabilised soil blocks because they are already in the building industry. Consequently, they have already established links with suppliers of raw materials like cement and sand, and have a share of the building materials market. It is easier for such firms, which are already established to expand their operations by venturing into the production of FCR tiles and stabilised soil blocks than for fresh entrepreneurs to set up a new building materials production unit for making FCR tiles or stabilised soil blocks or both.

A total of 4 firms which are involved in producing various concrete building products like blocks and tiles were surveyed. Only in one firm had the proprietor heard of stabilised soil blocks. However, this particular proprietor had no idea on how stabilised soil blocks are actually made or where to obtain information on the type of machinery or equipment necessary for making stabilised soil blocks. According to this proprietor, it was much easier to obtain ballast for making concrete blocks than murrum for making stabilised soil blocks. This particular firm is located in an area where the quarries for natural stone and ballast are nearby.

The other 3 firms where the proprietors had not heard of stabilised soil blocks were of the view that any building blocks made of soil cannot be as strong as a concrete block. This is not necessarily true because a properly compacted soil block which is adequately cured can achieve compressive strength equivalent to or

more than  $2.8 \text{ N/mm}^2$  which is the required minimum compressive strength for any building block according to the building code.

Although most of the proprietors of these building materials production firms interviewed had heard of FCR tiles and had seen them used in Komarock Estate, they did not know how FCR tiles are made or where they could obtain information on FCR tiles technology. Most of these potential producers of FCR tiles and stabilised soil blocks have no interest in producing these building materials because they do not know much about these technologies and are uncertain that there is demand for them. Very few entrepreneurs are willing to risk producing products which are not well known by the buyers.

The private commercial sector has yet to see where FCR tiles and stabilised soil blocks have been successfully used over a long period of time. Demand for FCR tiles and stabilised soil blocks is what will stimulate and encourage the private commercial sector to produce such materials on a scale that is comparable to that of conventional building materials. Until the time when FCR tiles and stabilised soil blocks are perceived by the general public as alternative building materials of equivalent quality in terms of performance in construction, there will be little demand for them. With continued little demand for FCR tiles and stabilised soil blocks, there is little chance of these building materials being produced and utilised on a wide scale comparable to other commonly used building materials.

Those in the private sector like small scale entrepreneurs who have ventured into producing FCR tiles and stabilised soil blocks face several problems that affect their productivity and ability to expand their operations. These problems include lack of basic inputs, like machinery, skilled labour, finance, energy, land or premises and affordable means of transportation. Other problems include the lack of a certain or assured market for the FCR tiles and stabilised soil blocks.

The majority of small scale entrepreneurs producing building materials have no access to formal sources of capital or credit. Because of this limited ability to obtain seed and working capital, such small scale entrepreneurs cannot easily obtain the basic inputs that are required in any building materials production unit. Apart from land, inputs like machinery and equipment are required for setting up a small scale building materials production unit.

In the case of FCR tiles, an ITW production kit may cost up to Kshs. 150,000<sup>1</sup>. This production kit includes at least 200 tile moulds, a vibrating table and other equipment and tools necessary for making FCR tiles. A cheaper tile production kit is available from Action Aid Kenya. This kit costs about Kshs. 35,000<sup>2</sup>. These costs include the construction cost of sheds and a water tank but exclude the cost of land. From these figures, one can see that even the cheapest tile production kit requires a potential entrepreneur to have access to credit to be able to purchase land and invest in the FCR tile production kit. For those entrepreneurs who are already manufacturing FCR tiles, access to credit facilities is necessary so that they can expand production and create surplus stocks. Once

stocks are created, the entrepreneurs can take advantage of sudden increases in demand, for example when a new residential estate is being developed and over one million roofing tiles are required over a short period of time.

With respect to stabilised soil blocks, the problem of lack of access to capital to purchase premises, machinery like block presses and the necessary raw materials like cement exists. The cheapest block presses available in Kenya are those designed by H.R.D.U. and fabricated by Western College of Arts and Applied Sciences (WECO) and Hartz and Bell which were being sold, in 1989, for Kshs. 5,000 and Kshs. 7,800 respectively<sup>3</sup>. The Bre-pak block press which was imported from Britain cost over Kshs. 50,000 for a single machine<sup>4</sup>. The Bre-pak is also expensive to maintain. The Action-pak block press designed by Action Aid Kenya and fabricated by Undugu Society of Kenya cost Kshs. 10,000 in 1989. In early 1991, it was costing Kshs. 11,000<sup>5</sup>. There is a cheaper block press from Action Aid Kenya, also fabricated by the Undugu Society of Kenya which costs just over Kshs. 5,000 per machine<sup>6</sup>.

The machinery, equipment or tools necessary for setting up and expanding FCR tile and stabilised soil block production unit are not very cheap and are not easily available throughout the country. Such machines as block presses and screeding tables are available at Action Aid Kenya, Undugu Society of Kenya, Hartz and Bell, WECO or through H.R.D.U. In the case of FCR tiles technology, vibrating or screeding tables can be bought from ITW at considerably higher prices than from the other sources. It is much easier for co-operatives or self-help groups

to accumulate funds to purchase block or tile making kits than for individual entrepreneurs.

Four small-scale producers of FCR tiles and one producer of stabilised soil blocks were surveyed. All these groups faced problems of lack of enough money. In the case of Humama and Kayole-Mihango Muungano Women's groups, the seed capital and initial working capital was provided by African Housing Fund through a loan to the groups. The purpose of the loan was to finance the purchase of equipment and machinery and train the members of the group in tile production and business management. Initially, the major problem faced by these women's groups' FCR tile production units was poor quality of FCR tiles that were made. This was due to the women's inexperience in the making of the tiles. With experience, the number of rejected FCR tiles dropped to an acceptable level.

The Kayole-Mihango Muungano group has only 384 FCR tile moulds; hence only 384 FCR tiles can be made in a day although there are 2 vibrating machines. If this group had more FCR moulds, they could work in shifts and produce twice as many tiles. This group also produces hollow concrete blocks and floor tiles for constructing their own houses. By March, 1991, 61 houses had been constructed but not completed, and 45 of these houses had been roofed using FCR tiles. The delay in completion of these houses is due to shortage of funds to buy the necessary components required to complete the houses. these include doors, windows, etc. The FCR tiles that the group was producing at that time were for sale so as to make

money to complete the houses already erected and start the construction of more houses for their members.

For the other FCR tile production units which were surveyed, the entrepreneurs obtained seed capital and initial working capital from Small Scale Enterprise Finance Company (SEFCO) which is a subsidiary of Industrial and Commercial Development Corporation. Shelter Sure and Shelter Works, both located in Nairobi, produce between them a total of 1200 FCR tiles per day when in full production. Both entrepreneurs purchased their equipment from Undugu Society of Kenya. Both Shelter Sure and Shelter Works would like to produce more FCR tiles but currently cannot do so because of financial constraints. So far, neither of these two producers keeps surplus stocks of FCR tiles. This is also due to lack of money to buy more raw materials, in particular cement, more screeding machines and hire more labourers who can work in shifts. There is also a problem with lack of storage space for stocks of FCR tiles, thus if more money was available, these entrepreneurs could buy bigger premises and build larger storage sheds. In places where there is no electricity, electrically powered screeding machines are expensive to run because one has to rely on a generator or rechargeable batteries. Rechargeable batteries are not always easily available throughout the country and generators may break down frequently. This is a problem that the Kayole-Mihango Muungano and Humama Women's groups FCR tile production unit face.

These women's groups did not have much choice on the type of machinery and equipment they could buy for setting up a tile production units. This was decided by their sponsors, ie, African Housing Fund (AHF). The machines used by these women's groups were purchased from ITW (Kenya).

Another major constraint to the widespread production and use of FCR tiles and stabilised soil blocks is the demand for these materials. Demand for FCR tiles and stabilised soil blocks is largely dependent on how acceptable these materials are to the general public, ie, the potential users. The acceptability of stabilised soil blocks and FCR tiles is in turn influenced by several factors that are closely interrelated. These factors include the costs of FCR tiles and stabilised soil blocks relative to the costs of other building materials that are commonly used and widely accepted like stone, concrete blocks and tiles, etc. There is also the aspects of how durable FCR tiles and stabilised soil blocks are relative to conventional building materials. Other factors that influence acceptability of building materials include the aesthetic qualities of the materials, cultural preferences of potential users and the social status that a building material is deemed to have. For instance, soil is seen as a building material for the poor since it is one of the cheapest building materials when it is used without any improvement or stabilisation. Small scale producers of FCR tiles and stabilised soil blocks have limited finance and consequently they cannot advertise their products aggressively. Advertising of new products is vital for stimulating demand so that potential users of these building materials are aware of them and their advantages over commonly used building



materials. As long as these small scale producers of FCR tiles and stabilised soil blocks do not advertise their products to promote their use, then stabilised soil blocks and FCR tiles will remain much as they are today, with little hope of their being widely used throughout the country.

