

# **TOWARDS POPULIZATION OF LOW COST BUILDING MATERIALS AND TECHNOLOGIES FOR URBAN HOUSING IN DEVELOPING COUNTRIES**

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## **Abstract**

*This paper is based on a literature review and an evaluation of practices that have been in place with respect to low cost building materials and technologies so as to lower costs and hence make the buildings, especially housing for the majority urban poor who have meager resources and hence cannot afford conventionally built houses.*

*The paper utilized both secondary data from the literature, and an empirical study of pilot projects that have been constructed in different regions of Kenya by utilizing traditional architectural research techniques akin to observational techniques in the social sciences, augmented by open-ended interviews and discussions with the different actors in the advocacy and use of low cost materials and technologies in building.*

*This study found out that topmost of the constraints that hinder wider application and universalism for the alternative materials and technologies is largely due to both lack of standards and specifications, and also information by the general populace about them. Otherwise in general, the alternative materials and their technologies are quite economical, durable, sanitary and safe in construction as attested to my findings from the case studies for this paper.*

## **Keywords**

Building materials, Building technology, Low cost, Developing countries, Urbanization.

## **Introductory Background**

Over the last five, or so decades, developing countries in particular have experienced phenomenal growth of urban areas partly due to policies that have tended to favour urbanization as an engine of rapid development (Duranton: 2008). However, this trend has had worsening urban housing conditions and in particular, the sprawl of informal settlements and slums is the single-most manifestation of the urbanization phenomenon that has brought about human misery, poverty, insecurity and failures of national policies, administration and economies (UN Habitat: 2008).

Proliferation of these settlements is a combination of rapid rural-urban migration, internal and external displaced persons due to conflicts and wars, high birth rates, increased poverty and marginalization, soaring land prices such that the urban poor cannot afford, weak urban planning and

ineffective housing policies, poor performing government institutions, high levels of corruption, and lack of political will (Angel: 2000).

According to the United Nations Center for Human Settlements (UN-Habitat: 2008), estimates indicated that more than half of the urban populations in developing countries, live in life- and health-threatening conditions. Unless dramatic and determined efforts are made on the housing front, trends and estimates point out that the situation is likely to become even worse.

Traditionally, most rural houses have been built with little or no cash expenditure. However, this is no longer the case owing to rapid population growth and the diminishing sources of local building materials. The trend now is to buy building materials - local and imported (poles, sand, corrugated sheets, etc.). The situation is further compounded by the simple fact that people have less time for building activities and have even tended to forget their traditional building skills. The situation is indeed more bleak in the urban centers, with respect to provision for adequate housing (Malpenzi & Mayo: 1987)

Studies in urban Kenya, for instance, have shown a considerable backlog as well as unsatisfactory quality of urban housing. Although emphasis by the Kenya Government policy on housing has been provision of decent housing of a minimum standard and affordable for all, this has largely been unmet (GoK: 2004).

Housing schemes in urban areas, especially for the low income households, have been attempted at high densities from the seventies. A vastly greater number of new housing units still need to be built. In the new millennium, this has been estimated to be approximately one million units per year for several years in order to offset the backlog (GoK: 2009).

Prompted in part by the startling revelations of shortages of decent and affordable housing, numerous researches mainly spearheaded by social scientists, and now embraced recently by environmental designers, have proliferated in the last four decades. Much of this work comprises of specific studies of specific settings. From these specific case studies, which have grown over time, it has become apparent that certain findings have tended to repeat themselves. For example, study after study of low income settlements in Kenya's major towns of Nairobi, Mombasa, Kisumu and Nakuru suggest that a majority of the households cannot afford to pay for a decent house constructed of conventional materials and at the current mortgage rates (SheltNet: 2014). What compounds the situation is the fact that conventional materials, or components of, are largely imported and hence dependence on them for building makes houses prohibitive in cost. In house building, it has been shown that materials account for as much as 80% of the total cost of a low cost house (Tuts: 1990). Thus a majority of the low income people have no access to decent shelter. The consequence of which is to resort to live in informal settlements and slums with deplorable and un-improvable houses made of scrap and other very temporary materials.