The main market for stabilised soil blocks and FCR tiles is supposed to be the low income households, but, more often than not, even the low income population regard these building materials as inferior to stone, concrete blocks, concrete and clay tiles, etc. This is not necessarily true, because properly produced and cured FCR tiles and stabilised soil blocks can be used to construct a house of equivalent quality to a conventionally constructed house. Unless such attitudes towards stabilised soil blocks and FCR tiles change, prospects for a growing market for them are limited.

It is not just the attitudes of potential users that influences demand. There is also the issue of reduction in cost when using FCR tiles and stabilised soil blocks compared to the alternatives that are commonly used. Using FCR tiles and stabilised soil blocks must result in more than marginal reduction in the total cost of a house when compared to the cost of using conventional building materials, ie,

"They must become competitive with other building materials in terms of quality and variety of products."<sup>7</sup>

To these small scale producers of FCR tiles and stabilised soil blocks, the lack of a certain market for their products is one of the major problems that they face. Humama Women's group FCR tile production unit was subcontracted by ITW

to produce 800,000 FCR tiles for roofing of houses in Komarock Estate. The group produced a total of 4200 FCR tiles per day. By the beginning of 1991, the contract to supply FCR tiles to Komarock Estate had been completed and production per day was minimal and largely dependant on the number and size of orders for FCR tiles received from individual clients. Given that the group does not advertise its products, the buyers of FCR tiles are not very many. The Kayole-Mihango Muungano Women's group will face a similar problem once they have completed the construction of houses for those members who already own plots.

Shelter Works produces about 700 FCR tiles per day and each tile is sold at Kshs. 7.50. So far Shelter Works does not advertise because of financial constraints. In the case of Shelter Sure, the same problem of lack of an assured market for the FCR tiles exists. Production per day is determined by the number and size of orders received from individual clients. Shelter Sure produces 5 different types of FCR tiles; this being according to colour and the thickness of the tiles.

**Table 4.2: FCR tiles produced by Shelter Sure.**

Colour	Thickness	Price per tile in Kshs.
Red	8 mm	8.00
Red	6 mm	7.00
Green	8 mm	12.00
Grey/Plain	8 mm	7.00
Grey/Plain	6 mm	6.00

SOURCE: Field Survey 1991

The green coloured FCR tiles are more expensive because the green pigment is expensive. Shelter Sure produces FCR tiles that are 8mm because some clients felt that a 6mm thick tile was too light.

With respect to the production of stabilised soil blocks, there are not many private small scale producers producing stabilised soil blocks for sale. The stabilised soil block production unit at Korogocho Primary School was producing stabilised soil blocks for sale, but this was mainly to help finance the construction of the school. The blocks produced here were sold at Kshs. 3.50 each for those who wished to buy them but this group does not go out of its way to sell the blocks, for instance like the producers of concrete blocks. There are not many buyers of stabilised soil blocks according to this group producing these blocks at Korogocho Primary School.

There are other stabilised soil block production units in Busia which have been set up with the help from Mazingira Institute and the Ford Foundation. The market for the blocks produced by these groups is still growing. These groups producing stabilised soil blocks in Busia are also dependent on orders from clients and do not have surplus stocks of stabilised soil blocks. An average of 120 blocks are produced from a single bag of cement. The blocks are sold at Kshs. 2.00 per block. \*

Small scale production of FCR tiles and stabilised soil blocks faces several problems including the lack of adequate finance and lack of a certain market for their products since the effective demand for FCR tiles and stabilised soil blocks

is limited. The demand for FCR tiles and stabilised soil blocks is closely related to how acceptable these materials are to the general public or potential users. All these complex and closely interrelated problems must be overcome by the small scale producers of FCR tiles and stabilised soil blocks before these materials are widely produced and used.

#### **4.4.0. CONSTRUCTION OF BUILDINGS USING FCR TILES AND STABILISED SOIL BLOCKS.**

There are several problems which are encountered when using new building materials like FCR tiles and stabilised soil blocks. These are mainly problems that arise out of lack of knowledge of these technologies and the inherent characteristics of these building materials.

Before a person chooses a building material to use on a house he wishes to construct, there are several things he would like to know about the material and the two most important are the cost and the durability of the material. For architects to be able to specify FCR tiles and stabilised soil blocks on any building that they design, they must know the following.

- (a) The sizes in which the building material is available, in this case, it is the sizes of FCR tiles and stabilised soil blocks.
- (b) The varieties available in terms of colours, textures etc.
- (c) Where these materials have been successfully used for construction of buildings.

- (d) The costs per square unit of stabilised soil block walling or FCR tile roofing.
- (e) The costs per unit of FCR tiles and stabilised soil blocks.
- (f) In the case of roofing materials like FCR tiles, the roof structure requirements, ie, the sizes and spacings of purlins, rafters and battens.
- (g) In the case of building blocks like stabilised soil blocks, the type and strength of mortar required for use with such blocks; the type of rendering and plaster suitable for use on stabilised soil blocks.
- (h) The main suppliers or producers of FCR tiles and stabilised soil blocks.

The above information is not easily available in the case of stabilised soil blocks and FCR tiles. This is a constraint to the widespread use of FCR tiles and stabilised soil blocks.

#### 4.4.1. Construction Problems when using FCR Tiles.

The construction of a roof using FCR tiles requires builders who are properly trained in laying FCR tiles. FCR tiles will break if they are not handled carefully. In cases where the FCR tiles are not being produced on site, consequently have to be transported from elsewhere, they should be stacked upright on a bed of straw or sand and some straw put in between them to prevent the tiles from breaking during transportation.

Research and Training, Karen, and ITW(Kenya). The problem in this is where those artisans who have not come into contact with any of these organisations can get training on FCR tile roofing. A potential user of FCR tiles can be deterred in his efforts to use FCR tiles if he cannot get a builder or artisan with experience in using these FCR tiles.

The quality of a roof built of FCR tiles will be determined by the following factors:

- (a) The quality of the FCR tiles themselves. If the FCR tiles are not properly made and cured, the roof is likely to leak because of cracks in the tiles. For instance, in Nyahururu, during the construction of those 26 houses roofed with FCR tiles, about 300 FCR tiles which were produced initially were found to be too brittle and porous, therefore very likely to leak once the roof was built. These tiles had to be destroyed. There is also the issue of the thickness of the tiles: tiles that are less than 6mm thick, which is the recommended thickness according to the Kenya Draft Standard on FCR tiles, KS02-749, are likely to lead to a roof that leaks easily. In Nyahururu, the FCR tiles used were 4mm thick. The result is a high proportion of houses that leak.
- (b) The quality of workmanship. In Nyahururu, there is the problem of ridges that were not adequately sealed, consequently, most of the roofs leak. The leaking is made worse because the polythene membrane normally laid on the

roof structure before the tiles to ensure no leaking occurs was omitted in a bid to keep construction costs low.

- (c) A properly constructed roof structure will result in evenly laid tiles especially if all the timber used is adequately seasoned.
- (d) The frequency of extreme weather conditions like hurricanes and hailstorms will determine the durability of a roof built of FCR tiles.

With the passage of time and as the use of FCR tiles gets more accepted, the problems of quality of workmanship and quality of roof structure will be minor problems that can be taken care of through adequate training of artisans and close supervision by experienced people during the construction of the roof.

#### 4.4.2. Construction Problems when using Stabilised Soil Blocks

Successful construction of a building using stabilised soil blocks requires that the builder or mason understands the inherent properties of stabilised soil blocks and appreciates the difference between stabilised soil blocks and stone or concrete blocks. The quality of a stabilised soil block wall is influenced by the following factors, among others:

- (a) The quality of the soil blocks.
- (b) The quality of workmanship during construction of walls.
- (c) The strength of the mortar used for joining the stabilised soil blocks.

- (d) The amount of exposure to the elements. This is closely related to the size of the overhang and whether a protective coat or render has been applied to the stabilised soil blocks.
- (e) Protection against dampness and resultant growth of mould.

Stabilised soil blocks that are not properly compacted and adequately cured will not make a good wall no matter how experienced the mason is. Badly compacted soil blocks may be due to a faulty block press or simply the application of less compaction during the manufacture of blocks. A case in point is Nyahururu, where a faulty block press resulted in poorly compacted stabilised soil blocks. A new block press had to be purchased before further production of soil blocks could be undertaken.

For a mason to be able to construct a building using stabilised soil blocks, he has to have had some training and experience in the use of these kind of blocks. Stabilised soil blocks do not have a compressive strength as high as that of stone. Consequently, the mortar used for joining stabilised soil blocks should not be the same as that used in constructing with stone or concrete blocks. A mortar with the proportion of cement to sand being 1:6 is of sufficient strength to be used for stabilised soil blocks. A mortar which is much stronger than the stabilised soil blocks will result in cracks through the blocks or loss of adhesion between the blocks and the mortar. Those people inexperienced in the use of soil blocks may use mortars that are too strong resulting in unnecessary expenses and weak walls. During the construction of stabilised soil block walls, it is necessary to ensure that



there is a sufficient amount of water for the proper setting of the mortar. Normally, the surface of the stabilised soil block in contact with the mortar is wetted to provide enough water for the mortar to set.