### **1.0: The Study**

This article is based on a literature review of studies that have been conducted, augmented by an evaluation and field study of projects that have been implemented using low cost building materials and technologies in Kenya. The field studies were funded by the Rockefeller Foundation, with the sole objective of popularizing as well as disseminating what has been researched and practiced with respect to the referenced materials and their technologies. The overarching justification for the study is that, low cost building materials are locally available, affordable and their innovative technologies readily understood and therefore best suited as an alternative to conventional materials whose costs and technologies are way beyond the reach of the poor who constitute well over 70% of the urban population in Kenyan cities (CBS: 2009).

Indeed most architects have been trained and inclined to implement their design solutions for building and construction by using conventional approaches, including low income housing projects, even in developing areas where resources are meager. Thus a majority of house building activities have largely depended on supplies of factory-made building materials, such as cement, steel and glass. The demand for factory-made materials greatly exceeds the supply, hence causing delays, wastage, escalating costs and even black marketeering (Spence and Cook: 1983). Indeed, as it was mooted by the Former President Nyerere of Tanzania (in Mwafongo: 1984), there seems to be a problem of prevalent attitude to the manufactured building materials: The present widespread addiction to cement and tin roofs is a kind of mental paralysis; a *bati* (corrugated iron) roof is nothing compared with one of tiles, but those afflicted with this mental attitude will not agree. Nyerere goes to argue that cement is basically earth, but it is called 'European Soil', and therefore people refuse to build a house with burnt bricks and tiles but rather insist on waiting for a tin roof and 'European Soil'. He (Nyerere) concludes that, if we want to progress more rapidly in the future, we must overcome at least some of these mental blocks and biases against alternative building materials.

Until recently, appropriate technology subjects were not included in the curricula of architectural schools and as a result, architects are reluctant to deviate from existing 'proven' approaches when designing buildings. The final product is therefore most unaffordable and inappropriate to the end user (Goodman, et al: 1976).

Time has been of essence for most house building projects, with the result that Architects do not always get the chance to research and investigate on the opportunities available of, for instance, promoting low cost building materials. As has been shown through studies and practices done elsewhere, the main obstacle to the use of these materials in house building is largely to do with attitudes of the low income end users that view them as being temporary, backward and cheap (Kvarnstrom: 2014).

## **2.0 Actors and practices of low cost building materials and technologies**

Research, development and dissemination of low cost building materials and technologies (dubbed 'appropriate technology', or 'alternative technology') world over is characterized by involvement of many organizations, including international, national and non-governmental organizations. The common objective has been the lowering of construction costs, especially in regard to housing so as to make it affordable to a majority of people who are predominantly in the low income cadre. The potential beneficiaries of the appropriate technology are invariably drawn from economically weaker sections of society, who have very limited purchasing power to afford houses that are constructed with conventional building materials and technologies. For indeed as Angel puts it, wherever appropriate technology has started taking root, four main attitudes are identifiable: Rejection of the concept, acceptance of the idea in principle, active involvement in knowledge, mobilization and experimentation, and willingness to apply the concept as a normal part of business administration and community activity (Syagga: 1993).

More effort is required to bring appropriate technology at par with conventional technology. Low cost building materials for housing have not been sufficiently institutionalized, unlike conventional technology whose dissemination has largely been effected through commercial organizations and the profit mechanism. In addition, there has been insufficient emphasis on the development of support structures, political and economic backing and the implementation machinery – hence a constraint which is highly inhibitive to the process of dissemination and full embracing of the technology.

The provision of support structures and infrastructure for the dissemination of low-cost building materials for housing has been a responsibility of a number of actors in form of government agencies

(central and local), Non-governmental Organizations (NGOs), Research and Development Institutes, Religious and Community Organizations. There is however lack of interaction and partnership framework, within which these organizations can co-operate. They have largely tended to work independently and hence mistakes made and lessons learnt have not been shared without necessarily going through the bitter lessons of experience.

Thus political will and support from both central government, as well as local authorities, for the dissemination of low cost building materials and technologies is quintessential. This includes enactment of enabling legislation to remove any planning and building regulations that may hinder the use of the alternative building materials and technologies. Currently in Kenya, a number of positive steps have been undertaken towards this end by the Kenya Bureau of Standards' (KBS), such as enactment of guide standards, application of these materials and technologies in 'Special Scheduled Areas' in the major urban centers of Nairobi, Mombasa, Nakuru, Eldoret, Kisumu and Embu.

Equally important for effective dissemination of the alternative technology is the involvement and active participation of the 'Target Groups'. Through the concept of 'Self-help', by way of production and use of alternative technologies, low income individuals and households have been important show-cases for the technology (Muturi: 1993).

There is a need, therefore, for all those involved in research, development and dissemination of alternative building materials and technologies to focus on the development of a political economic climate that is conducive to the dissemination and acceptance of these technologies and products. Whereas the concept of alternative building materials and their attendant technologies have come of age, the national and international action required for their implementation is not yet common practice, especially with the magnitude of the tasks and challenges posed.

Several institutions and organizations in Kenya are involved in the research, development and implementation of alternative building materials and technologies especially in projects for urban housing provision, where there is massive demand. These mainly include Local and International NGOs, Central and Local Government Authorities, Religious and Community-based Organizations as shown in Table 1.1 below.

**Table 1.1: Organizations promoting low cost building materials**

<b>Name of Organization</b>	<b>Material being Promoted</b>	<b>Emphasis or Thrust of Organizations Work</b>
Action Aid Kenya	FCR Tiles, SSB	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)	Fibre-concrete Roofing Tiles (FRC) and Stabilized Soil Blocks (SSB)	Dissemination through Seminars, Workshops and Demonstrations on the use of FRC and SSB, and production support to local small enterprises
Undungu Society	FCR tiles SSB	
	FCR tiles	Focuses mainly on research but carries out a few demonstrations in how the technology works.

	FCR tiles SSB	Research, dissemination through the training of potential producers
	FCR Tiles/SSB Pozzolanas (from Rice Husk Ashes, RHA)	Research and dissemination. Design and fabrication of equipment and machinery. Carrying out demonstrations on the use of FCR tiles, SSB and RHA Pozzolanas.
	FCR tiles	Dissemination through helping groups to set up small scale FCR tile production units.
Ministry of Works and Housing, Government of Kenya	FCR/SSB tiles	Dissemination and support of local work groups through equipment and machinery and training.
UNCHS	FCR/SSB/pozzolana (Appropriate Technology)	Dissemination publication especially network.
Department of Architecture and Building Science, University of Nairobi	Application	Typologies, construction systems Integration into a wider modular open building system, and forms of contract and projects management.
(K-Map)	Small scale business administration	Marketing and popularization of Alternative Building Materials and their Technologies.

### 2.1: Action Aid Kenya

Action Aid Kenya (AAK) is a non-governmental development agency with a strong commitment to the promotion of basic education in all forms. Part of its Mission is the ‘commitment to working with communities to design, fund and manage integrated development programs while respecting their cultures and values’.

Active involvement of AAK in low cost building materials and technologies dates way back to 1982. AAK established its main areas of operation in Isiolo, Mwingi, Ikanga, Kibwezi, Webuye, Nambale and Kiboswa. Currently this organization works with communities in seven development areas. Kyoso and Ikanga in Kitui District, Kibwezi in Makeni District, Merti in Isiolo District and Kapsakwony in Bungoma District and Kariobangi in urban Nairobi.

Prior to internal restructuring process, Action Aid Kenya, through its technical support unit, used to channel its assistance through primary schools in form of technical support and building materials. The local communities were expected to offer labor and to produce building materials. AAK’s assistance was conditional - subject to the communities agreeing to use locally available materials, sun-dried bricks, burnt bricks, stabilized soil blocks, sisal cement tiles, etc., in their building programs.

Action Aid Kenya has thus been actively involved in the training of the local communities in production of better bricks, in producing and using 'on site' produced stabilized soil blocks and fiber concrete roofing tiles. AAK has, on several occasions, been called upon to assist in the training and setting up of small scale 'Community-Based' production plants. AAK's involvement in low-cost building materials and technologies has been note-worthy, particularly with respect to the introduction and promotion of 'Fiber Concrete Roofing' tiles (FCR) as an alternative roofing material.

AAK's involvement with FCR tiles started in mid 1984 when they purchased tiles from Intermediate Technology (IT) workshops for their sponsored school projects in Ikanga in Kitui. The success of this demonstration led AAK to order for its own tile machines from Pany Associates, England, with a view to establishing its own tile plants to meet the high demand for roofing structures with durable low-cost materials. The speed with which the FCR tiles technology spread in the initial stages may be viewed as a positive indicator of general acceptance of FCR tile technology by the communities.