Skilled builders are needed to ensure that damp proof courses are properly laid to protect stabilised soil block walls against rising dampness. In Nyahururu, most of the 26 houses built using FCR tiles and stabilised soil blocks have a problem of damp walls. This because damp proof courses were omitted, perhaps in a bid to save on construction funds. There is not much a mason or builder can do in such a case even if he realises the importance of a damp proof course.

Experience in constructing stabilised soil block walls is also necessary when applying rendering to external walls and plastering of internal walls where necessary. In areas where a lot of rainfall is received, stabilised soil block walls last longer if they are rendered. The application of render on a stabilised soil block surface requires skill and experience. The render to be used on stabilised soil blocks must be of equal strength to the blocks. This is to ensure that there is no loss of adhesion and to limit the subsequent cracking, spalling or peeling off of the render. For cement based renders to be used on stabilised soil block walls, these walls must have dried adequately before the render is applied. If this is not done, there is a risk of the render cracking or peeling off after it has dried. At Korogocho Primary School in Kariobangi, Nairobi, a block of classrooms constructed in 1988/89 and plastered almost immediately has large patches where

the rendering has peeled off. Classrooms built in 1984 using the same kind of stabilised soil blocks, but were not plastered, do not have any cracks in the walls.

Construction of stabilised soil block walls requires close supervision of the builders especially if they have little experience in handling and constructing with stabilised soil blocks. Stabilised soil blocks should be handled very carefully when being moved from the storage place to the site of the construction. This is because there is a danger of the soil blocks breaking if they are roughly or carelessly handled.

#### 4.5.0. THE DURABILITY OF FCR TILES AND STABILISED SOIL BLOCKS

##### 4.5.1. The Durability of FCR Tiles.

The durability of FCR tiles once a roof is built is influenced by the following factors, among others:

- (a) The quality of the FCR tiles, ie, whether they meet the minimum requirements as stated in the draft Kenya Standard on FCR tiles, KS02-749.
- (b) The quality of workmanship in building the roof framework and laying the FCR tiles.
- (c) The frequency of extreme weather conditions.

The strength of FCR tiles is influenced by several things, including the following:

- i) The quality and quantity of fibre used for making the tiles.
- ii) The proportion of cement used in the mixture.
- iii) The amount of water used for mixing; too much water makes the tiles porous, too little water, the mixture will not be workable.
- iv) The amount of vibration. The right amount of vibration ensures that the tiles is evenly compacted and no voids exist in the tile.
- v) The amount and type of sand used in the mixture.<sup>9</sup>

The amount of fibre used in making FCR tiles is usually about 1% by weight.

The main function of the fibre is to hold the mixture together and prevent shrinkage cracks during moulding, ie, when the wet mix is on the mould and during the period of curing. The fibre adds very little to the final strength of a properly cured tile.

As mentioned before, in the Nyahururu Tenant Purchase Housing Scheme, the FCR tiles used for roofing the 26 houses were too thin, only 4mm thick, instead of the accepted 6mm thickness. Because FCR tiles used here were thin, most of these tiles have cracked and consequently these houses leak. A proportion of 72.7% of the houses had broken or cracked tiles. In 4 houses, the occupants had removed the FCR tiles and replaced them with corrugated iron sheets because the tile roof used to leak. There was no possibility of replacing broken FCR tiles with FCR tiles because these tiles are not available in Nyahururu. The Nyahururu Municipal Council provided extra tiles for replacing broken ones but this was only for a few months immediately after the scheme was completed in 1987. Currently,

there is no private entrepreneur producing FCR tiles for sale within or around Nyahururu Town.

In other places where FCR tiles have been used, for instance, St. Joseph the Worker Parish in Kangemi, the thickness of the tiles was increased to 8mm to ensure a more durable tile. So far all the roofs at the parish are in good condition, with only a few tiles needing replacement on the roof of the church which was completed in 1989.

At Korogocho and Ngunyumu Primary Schools in Nairobi, the FCR tile roofs are still in good condition. The oldest buildings at Korogocho Primary School dates back to 1984 while at Ngunyumu, the oldest buildings roofed with FCR tiles were completed in 1987. Most of these roofs are in very good condition. There are a few broken tiles here and there, which are often due to pupils throwing stones or similar objects onto these roofs. The broken tiles are easily replaced from stocks kept on site and the construction of the schools is still on going so builders to carry out the repairs are easily available.

FCR tiles have also been used for roofing Kariobangi Housing Co-operative Society's 9 condominiums in Kia Maiko Village in Kariobangi, Nairobi. The construction of these Condominiums was started in 1978 and completed in 1980. These FCR tiles are still in good condition despite the accumulation of dirt and soot on the roofs. These roofs do not leak.

Komarock Estate, where FCR tiles have been used for roofing 1750 houses, is relatively new. The FCR tile roofs are in good condition. The tiles used for

roofing these houses were of good quality and were produced by people who were properly trained and the production was closely supervised by qualified ITW staff. The staff from ITW also checked the quality of the finished tiles before they were sold to the developers of Komarock Estate.

Apart from the quality of the FCR tiles, the quality of the workmanship during construction of the roof structure and laying of the FCRs has a bearing on the durability of the roof. Tiles that are not laid tightly and accurately will lead to a roof that leaks. Yet the tiles cannot be laid tightly and accurately if the roof structure is very uneven or the rafters and battens are badly warped because they were not properly seasoned. In cases where the tiles are laid properly and the builders do not step on the roofs, FCR tiles are quite durable.

In the case of Nyahururu, most of the 22 houses still roofed with FCR tiles had cracked tiles, and at the edges of the roofs, the tiles are missing. The tiles at the edges of the roofs were not nailed to the battens, consequently they have been removed by strong gusts of wind. FCR tiles are normally made with either a hole or wire loop in the nib through which they can be nailed. This does not seem to have been done in the case of the houses in Nyahururu Town. In areas where extreme weather conditions like hailstorms or hurricanes are frequent, it may be advisable not to use FCR tiles if most of these tiles cannot be nailed to the battens.

FCR tiles are relatively durable provided they are properly made, adequately cured, properly laid on a strong roof structure and not subjected to impact weight like falling objects and people walking on the roofs.

### 4.5.2. The Durability of Stabilised Soil Blocks.

Stabilised soil blocks are relatively durable building blocks although they are more susceptible to damage resulting from moisture penetration than stone or concrete blocks. The durability of stabilised soil blocks is therefore largely influenced or determined by the following factors.

- (a) The compressive strength of the stabilised soil blocks
- (b) The quality of workmanship during the construction of the walls
- (c) The amount of exposure of stabilised soil blocks to the elements especially rain

It is necessary that good quality stabilised soil blocks are used when constructing a building using these kind of blocks. Blocks that are not adequately compacted and cured will not make a durable wall. The quality of stabilised soil blocks is to a large extent determined by the following:

- i) The type of soil used for making the blocks. Some soils are more suitable for stabilisation than others. For instance, the red coffee soils are more suitable for stabilisation than black cotton soils.
- ii) The proportion of stabiliser (in this case cement) used for stabilisation. Too little cement may not adequately bind the soil particle together especially where compaction is not very high. Too much cement is not economical.
- iii) The amount of compaction applied to the block during the manufacturing process.

ii. Correct mixing of the soil and cement before wetting. The dry soil and cement should be evenly mixed before addition of water to ensure an evenly stabilised block. There should also be very little delay between mixing and compaction once water has been added to the mix. Delay will result in the cement beginning to harden, hence more compressive effort will be needed to produce a good quality block.

iii. The amount of water used for mixing the soil and cement. Too much water will result in a block that is easily damaged particularly when wet, i.e. when it is being removed from the block press. There is also the danger of shrinkage cracks forming on the block when it is being cured if too much water was used.

iv. Proper curing and storage of the stabilised soil blocks will ensure blocks do not have cracks and chipped or broken edges respectively.

In the places where stabilised soil blocks have been used for constructing houses, there does not seem to have been a problem with the quality of the blocks used in the initial days of constructing the 26 houses in Nyahururu.

The block press originally used produced blocks that were not adequately moulded. These blocks were not suitable for use as building blocks and a better one was had to be purchased before further production could be undertaken. In the places like Kangochoko and Ngunyumu Primary Schools in Kariobangi, St. Joseph's Worker Parish in Kangemi and Wanyee's Estate in Riruta, there were problems with the quality of the stabilised soil blocks used.

Apart from the quality of the blocks, the durability of a stabilised soil block wall is influenced by the standard of workmanship during the construction of the wall. A mason using stabilised soil blocks has to understand and appreciate the characteristics of soil blocks and how these differ from stone or concrete blocks and burnt clay bricks. Where it is not possible to find a mason or fundi with the experience of building with soil blocks, such a mason must be trained and closely supervised. This is to ensure that such a mason knows the correct proportions of cement and sand to use for the mortar and rendering or plaster where necessary. At Korogocho Primary School, a block of 4 classrooms built with stabilised soil blocks on which render has been applied had patches where the render has peeled off. This was because the render had not been properly applied and the cement content in the mix may have been too high resulting in loss of adhesion between the stabilised soil blocks and the rendering once the rendering had dried. These patches where the rendering had peeled off were being repaired.

Rendering of stabilised soil block walls is necessary especially in very wet areas because the rendering provides water proofing and resistance to wear by erosion. In Nyahururu, most of the 26 houses built of stabilised soil blocks, on which a thin coat of cement render was applied, have many large patches where this render has peeled off. This is mainly because of the effects of rain. Some of the occupants of these houses have applied a thicker coat of render on the external walls of these houses to protect them against the effects of driving rain and rain water splashing from the ground.



At St. Joseph the Worker Parish in Kangemi, all buildings with stabilised soil block walls have been plastered with a cement render. The rendering is dark brown in colour. Most of these buildings are still in very good condition since their completion in 1989.

At Wanyee's Estate in Riruta, the 14 houses are in good condition. The stabilised soil block walls have been plastered to a height of about 0.75m from the ground. At Ngunyumu and Korogocho Primary Schools, all buildings built of stabilised soil blocks have rendering at least up to a height of 0.5m from the ground.

Apart from application of render, the provision of wide roof overhangs will help protect stabilised soil block walls from the effects of driving rain, consequently making the walls last longer.



PLATE 4.1; NYAHURURU TENANT PURCHASE HOUSING SCHEME.

The picture shows a roof with several broken and missing tiles especially at the edge of the roof.



PLATE 4.2: NYAHURURU TENANT PURCHASE HOUSING SCHEME.

This picture shows two houses, both have roofs with missing tiles. The dark patches at the bottom of the walls show the effects of rising dampness and the resulting growth of mould.

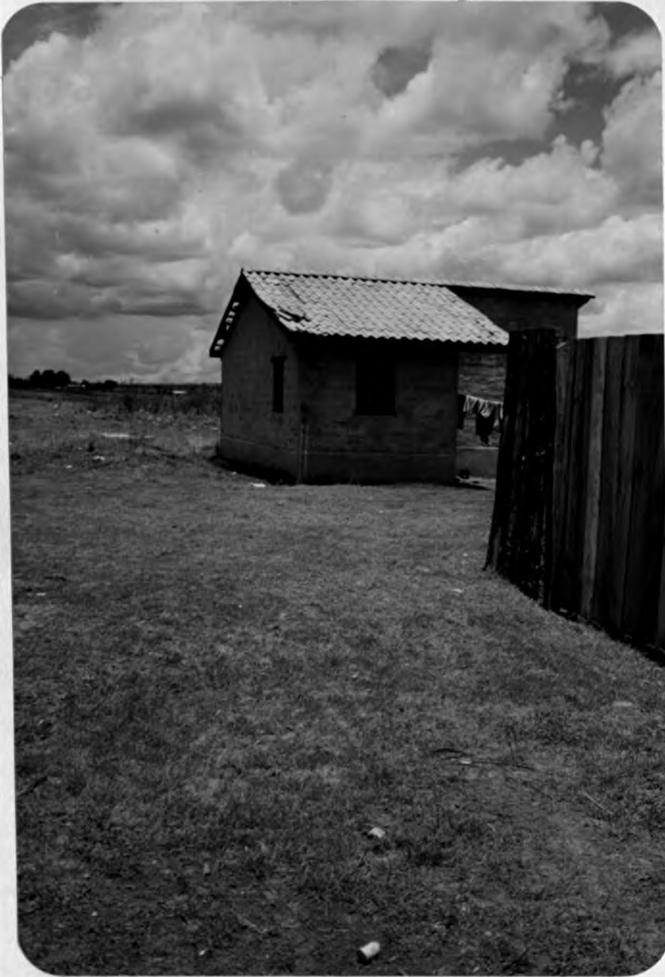
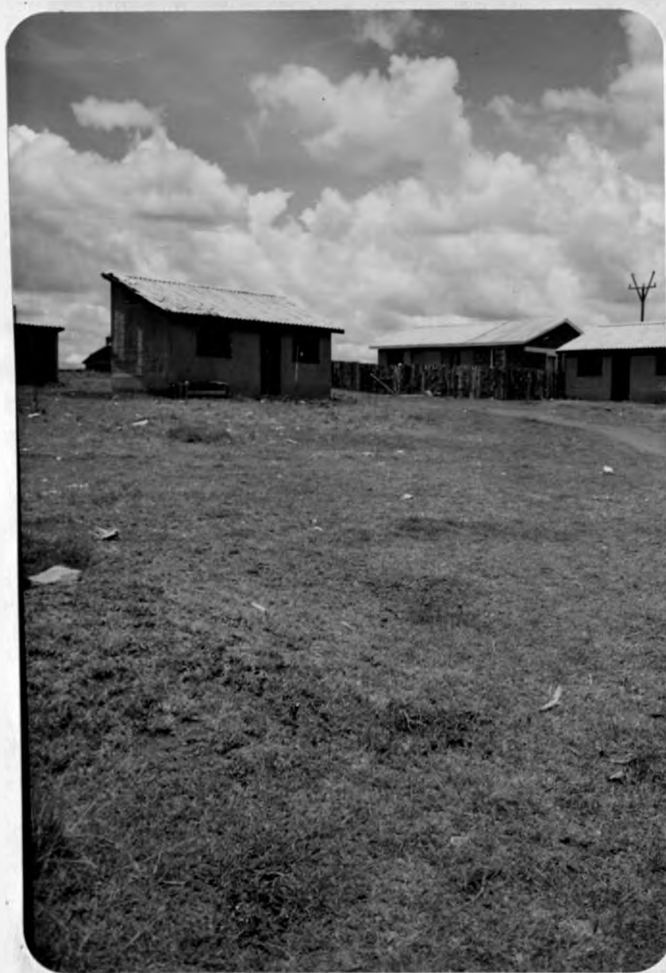


PLATE 4.3; NYAHURURU TENANT PURCHASE HOUSING SCHEME.

This picture also shows a house with a roof which has several tiles missing, particularly at the edge.



**PLATE 4.4; NYAHURURU TENANT PURCHASE HOUSING SCHEME.**  
The roof of the house in the fore ground has several loose tiles.



PLATE 4.5; NYAHURURU TENANT PURCHASE HOUSING SCHEME.

The extension to the original core house is being done using concrete blocks and corrugated iron sheets.



PLATE 4.6; NYAHURURU TENANT PURCHASE HOUSING SCHEME.

The extension to the original core house is also being done using concrete blocks and iron sheets.



**PLATE 4.7; NYAHURURU TENANT PURCHASE HOUSING SCHEME.**

The picture above shows the effects of rain on the walls of a V.I.P. latrine. The walls are built of stabilised soil blocks. The brown patches indicate where the cement render or coating has peeled off exposing the soil blocks.



**PLATE 4.8; NYAHURURU TENANT PURCHASE HOUSING SCHEME.**

This picture shows a V.I.P. latrine where the cement render has peeled off in patches because of rain.





PLATE 4.9: RIRUTA, NAIROBI.

Wanyee, Riruta in Nairobi. The stabilised soil block walls have been plastered from ground level to a height of about 0.75m.



PLATE 4.10; RIRUTA, NAIROBI.

Wanyee, Riruta in Nairobi. Some of the stabilised soil block walls are plastered from ground level to wall plate level to provide protection against rain.





PLATE 4.11: KANGEMI, NAIROBI  
 St. Joseph the Worker Parish, Kangemi, Nairobi. Offices and Residence built of FCR tiles and soil blocks still in very good condition.



PLATE 4.12: KANGEMI, NAIROBI  
 St. Joseph the Worker Parish, Kangemi, Nairobi. A classroom built of soil blocks with a cement rendering to which a brown pigment has been added.

4.6.0. **ACCEPTABILITY OF STABILISED SOIL BLOCKS AND FCR TILES TO THE USERS OF HOUSING BUILT USING THESE MATERIALS.**

The degree of acceptability of innovative building materials is an important determinant of demand for such materials, consequently how widely they are used.

"This acceptance by consumers is a complex interrelation of various forces including structural stability or safety, aesthetic appearance, cultural preferences, social status and the relative costs of innovative building materials when compared to the conventional building materials."<sup>10</sup>

Comfort to the occupants of housing or buildings constructed using innovative building materials is also an important factor in how acceptable such materials are to the consumers. Stabilised soil blocks have very good thermal insulating qualities. This makes it possible for houses built of stabilised soil blocks to be cool when the temperatures are high outside and warm when the temperatures drop. Consequently, extreme temperature variations do not affect the internal environment of a house built of stabilised soil blocks.

Stabilised soil blocks have very good sound absorbency. This is a desirable quality in a building material, especially materials to be used in the construction of houses in urban areas.

In the Nyahururu Tenant Purchase Housing Scheme, a total of 18 occupants were interviewed. All these respondents said that these houses built of stabilised

soil blocks and FCR tiles were cold during the nights especially during the cold season. But then, Nyahururu is in the highlands and is relatively a cold place, especially during the months of April to July. This problem of cold during the night, in these houses, may have been aggravated by the leaking roofs and damp walls in most of the houses.