Some of the problems that have been experienced with the FCR technology include lack of quality control, wrong specification for timber roof support system, and the relatively high cost of installing conventional tile plants (electric vibrator, plastic/fiber glass moulds and curing moulds). The first two problems need to be tackled, through training. While the third problem has been somewhat resolved through further innovations - alternative vibrator and moulds - made by Housing and Building Research Institute (HABRI) of the University of Nairobi, Architectural Association of Kenya (AAK), and others.

Thus AAK in particular, has been instrumental in training, financing and promoting FCR tile technology in Kenya. This has been done by adopting a more innovative and pragmatic approach that can be summarized as follows:

- i. selection of an interested group of young men and women from the locality where a plant had to be established
- ii. a three months production training period when the group produced tiles under the management of AAK
- iii. all building materials were provided by AAK. During this period, the group was only paid for labor, a nominal rate for every good tile produced
- iv. registration of a group, as a self-help group, with the Ministry of Culture and Social Services was done
- v. AAK then provided the group with all the necessary tile production package, and a working capital for 3 months. A soft loan arrangement was then drawn between the group and AAK
- vi. for servicing of the loan, pay-back period was arranged over 5 years, and terms and conditions of the loan were made flexible that depended a great deal on sales realized.

The training and promotional activities of AAK led to establishment of a number of decentralized tile making groups throughout the country. Their numbers, however, have been rather too low relative to potential demand for low cost roofing materials.

## *2.2: Intermediate Technology Development Group (ITDG)*

ITDG works with communities in the development and dissemination of low cost building materials and technologies in order to help the less privileged communities in developing countries acquire the necessities of life and have enough surpluses to invest in their families, businesses and communities. This group, while realizing the need for continued research, has placed greater emphasis on the training, promotion and dissemination of alternative building technologies already developed.

ITDG's approach to the promotion of alternative technologies, particularly for roofing tiles, has mainly been on two fronts. Firstly, dissemination of technologies through seminars, workshops, participation in national agricultural shows and other demonstration fora; and secondly, promotion of small private entrepreneurs.

ITDG's has been keen in promoting and placing intermediate technologies in the hands of local small scale producers. In pursuit of this goal, ITDG from the early 1980's attempted to promote individual tile entrepreneurs. Initially, 10 - 12 would-be tile entrepreneurs were selected to be supported on a pilot basis and their performance evaluated with a view to establishing their efficacy. Basically the private tile entrepreneurs program consisted of two main components: the training and follow up services; and availing of funds for establishing the business. Under this program, ITDG funded the training and follow up services while the would-be 10 - 12 pilot entrepreneurs were expected to get funds from local financial institutions.

ITDG, especially in the 1980's, carried out its training, dissemination and promotional activities in collaboration with a number of Kenyan organizations. ITDG offered particularly free technical and business training, free access to technical follow up and trouble shooting service and assistance in marketing and promotion.

The ITDG training package laid special emphasis on both technical and business-cum-management training. A one-week intensive technical training packages in the making and laying of tiles was mounted. The business training was conducted in phases. The first one covering basic business management techniques was conducted for 2 days in Nairobi. This was rather ineffective, because the complex issues involved could not be adequately tackled within the time frame allocated. The training component was to be followed by fortnightly individualized and localized business training sessions. At least two technical monitoring sessions were planned for each of the ITDG-assisted tile producers. The purpose of these scheduled visits was to ensure that all aspects dealt with during the one week technical training were understood and were being implemented correctly. However, due to shortage of resources, more so manpower, the follow-up was not very effective.

As part of promotion and dissemination efforts, ITDG distributed leaflets free of charge, to the ITDG assisted FCR tile producers. The leaflets indicated the merits of FCR tiles and provided space where each producer could indicate his or her name, address and unit price. This information could then be passed to potential customers. Further more, a grant was made available to each sponsored producer to enable him/her to mount a stand and display at their respective local Annual Agricultural Shows as part of the dissemination campaigns.

ITDG had hoped to assist establish over 100 tile making businesses in a 5 year period. However due to funding constraints, the potential benefits of this worthwhile project were seriously reduced - hence showing that lack of adequate resources, manpower and capital, greatly minimized the promotion of the low cost building materials.

### 2.3: Housing Research and Development Unit (HRDU), University of Nairobi

In the past 30 or so years, Housing Research and Development Unit (HRDU), later Housing and Building Research Institute (HABRI), of the University of Nairobi has laid a lot of emphasis on research and development, field tested and piloted a number of low cost building materials and technologies in different environments in Kenya. HRDU has experimented with different vehicles in creating awareness and promoting effective community involvement in projects utilizing low cost building materials and technologies. In all of HRDU's demonstration projects, training and dissemination have been given top priority.