With respect to the privately built estate in Riruta where stabilised soil blocks have been used for construction of 14 houses which are roofed with corrugated iron sheets, only 5 occupants responded to the questionnaires. All those interviewed said that these houses were hot during the day. This problem of heat during the day was due to the use of corrugated iron sheets for the roof and the omission of a ceiling. This problem of heat in the house is felt during the hot spells. During the cold months of May, June and July, the daytime temperatures in these houses are acceptable.

FCR tiles have superior thermal insulation when compared to corrugated iron sheets. The thermal insulation capacity of a material is measured and expressed in terms of " $\text{mm}^2 \text{ } ^\circ\text{K/Watt}$ " and this is referred to as the R factor of that material.

"The "R" factor of FCR tiles is 2700.0 when compared to 5.0 for corrugated iron sheets (gauge 30)."<sup>11</sup>

The higher the R factor of a material, the greater the capacity of that building material to maintain a relatively constant internal temperature in the house despite large variations in external temperatures. FCR tiles are therefore suitable

for use as roofing material in tropical areas where diurnal temperature variations can be quite large.

In Komarock Estate, where FCR tiles have been used to roof 1750 houses, a sample of 10% of the occupants of these houses were interviewed with respect to the use of FCR tiles for the roofs. Although Nairobi can be quite cold, especially in the months of May to August, 77.2% of those interviewed said that the houses were comfortably warm at night during the cold period and relatively cool during the day in the relatively warm months. A small proportion of 22.8% of those interviewed said that the houses were cold at night during the cold season and too warm during the relatively warm months of the year. From the figures given, a large proportion of the occupants of Komarock Estate find the internal environment of these houses roofed with FCR tiles quite acceptable and comfortable. The only thing about the roof that some of these occupants did not like was the omission of a ceiling in some of the houses. In most of those houses where there was no ceiling the respondents did not like seeing shafts of light through the gaps where the tiles have not overlapped tightly, although these roofs do not leak.

In Nyahururu, 5 years since these 26 houses were completed, 4 houses have had their FCR tile roofing replaced with corrugated iron sheets. The reasons given were that the FCR tiles used to leak and there was no chance of replacing them with FCR tiles since they were not available in Nyahururu any more. In 2 other houses, the owners were in the process of replacing the FCR tiles with corrugated iron sheets for the same reasons. There is actually a total of 22 houses partially or

completely roofed with FCR tiles. All the 18 occupants who were interviewed said the houses were cold at night particularly during the cold season. This can be attributed to the fact that Nyahururu is a cold place. Secondly, most of these roofs are defective, hence they leak. This is aggravated by damp walls, especially during the long rains season. The effect of leaking roofs and damp walls on the internal environment of a house is significant. Such a house only becomes warm when the rains cease and the walls dry out. Otherwise, when it is not raining, the internal environment of most of these houses is comfortable and acceptable to the occupants.

The acceptability of stabilised soil blocks and FCR tiles is also seen in terms of how affordable these materials are. Affordability in this case refers to the price or rent of houses built of FCR tiles and stabilised soil blocks compared to the prices or rents of houses of similar size and accommodation built of conventional building materials. Affordability is also seen in the light of what the occupants of houses built of stabilised soil blocks or FCR tiles can comfortably pay for. It is not practical for one to spend half or more than half of his or her monthly income on the cost of housing.

The majority of Komarock residents are medium and high income earners. only 4.7% of those interviewed earned less than Kshs. 3,000.00 per month which is what is considered low income within the urban areas.<sup>12</sup> 62.2% earned between Kshs. 3,000.00 and 8,000.00 per month and 33.1% earned over Kshs. 8,000.00 per month.

A large proportion of the respondents said they rented or bought the houses in Komarock Estate because they were more affordable when compared to houses of similar size and accommodation in other parts of Nairobi. For instance, the four bedroom houses in Komarock were being sold, in 1990, for Kshs. 468,000.00 for those completed in the early part of the year and Kshs. 498,000.00 for those completed later in the year. A three bedroom house in Sunrise Estate or Greenfields Estate also within Eastlands area is priced at Kshs. 750,000.00.<sup>13</sup>

**Table 4.3: Prices of the different types of houses in Komarock Estate (1989/90 prices).**

Number of bedrooms	Price in Kshs.	Phase
One bedroom	243,000.00	MMI
	236,000.00	PSS
Two bedroom	317,000.00	MMI
	314,000.00	PSS
Three bedroom	479,000.00	MMI
	451,000.00	PSS
Four bedroom	498,000.00	MMI
	468,000.00	PSS

Source: Field Survey 1991

MMI denotes the second sector of Komarock built after the PSS phase.

Out of the 172 occupants of Komarock who were actually interviewed, 81.4% of them bought or rented the houses because it is what they could afford given their monthly income. The rest, ie, 18.6% gave other reasons such as the houses were

spacious and they were the only ones available. These were the deciding factors in their choice of house to buy or rent.

In the case of Nyahururu, a large proportion of the occupants earn less than Kshs. 3,000.00 per month. In fact 77.8% of those interviewed were low income earners and they said these houses or rooms within these houses is what they could comfortably afford. The majority of those who earned less than Kshs. 3,000.00 per month occupied a single room within the 3 room core unit, meaning that some units had 3 different tenants. For the owner occupiers in this tenant purchase scheme, the monthly payment to the Nyahururu Municipal Council was Kshs. 395.00, payable for a period of 24 years. A smaller house of two rooms built of stone and corrugated iron sheets within the same Nyahururu low cost housing scheme costs Kshs. 450.00 per month for a period of 24 years. The rooms in the core units built of stabilised soil blocks and FCR tiles are larger than those of the houses built of stone and corrugated iron sheets which cost more. The rent per room for the rooms in these core units vary between Kshs. 200.00 to Kshs. 300.00 per month. This is low compared to rents payable for a single room in the stone houses in the same area, where the rents are over Kshs. 450.00 per month.

Rents charged for the house built of stabilised soil blocks in Riruta are equivalent to rents charged on conventionally built houses in the same area. Tenants for these houses chose to live here for other reasons and not because the rents were low compared to rents for other houses in the same area.

Apart from comfort to the occupant and affordability of the building materials, there is also the issue of personal preferences in the choice of building materials. Personal preferences have an important bearing on the acceptability of relatively new building materials because of the symbolic value and the social status that comes from owning a house that is built of modern or conventional building materials.

Earth is considered by many people to be a construction material for those who cannot afford to use materials like concrete or stone. With the introduction of stabilised soil blocks which can be used to construct a relatively durable building, most people are still not convinced that a building made of stabilised soil blocks is as good as one built of stone or concrete products.

FCR tiles are relatively unknown. People have yet to see where FCR tiles have been used extensively over a long period of time. Because of their relative newness when compared to roofing materials like clay or concrete tiles, corrugated iron sheets or asbestos sheets, etc, FCR tiles are still not widely known let alone accepted as a roofing material which is durable.

There was the need, therefore, to find out whether the possibility of potential use of FCR tiles and stabilised soil blocks existed among those who are occupying housing built of these two materials. All those who were interviewed in Nyahururu, Komarock and Riruta were asked whether they would use FCR tiles and/or stabilised soil blocks in future or if they were to construct a house in another place.



Out of 172 respondents in Komarock, only 36% said that they would use FCR tiles if they were to construct a house in future. A proportion of 53.5% said that they would not use FCR tiles and that they preferred a roof built of conventional building materials. The main reason given for these preferences was that FCR tiles are not as durable as concrete or burnt clay tiles. Although in the case of Komarock Estate, the roofs were still in good condition and there were no broken tiles. So these occupants' claims that these tiles were not durable were not supported by any evidence they had seen on their roofs. It was just a fear they had. FCR tiles break easily if someone walks on them or when objects like stones are thrown on them or large fruits falling on them. A proportion of 10.5% in Komarock said that they were not sure whether they would use FCR tiles or not. The reason given for this was that FCR tile technology was still very new, hence they did not know much about it and they would prefer to use roofing materials that have proved themselves over a long period of time.

There is a growing awareness among those people who live in and around Komarock Estate of the advantages of using FCR tiles over similar roofing materials. With the passage of time, more people will be willing to use FCR tiles after seeing them successfully used in Komarock Estate.

None of the occupants interviewed in Nyahururu felt that houses built of stabilised soil blocks and FCR tiles were equivalent to houses built of stone or concrete blocks and roofed with corrugated iron sheets. This view may be justified in the light of conditions in which some of these houses built of stabilised soil

blocks and FCR tiles are. The roofs leak because the tiles are cracked, broken or missing. The walls have large patches where cement render has peeled off exposing the stabilised soil blocks. The fact that some of the houses built of stabilised soil blocks and FCR tiles are in a bad condition implies that the image of these materials that the occupants and the people living around there have is not very positive. A proportion of 83.3% of those interviewed said that they preferred a roof built of iron sheets to the FCR tile roof they had. This same proportion declared that they would not use FCR tiles if they were to construct a house. The reason given for this preference was that FCR tile roofs were liable to leak because the tiles broke or cracked easily. Only a small proportion of 16.7% stated that they would use FCR tiles if they were to construct a house because FCR tiles are cheaper than similar roofing materials.