Kabiro Clinic, located in one of the informal and densely populated settlements of Nairobi city, was among the very first of HRDU's projects. The focus here was the need to introduce tested low cost building materials and building technologies in a community that was in dire need of lowly-priced, but durable, building structures. The main features of the project entailed the following stages:

- i. mobilizing the community for self-help activities particularly through the women groups
- ii. training selected members of the community in the selection of soils (including field tests), inculcating proper production procedures, and emphasis on practical design considerations by sensitizing participants on the implications of low cost materials for walling and roofing
- iii. involvement of a number of institutions in the project (such as HRDU and Community-based organizations)
- iv. construction and completion of a 50 square meter demonstration clinic at half the cost of building in conventional building materials.

The Second project aimed at improving rural teachers' houses through introduction of appropriate building materials and construction techniques. Ten 3-roomed houses, each with a kitchen, a bathroom, a ventilated pit latrine and a water storage tank were constructed at five strategic sites in Busia and South Nyanza Districts in Western Kenya. The communities participated through two housing co-operatives which were formed as part of the project. The United States Agency for International Development (USAID) funded the project while HRDU provided training, technical and supervisory services. In summary, this Second project covered the following aspects:

- i. creation of new institutions (parents schools housing co-operative societies
- ii. (PSHCS) to mobilize, organize and channel community resources into the project and to replicate the technologies elsewhere
- iii. mounting of three week training at Kabiro, in Nairobi, for the artisans from the project sites
- iv. on-site training and demonstration sessions for the local communities



- v. practical involvement of the communities in site selection, planning and house design
- vi. on-site production of building materials and erection of the residential units.

The Third project was the bilateral HRDU/GTZ low cost technologies project whose overall aim was to develop, test and disseminate low cost building materials and building technologies for house construction and basic services from the 1980s. GTZ is a Germany-sponsored NGO that has partnered with HRDU in a number of autonomous houses that were constructed in different climatic regions to test and improve building materials and technologies, equipment for basic services (such as water, energy and food supplies) and the recycling of liquid wastes to enable households to be independent of public services which are largely inadequate.

Under this project, the training for (and transfer of) low cost building materials and technologies to local communities was through strategically located Youth Polytechnic Centers in the different Climatic Regions.

The Fourth demonstration project that HRDU has implemented is located in Kibera, which is the largest informal settlement in the city Nairobi. This project was part of a large low cost housing project designed by the National Housing Corporation (NHC), a government parastatal housing agency, in which provision had initially been made to allow the use of low cost building materials and technologies. The design concepts of this scheme were later on changed and this greatly mitigated against the use of low cost building materials and technologies in the scheme.

Two roomed expandable structures together with related amenities were constructed using on-site produced soil-stabilized blocks (SSB), rammed murrum floor and FCR tiles. Local artisans (*fundis*) were engaged, who worked under the supervision of HRDU technical staff. The project was funded from proceedings of a play organized under the umbrella of International Year of Shelter for the Homeless (IYSH) and has since been handed over to the Ministry of Housing.

#### 2.4: United Nations Center for Human Settlements (UNCHS, Habitat)

As part of its support efforts, UNCHS (Habitat) set up in 1985 a network of African countries on local building materials and building technologies in collaboration with the Commonwealth Science Council (CSC) to solely facilitate the flow and exchange of technological information appertaining to the alternative building materials and building technologies.

The major achievements of this network has been the organization of regional workshops in some of the participating countries (which are: Cameroon, Ethiopia, Ghana, Kenya, Lesotho, Malawi, Mauritius, Namibia, Nigeria, Sierra Leone, Tunisia, Uganda, United Republic of Tanzania, Zambia and Zimbabwe), aimed at supporting these countries in formulating standards and specifications for local low cost building materials.

In 1989, for instance, the Network organized a regional workshop in Kenya aimed at disseminating the experiences and achievements of the previous workshops and subsequent to this in the 1990s, frameworks for other participating countries have been established to solely replicate adopted methodologies and approaches in formulating standards and specifications. Thus efforts by UNCHS have made it possible to convince policy- and decision-makers in the member countries to take effective measures to develop new standards and specifications, hence contributing towards the improvement of the productivity and quality of locally-produced low cost building materials such as stabilized-soil blocks (SSBs), fiber-concrete roofing tiles (FCR), lime and other binding materials.

### 3.0 Case Studies

The projects that were evaluated for the case studies were drawn from the four climatic zones in Kenya (Coastal, Lake, Savannah and Highland), solely to gauge the extent of the horizontal expansion of the low cost building materials and building technologies in the country.

#### 3.1: Coastal Climatic Zone

Two number residential units (Figs. 3.1) for instructors were evaluated. These houses were in Mazeras Youth Polytechnic, located in Kwale District about 30 km west of Mombasa on the Mombasa-Nairobi Road.



**Fig. 3.1:** *Instructors' Houses at Mazeras*

Training time lasted for approximately one month, and 36 people were trained (instructors and builders). A number of institutions were involved in the training program, among them Concrete Roofing Tiles (CRT) company based in Karen, Nairobi, ITDG, Bellevue Foundation, Department of Sociology (University of Nairobi), Ministry of Culture and Social Services and the National Christian Council of Kenya (NCCCK). The training was successfully completed and the construction work for the houses was complete by the time of this evaluation study.

The main bulky materials were the sandy soils which were subjected to average compressive strengths. Cost per ton, including transport, was very modest. The cost of cement, given the proximity to the cement factory at Bamburi, was relatively lower than in the other parts of the country - bringing the average cost per house to Kshs. 46,723.30, compared to a conventional building cost of Kshs. 180,000.00.

The main equipment required were the Block Presses (Bre-Pack and Action Pack types) and productivity measured as average number of blocks per day was two blocks for both machines. The Bre-Pack was still in good condition after completion of the project whilst the Action Press required re-fixing

of the locking system. As for tiles, two types of vibrators were used: Manual and Electric from Undugu. Productivity, considered as average number of tiles per day, was 120 tiles. The condition of the machines after the project were good, except the turning handle of the manual vibrator which looked loose - and this is because the trainees were poor at handling the equipment.

The SSB blocks (Bre-Pack and Action Pack) are all designed to be load bearing. This means they provide a wall which can easily support the weight of the roof and any other anticipated loading, such as rain.

In Mazeras, only load bearing wall constructions were encountered during the evaluation, and all the buildings are single storeyed. This is because people, even if they accept the load bearing capacity of the SSB wall, do not venture into two storeyed buildings for fear that the building may collapse. This is clearly illustrated by the case of one client who wanted to build a two-storey building in Mazeras using SSB/FCR technology but the Youth Polytechnic instructors turned her down.

A simple rule of thumb requires that the height of a load bearing wall should not exceed 20 times its width. In Mazeras, a 140mm wide block has been used, at a height of about 3950mm. This can still take possible lateral load effects and have a fairly good margin of safety. Mazeras is a good example of a building design which exploits this interesting structural capacity of SSB.

The HABRI/GTZ projects and conducted research on earth construction technology strongly emphasized the need for 'appropriate design' as a necessary condition for sound (SSB/FCR) technology details and standards. While there is clear sensitivity to design of layout, the issue of construction details seems rather neglected in the Mazeras case. At present, hardly any manual is available to provide guidance for use of design solutions and architectural details for building with SSB and FCR. Observations from Mazeras illustrated some of these issues which should receive attention in order to improve on the low cost building materials and building technologies. Among them is the issue of modular co-ordination.

The problem of modular co-ordination is apparent in Mazeras. For example, the relationship of material (SSB) dimension to fenestrations (doors, windows and vents) are not well coordinated, and neither are the relationships of material (SSB and FCR) dimensions to space dimensions. Just like some standardization for the soil-cement ratios has been done, this should be the case for modules of the building components. For instance, window (timber-frame or steel) lintels and the ring beam if not harmonized will give rise to un-uniform horizontality. Similarly, lack of relationships between material dimensions and space dimensions would lead to situations of wastage owing to cuttings of walling blocks and roofing tiles.

Mazeras has a hot humid climate, where both day and night temperatures are high. The Annual mean maximum temperature is about 30.2°C, while mean minimum is about 22.5°C. The Diurnal temperature ranges is about 7.8°C, and is among the lowest in Kenya, which gives rise to a degree of equatorial monotony. During the long rains from April to June, days are cooler due to cloud and rain, but nights are dumper.