With respect to the use of stabilised soil blocks, a proportion of 66.7% of those interviewed preferred concrete or stone for walls rather than stabilised soil blocks. The main reason given for this preference was that stabilised soil blocks were made of soil and consequently they could not be good enough for the construction of houses especially in an urban area. This same proportion declared that they would not use stabilised soil blocks if they were to construct a house because they felt that stabilised soil blocks are not durable. The view that stabilised soil blocks are not durable is not necessarily true. In the other places in Kenya where stabilised soil blocks have been used, eg in Korogocho and Ngunyumu Primary Schools and St. Joseph the Worker Parish, Kangemi, the buildings are in

good condition. This shows that stabilised soil blocks are relatively durable unlike the picture presented by the Nyahururu houses. A proportion of 33.3% of those interviewed said they might choose to use stabilised soil blocks if they were to build a house. This was mainly because the use of stabilised soil blocks would result in reducing the construction costs.

In the case of Wanyee's tenants in Riruta, where there are 14 houses built using stabilised soil blocks, all those interviewed said they preferred concrete or stone walls to stabilised soil block walls although the houses they were occupying were in good condition. Despite this preference they all said they might use stabilised soil blocks if they were building a house in the rural areas because, according to them, soil blocks are more suited for use in the rural areas than in urban centres.

In conclusion, one can say that there is potential for more use of FCR tiles for roofing houses in Kenya especially Nairobi and its environs given that 36% of those interviewed in Komarock Estate said that they would use FCR tiles. (See table 4.4 on potential use of FCR tiles) With time there is a greater likelihood of widespread use of FCR tiles as alternative roofing material to clay and concrete tiles.

Table 4.4: Potential use of FCR Tiles

Response	Komarock Estate in Nairobi	Nyahururu Tenant Purchase Housing Scheme, Nyahururu
Proportion who would use FCR tiles	36.0%	16.7%
Proportion who would not use FCR tiles	53.5%	83.3%
Proportion who are not sure whether they would use FCR tiles	10.5%	
Total	100.0%	100.0%

Source: Field Survey 1991

Table 4.5: Potential use of Stabilised Soil Blocks

Response	Nyahururu Tenant Purchase Housing Scheme, Nyahururu	Wanyee's Estate in Riruta, Nbi
Proportion who would use stabilised soil blocks	33.3%	33.4%
Proportion who would not use stabilised soil blocks	66.7%	50.0%
Proportion who are not sure whether they would use stabilised soil blocks		16.6%
Total	100.0%	100.0%

Source: Field Survey 1991

In Nyahururu, most people within and around the town perceive both FCR tiles and stabilised soil blocks to be poor imitations of conventional building materials that are commonly used. (See table 4.5 on potential use of stabilised soil blocks). In Riruta, the use of stabilised soil blocks to construct houses are cheaper

than stone or concrete block houses has generated quite an amount of interest in stabilised soil block technology in the area. Several people within the area are beginning to use stabilised soil blocks. Most of these people hire the block press from the private entrepreneur who has constructed the 14 rental houses that were surveyed as part of this study. It is cheaper to hire the block press than buying a new block press for most of these people.

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## **CHAPTER FIVE**

### **SUMMARY, CONCLUSIONS AND RECOMMENDATIONS.**

#### **5.1.0. SUMMARY AND CONCLUSIONS.**

This study set out to investigate the constraints that have inhibited the widespread production and use of stabilised soil blocks and FCR tiles. The study aimed at highlighting these constraints and consequently give some recommendations on how these constraints could be overcome to enhance widespread production and use of FCR tiles and stabilised soil blocks.

This study has looked at the advantages and disadvantages of using stabilised soil blocks and FCR tiles when compared to using the conventional building materials that are commonly used. It has also looked at the historical development and spread of stabilised soil block and FCR tile technologies in Kenya and the role played by the various promoting organisations that are involved in disseminating both or one of these technologies. This study focuses on the reasons for the lack of widespread use of these two building materials, namely FCR tiles and stabilised soil blocks. The constraints to the widespread dissemination, production and use of stabilised soil blocks and FCR tiles that were identified in this study are;

- i) Problems of disseminating information on FCR tiles and stabilised soil blocks.
- ii) Problems in the production of FCR tiles and stabilised soil blocks especially by the private commercial sector.



- iii) Problems of constructing buildings using FCR tiles and stabilised soil blocks.
- iv) Issues that relate to the quality and durability of stabilised soil blocks and FCR tiles as building materials.
- v) Questions about how acceptable FCR tiles and stabilised soil blocks are to the potential users.

The dissemination of both FCR tile and stabilised soil block technologies in Kenya has been done mainly through the use of demonstration or pilot projects. The impact of these demonstration projects has not been very big, ie, they have not created widespread interest in and awareness of FCR tiles and stabilised soil blocks. This is mainly due to three factors that are closely interrelated. These factors are

- a) Lack of funds.
- b) Lack of adequate professional staff to carry out demonstrations.
- c) Lack of adequate physical facilities like workshops and laboratories where testing of these building materials and training on the use of such materials can be undertaken.

Central to all these factors is the issue of availability of funds. If more money was available to the organisations promoting the use of stabilised soil blocks and FCR tiles, then the other two factors would be solved to a large extent. If more funds were available, more pilot projects could be undertaken, more staff would be engaged to man these projects and train the potential users in the production and use of the said building materials. Acquisition of workshops and

laboratories would be an easy task once more funds are available to organisations that are disseminating the use of FCR tiles and stabilised soil blocks.

The dissemination of stabilised soil block and FCR tile technologies are severely limited by the inability of promoting organisations to obtain adequate funding for their activities, consequently not very many people in Kenya are aware of the advantages of FCR tiles and stabilised soil blocks over the conventional building materials. This lack of awareness and interest in stabilised soil blocks and FCR tiles on the part of potential users of these building materials cannot result in the widespread production and use of such building materials.

In the development of any building material, the private commercial sector normally takes over from research and development institutions. If such a building material is to take off commercially and compete favourably with comparable building materials that have been in use for a long time, the private sector must become interested in producing or manufacturing such a building material.

The production of FCR tiles and stabilised soil blocks by the private commercial sector in Kenya has faced several obstacles that have hindered its growth and expansion, consequently FCR tiles and stabilised soil blocks have yet to be produced on a scale comparable to conventional construction materials like concrete blocks, concrete tiles, burnt bricks and clay tiles. This is mainly because the production of stabilised soil blocks and FCR tiles is done by small scale producers (either individuals or self-help groups).

Most of the problems that are faced by small scale producers of FCR tiles and stabilised soil blocks in Kenya are due to the following.

- i) The shortage of funds or the lack of access to credit facilities.
- ii) The absence of widespread effective demand for the materials being produced.

Lack of adequate funds among small scale producers of building materials and the lack of access to conventional sources of finance for such enterprises is a major obstacle to increased production of FCR tiles and stabilised soil blocks. Basic inputs are difficult to obtain where finance is limited. Some of the equipment and machinery that is necessary for making FCR tiles and stabilised soil blocks, for instance, vibrating tables and block presses are not as cheap as expected and are more affordable to co-operatives or self-help groups rather than individuals. Because finances are limited for most of these small scale producers of FCR tiles and stabilised soil blocks, the finished products cannot be aggressively advertised so as to stimulate more demand. Due to limited amounts of money available to such producers of FCR tiles and stabilised soil blocks, surplus stocks of these materials cannot be kept and since no stocks are kept, such entrepreneurs cannot take advantage of sudden increases in the demand for either FCR tiles or stabilised soil blocks. Without access to sources of finances, the production of FCR tiles and stabilised soil blocks will remain much as it is, ie, prospects for its growth and expansion are very limited.

The problem of lack of widespread demand for FCR tiles and stabilised soil blocks is also a major constraint to the widespread production and use of these two building materials. Absence of widespread demand for FCR tiles and stabilised soil blocks stems from the fact that these two building materials have yet to become widely acceptable to many people in Kenya. Those people who have heard of FCR tiles and stabilised soil blocks are still sceptical about the durability of these two building materials. Consequently, they prefer to use building materials that have proved themselves over a long period of time. Most Kenyans have yet to see where FCR tiles and stabilised soil blocks have been extensively used over a long period of time. The situation is worse for stabilised soil blocks than for FCR tiles which have been used in Komarock Estate in Nairobi. Until such a time when FCR tiles and stabilised soil blocks have become acceptable to a wide majority of Kenyans as building materials that are relatively cheap and yet durable when compared with comparable building materials that are conventionally used, lack of widespread demand will still be a major problem.

When it comes to the construction of buildings using FCR tiles and/or stabilised soil blocks, a few problems arise out of most people's ignorance of the differences between these two materials and other building materials like concrete blocks and tiles. Many artisans or fundis are not well versed in constructing with FCR tiles or stabilised soil blocks. Because these artisans are ignorant of inherent properties of FCR tiles and stabilised soil blocks, their handling of these building materials during construction may result in a faulty building that will ultimately

fail. Such building failures may result in these building materials being termed as temporary when the workmanship is faulty. Generally, one can say that problems associated with building using FCR tiles and /or stabilised soil blocks are basically those that arise out of people not appreciating the differences between FCR tiles and stabilised soil blocks on one hand and the conventional building alternatives on the other hand. Most artisans constructing buildings using FCR tiles and stabilised soil blocks tend to treat them in the same way they treat concrete blocks and concrete or clay tiles unless they have been specially trained in the use of FCR tiles and stabilised soil blocks.

Until a time when many local artisans are well versed in the correct procedures of handling FCR tiles and stabilised soil blocks during construction, FCR tiles and stabilised soil blocks will not be used on a scale comparable with that of conventional building materials.

Another deterrent to the widespread use of FCR tiles and stabilised soil blocks is people's attitudes towards issues like the durability of both these materials when compared to conventional building materials. Many people would only be inclined to use FCR tiles or stabilised soil blocks after seeing the material in use, i.e. buildings on which these materials have been used that have lasted for a considerable period of time. As it is now, in places like Nyahururu, where the few houses constructed using FCR tiles and stabilised soil blocks in 1986/87 are not in very good condition, not many people view both these building materials positively. The bad condition of the houses in Nyahururu is not because FCR tiles and

stabilised soil blocks are temporary or poor building materials but because of the poor design of the houses and poor workmanship during construction of the houses.

With increased use of stabilised soil blocks and FCR tiles in more pilot projects, government funded housing projects and government offices, there is a greater likelihood of FCR tiles and stabilised soil blocks becoming more acceptable, consequently, they will be used by more people throughout Kenya.

Apart from durability, there are factors that determine how acceptable a building material is to the potential user. Issues like how affordable such a building material is, personal preferences and tastes play an important role in the choice of a building material. In cases where FCR tiles and stabilised soil blocks are marginally cheaper than concrete or clay tiles and concrete blocks respectively, then the potential buyers opt to buy concrete or clay tiles and concrete blocks. The reduction in the cost of construction when using FCR tiles and stabilised soil blocks relative to the cost of using the commonly used building materials must be big enough to induce potential users to choose FCR tiles and stabilised soil blocks as opposed to the other building materials.

Although FCR tiles and stabilised soil blocks are more often than not, more affordable than conventionally produced building materials, people's tastes and preferences still run in favour of these conventional building materials that are status symbols. Until such a time when people's attitudes towards FCR tiles and stabilised soil blocks have changed and become more positive, prospects for their widespread production and use are limited despite the apparent advantages that FCR

tiles and stabilised soil blocks have over comparable conventionally produced building materials.

### 5.2.0 RECOMMENDATIONS

To achieve widespread production and use of stabilised soil blocks and FCR tiles, more effort is required on the part of those promoting the use of these materials and active support by the government.

The dissemination of FCR tiles and stabilised soil blocks could have a greater impact in terms of capturing the interest of more potential users if the demonstration projects that are used for introducing these technologies in the community were strategic in terms of their location and the use to which the buildings are to be put, for instance, using FCR tiles and/or stabilised soil blocks on government financed housing, be it local authority housing or government staff housing. The use of FCR tiles and stabilised soil blocks for the construction of government offices in most of the rural areas, and where possible, in urban areas, is more likely to generate more interest in the use of these building materials than is currently possible through the isolated pilot projects done by the various promoting organisations that are found in Kenya. Active support by the government is vital if more demonstration projects are to be carried out. This will require changes in the procedures for tendering and awarding of government contracts to allow the use of building materials like FCR tiles and stabilised soil blocks. This

implies that KBS Standards on FCR tiles and stabilised soil blocks must be gazetted as soon as possible.

There are many organisations, both local and international, that are involved in disseminating the use of FCR tiles and/or stabilised soil blocks in Kenya, each acting on its own, but there is little interaction and exchange of information with respect to the use of facilities like workshops, laboratories and libraries. The efforts of these organisations would be more fruitful if there was a national body or public agency charged with the task of co-ordinating all their activities with respect to the dissemination of appropriate building technologies. Such tasks include sponsoring short term training programmes in the production and use of FCR tiles and stabilised soil blocks in the construction of buildings. Such a public agency could also help educate the public about the advantages of FCR tiles and stabilised soil blocks over conventional building materials, ensuring that such building materials became acceptable to the general public. This could be done through the publication of magazines or articles on the use of FCR tiles and stabilised soil blocks with pictures of places within this country where these building materials have been successfully used.

Dissemination of FCR tile and stabilised soil block technology in Kenya could also be achieved through helping individuals, self-help groups and co-operatives to set up small scale FCR tiles and stabilised soil block production units. This is already being done by African Housing Fund and seems to be more successful in generating more interest among the general public than would be



possible with isolated demonstration projects carried out by the sponsoring agency. The setting up of building materials production units, providing continuous training in production, marketing, business management and the actual construction of buildings using FCR tiles and/or stabilised soil blocks requires more resources in terms of money and trained staff to carry out the necessary tasks. Setting up small scale producers of FCR tiles and stabilised soil blocks requires that they have easy access to sources of capital. Hence the need to set up financial institutions for this purpose, ie, of providing credit to small and medium scale firms since conventional financing is out of reach for most entrepreneurs at this level of production. This requires more support and greater commitment on the part of the government to effect the necessary legislative changes necessary to set up financial institutions and give tax exemptions for small scale firms and individual entrepreneurs producing FCR tiles and stabilised soil blocks. It is upon the government to make the economic climate more favourable for these small scale building materials production units to thrive and expand their production. Access to credit on the part of producers of FCR tiles and stabilised soil blocks will ensure that they have the necessary working capital to create surplus stocks and advertise their products aggressively to stimulate the demand for these building materials.

With respect to the construction of buildings using FCR tiles and stabilised soil blocks, there is need for continued training of artisans in the use of these building materials. This is because the durability and safety of buildings that are roofed with FCR tiles and have stabilised soil block walls depends to a large extent

on the competence of the builders among other things. The training of artisans could start with the changing of the curricula for those doing construction courses in technical schools and polytechnics to include construction using FCR tiles and stabilised soil blocks. This will ensure that most future fundis or builders are well versed with the use of FCR tiles and stabilised soil blocks and appreciate the differences between these two building materials and those that are conventionally produced.

With the gazetting of draft KBS Standards on FCR tiles and stabilised soil blocks, the government would ensure standardised production of these two building materials. Rigorous enforcement of these standards will ensure that there are few quality control problems in the production of FCR tiles and stabilised soil blocks. Ultimately, only quality building products will be marketed by producers of stabilised soil blocks and FCR tiles. Codes of practice on the use of FCR tiles and stabilised soil blocks should be formulated and adherence to these should be enforced. If good quality FCR tiles and stabilised soil blocks are produced and buildings constructed with these materials are done in accordance with the relevant codes of practice, then the issue of durability of these materials in construction will not be a major constraint to their widespread use.

With the passage of time more people are likely to use FCR tiles; considerably more time will pass before stabilised soil blocks become more popular.

### **5.3.0 SUGGESTED AREAS FOR FURTHER RESEARCH**

The chemical properties of FCR tiles and stabilised soil blocks and how this affects their durability. In the case of FCR tiles, what happens to the fibre after a long period of time? Does the decay or deterioration of the fibre mean that such a tile has lost its useful life hence needs to be replaced? Questions about the durability of FCR tiles and stabilised soil blocks are among the reasons stated by respondents in Nyahururu and Komarock for preferring other roofing and walling materials that have proved themselves over a long period. The durability of FCR tiles and stabilised soil blocks is also an issue that affects the costs-in-use or maintenance costs of houses/buildings constructed using these materials. Many of those interviewed in Nyahururu and Komarock had a fear that maintenance costs for buildings constructed using FCR tiles and stabilised soil blocks may be much higher than for comparable buildings built using conventional building materials even if the initial construction costs for the former were less.

There is therefore a need to find out how buildings constructed using FCR tiles and stabilised soil blocks compare with similar buildings constructed with conventional roofing tiles or sheets and building blocks in terms of maintenance costs.

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**APPENDIX 1****QUESTIONNAIRE FOR THE PROMOTERS OF APPROPRIATE BUILDING TECHNOLOGIES AND MATERIALS.**

1. Name of institution/organisation.  
Postal Address.  
Telephone Number.
2. Are there any institutions/organisations that finance your work? Yes/No  
If Yes, name them.
3. What is the main emphasis or thrust of your activities?
 

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  - a) Technology development
  - b) Technology dissemination
  - c) Technology development and dissemination
  - d) Any other (specify)
4. What is your understanding and definition of the term "appropriate building materials"
  - a) Appropriate for the area in which you are working
  - b) Appropriate to the needs and means of potential beneficiaries of such materials
  - c) Appropriate for the poorest sections of the society

d) Any other (specify)

5. Is the development and promotion of appropriate building technologies and materials a major policy of your institution? Yes/No

6. a) List appropriate building technology demonstration projects which your institution has completed.

PROJECT	NO. OF UNITS/ BUILDINGS	DATE OF COMPLETION	COST IN KSHS	NO. OF BENEFICIARIES

b) Are you currently carrying out any demonstration projects? Yes/No

If yes, where (list)

7. Is there a report on these projects you have carried out? Yes/No

If yes, provide a copy of the report.

8. What proportion of your institutions total annual budget is set aside for the development of appropriate building technology projects?
9. Are the available funds adequate for the projects that have been planned for?
10. List professionals in your institution participating in the demonstration projects.

11. Do you have any in-house facilities for testing developed building materials, and facilities for training potential users of these materials? Yes/No

If yes, list the facilities

12. Are these facilities adequate for your needs and purposes? Yes/No

If No, what other facilities do you require?

13. Do you have a library for the documentation of relevant information, eg, reference, record keeping on projects, evaluation of projects? Yes/No
- Is the library adequate? Yes/No
- If not, what do you need?
- (i) Books
  - (ii) Journals
  - (iii) Access to experts
  - (iv) Bibliographies
  - (v) Any other (specify)
14. If the main emphasis or thrust of your organisation's activities is appropriate building technologies and materials research and development only, does your organisation have links with institutions that are involved in disseminating such technologies and materials? Yes/No
- If yes, name the institutions
15. If your primary objective is technology dissemination, do you have links with technology development institutions? Yes/No
16. If no, what is/are the source(s) of the building technologies and materials which you disseminate? (List)

17. Do you interact directly with the potential beneficiaries of these appropriate building materials and technologies before identifying their felt needs?

Yes/No

If no, why?

18. When you disseminate these appropriate building technologies and materials, do you work with any of the following? (Explain nature of the relationship)

a) Government departments

b) Non-governmental development agencies

c) Training institutions

d) Beneficiary organisations, eg, co-operatives within the target community

19. Does your institution ensure that the potential beneficiaries are adequately trained in the production and use of these appropriate building materials?

How long is the training

a) for potential producers

b) for potential users

20. Any other relevant information

Adapted from

"National and Regional Technology Groups and Institutions: An Assessment",  
by Reddy A. K. N in Towards Global Action for Appropriate Technology  
Bhalla A. S (ed), Geneva, 1977.

## APPENDIX II

### QUESTIONNAIRE FOR DEVELOPERS OF APPROPRIATE TECHNOLOGY BUILDINGS

#### General Information

1.a) Name of Developer

Full Postal Address and Telephone Number, if any

b) If developer is a group/society

-Year of formation

-Number of members

2. Finance

What are the sources of your funds?

a) Personal savings

b)(i) Loans/Grants

(ii) Name institution/bank that provided the loan/grant

c)(i) Is there any organisation/agency/institution that financed your project?

(ii) Provide the name(s) of such sponsors

3. Production

i) What appropriate building materials are you producing?

**FCR tiles/Stabilised soil blocks**

- ii) **How did you get to know about these materials?**
- iii) **What is the production rate per day?**
- iv) **Where are these materials used or sold?**
- v) **If sold, at what price per unit?**
- vi) **What are the prices of the following?**
  - Concrete blocks
  - Concrete tiles
- vii) **What training did you receive before you started production?**
  - How long was the training?
- viii) **Were there any problems encountered during training?**
- ix) **What are the problems you are facing in the production of these materials?**



x) What problems do you face in the marketing of these building materials?

xi) a) Are there any plans of expanding production?

Yes/No

b) If yes, how many units do you intend to produce?

4. Questions about housing already developed using FCR tiles or Stabilised Soil Blocks.

i) Why did you choose to use this particular material for walling/roofing?

ii) Were there any problems encountered in the approval of proposed plans for these buildings?

iii) How many units/buildings have you built using these materials?

iv) What problems were encountered in the actual construction of these buildings with respect to using these materials.

v) What are the advantages of using these materials rather than the alternative conventional materials like concrete blocks and concrete tiles?

vi) What do you feel are the disadvantages of these materials?

vii) Do you plan to use these FCR tiles/Stabilised soil blocks in future or elsewhere?

5. Any other relevant information.

### APPENDIX III

#### QUESTIONNAIRE FOR OCCUPANTS/USERS OF FIBRE CONCRETE ROOFING AND/OR STABILISED SOIL BLOCK WALLING.

1. Name of head of household

2. Occupation of head of household

3. Is the occupant the owner or a tenant?

If occupant is a tenant, state the amount of rent paid per month in Kshs.

If occupant is the owner, state the amount of mortgage repayment per month in Kshs.

4. State the approximate amount of income per month. (tick)

Below 1,000 Kshs

1,001 - 2,000 Kshs

2,001 - 3,000 Kshs

3,001 - 4,000 Kshs

4,001 - 5,000 Kshs

5,001 - 6,000 Kshs

6,001 - 7,000 Kshs

7,001 - 8,000 Kshs

8,001 Kshs and above

5. How many bedrooms are there in this house?
6. For those occupants who are tenants, what were the reasons for moving from where you lived previously?
- a) You needed a bigger house. Yes/No
  - b) You needed a cheaper house. Yes/No
  - c) You wanted to live closer to your place of work. Yes/No
  - d) You wanted to live near your friends. Yes/No
  - e) Any other reasons. (please specify)
7. For those occupants who are owners, why did you choose to buy this house?
8. What was the total cost of the house (in Kshs)
9. i) What construction materials have been used for construction of
- a) the roof
  - b) the walls
- ii) If the roof is made of FCR tiles, would you have preferred to have a roof made of g.c.i, concrete tiles or clay tiles? Yes/No

If yes, why

If no, why

- iii) If the walls are made of stabilised soil blocks, would you have preferred to have a house with walls made of bricks, concrete blocks or quarried stone?

If yes, why

If no, why

10. Is the house
- a) cold at night
  - b) hot during the day

11. The sanitation facilities provided

- a) Flush toilet
- b) V.I.P. (Ventilated Improved Pit) Latrine

If V.I.P. Latrines, is there anything you feel is wrong with the provision of a V.I.P. latrine rather than a flush toilet within the house?

Where is the bathroom?

- i) Within the house
- ii) Outside

Physical observation of the house.

- cracks in the walls
- walls overgrown with mould
- roofing tiles that are missing
- does the roof leak?
- roof that is overgrown with mould
- any other defects in the roof and walls (specify)

a) What are the occupants' views on FCR tiles?

- cheap but poor in quality when compared to similar products made of concrete or clay tiles, asbestos sheets, or g.c.i. sheets
- they are equivalent in quality and performance to concrete tiles and clay tiles, asbestos sheets, g.c.i
- any other opinion. (please specify)

b) What are the occupants' views on stabilised soil blocks

- cheap but poor in quality when compared to concrete blocks, etc
- not as strong as concrete blocks

- they are made of soil/mud
- their appearance is not pleasant or nice to look at
- any other opinion. (please specify)

15. If you were to construct a house in future, would you use

a) FCR tiles for the roof? Yes/No

If yes, why?

If no, why?

b) stabilised soil blocks? Yes/No

If yes, why?

If no, why?

c) Both FCR tiles and stabilised soil blocks? Yes/No

If yes, why?

If no, why?

## APPENDIX IV

### QUESTIONNAIRE FOR THOSE IN CHARGE OF COMMUNITY FACILITIES (EG. SCHOOLS, CHURCHES, CLINICS, ETC) THAT HAVE BEEN CONSTRUCTED USING FCR TILES FOR ROOFING AND/OR STABILISED SOIL BLOCKS FOR WALLING.

1. Name of Community facility

- Is it a church, clinic, school, or other (specify)
- Approximate number of users per day
- Date facility was constructed
- Approximate construction cost of the facility in Kshs.  
Cost of roofing in Kshs  
Cost of walling in Kshs

2. a) What materials have been used for roofing?

If it is FCR tiles, why did you choose to use FCR tiles and not other materials like g.c.i., concrete tiles or burnt clay tiles?

- it is cheap
- it was chosen by the organisation that funded the project
- any other reasons (please specify)



b) What materials have been used for walling?

If it is stabilised soil blocks, why did you choose to use this particular material rather than concrete blocks of bricks?

- the material is cheap
- it was chosen by the agency/organisation that sponsored the project
- any other reason (please specify)

3. Where were these materials obtained?

- Stabilised soil blocks
- FCR tiles

4. If these materials were produced on site, were there any problems encountered during the production?

5. Were there any problems encountered during the actual construction of this church/school/clinic/etc

6. In the period since this school/church/clinic/etc was constructed, how many times have repairs to
- a) the roof
  - b) the walls
- been necessary?

What was the cost of any repairs to the roof within the last one year? Kshs

What was the cost of any repairs to the walls within the last one year? Kshs

7. Observe the physical condition of the building

- cracks in the walls
- walls covered by mould
- missing roofing tiles
- roof covered by mould
- any other defect