The proportion of direct to indirect solar radiation is greater and the level of outgoing long wave radiation is rather high as a result of lower level of cloud cover. The region is very humid. Mean annual humidity is 93% at 0600 Hours and 66% at 1500 Hours. The annual rainfall is about 900 mm. During the wettest months (April to June) there are occasions when continuous rainfall for several hours is experienced.

The form of houses was primarily determined by the requirement that all habitable rooms be cross-ventilated amongst other requirements. The Mazeras houses reflect this sensitivity and internal partitions are reduced to necessary minimum so as to minimize obstruction to internal air movement. Observed orientation is in NE/SW direction which is not very ideal. The ideal is the NS orientation.

Ceiling heights vary with the roof slope and as such there is no independent ceiling - in some spaces being as high as 3950mm. Ceiling height is important because of being a decisive factor in determining internal comfort - lower ceilings contribute to internal heat gain and this is not desirable in the hot and humid zone. Openings are generally in the North-East and South-West walls. Low cill heights towards the working yard provide low level comfort ventilation to occupants seated in low chairs.

The principle functions of walls are those of excluding weather elements as well as providing for privacy, while allowing for air flow and light. The SSB blocks are particularly satisfactory in so far as thermal considerations are concerned. The wind-driven rain constitutes more of a problem and appropriate protective measures have to be put in place.

The FCR tiles performed satisfactorily well. Walls and roofs exposed to direct sunlight should be finished in a light color that is reflective to solar heat. Since the amount of cloud cover is comparatively low for a hot humid climate, external surfaces particularly roofs that are emissive to long-wave radiation are advantageous in that they increase the rate at which buildings can loose heat.

In Mazeras, strong winds rather than earthquakes cause relatively modest lateral loading of buildings. The main partition wall had minor vertical cracks (1400mm width to 3950mm height). This aspect of lateral loading requires further investigations.

In general the SSB walls were largely well resistant to erosion, compared to other building materials (Fig. 3.2). Even the unprotected first two Courses showed indications of very little erosion. But special architectural detailing of basic works (mainly affected by water splash and standing water) is necessary. The 6mm FCR tile in production in Mazeras was fragile and prone to a lot of cracks and consequently roof leakages.



**Fig. 3.2:** Effect of high humidity on timber (fascia board) - no effect to SSBs

As for vermin, there were some cases of termites investing the SSB walls. This, however, was not a serious problem as the termites did not in any way change the surface finish of the material rather, they affect the aesthetics of the wall. This needs further investigation.

On maintenance and durability, generally many building materials are affected by high humidity and the high atmospheric salinity of the sea air. The SSB wall in Mazeras does not ask for any rendering, especially finishing, and needs very little maintenance. The only problem noticeable was the accumulation of dust in the joints. This problem can be avoided by rendering the joints with cement slurry. With the exception of the tiles, the two houses seemed to have been built to last a lifetime, judging from their solid nature and appropriateness of the load-bearing walls.

The SSB often takes after the color of local earth. The block can be very decorative. The tile is often more appreciated when red-colored (add red-oxide). Earth cannot be as easily re-used in cases of modification of the existing structure and hence much less flexible. Therefore it is necessary to incorporate possibilities for future extension, upgrading and renovation in the designs, right from the beginning.

Attempts by individual clients to expand use of this technology have not been very successful. Mrs. Dorcas Kajirwa (residing in a two-bedroom unit), for example, wanted to expand her unit to a 3-bedroom house. This could not be realized because of lack of a 3-bedroomed prototype plan, and the instructors could not venture into a more than 2-bedroom unit, and secondly, due to lack of an SSB machine - the one that was given by HABRI to the Polytechnic was borrowed and its whereabouts was not known.

### *3.2: The Lake Climatic Zone*

The Lake Zone comprises the area around Lake Victoria that lies below 1,250 meters in altitude. The climate displays comparatively small seasonal variations in temperature, humidity and in wind speed and direction. In this climatic zone, rainfall is well distributed throughout the year. Except for the flat Lake Plains, the topography is largely made up of undulating and rolling hills. A green, and often dense, bush land vegetation is interspersed with cultivated land.

As part of HABRI/GTZ dissemination strategies, a number of institutions have been built in the Lake Zone, in form of school buildings (classrooms, dormitories, and teachers' houses). The building efforts have been largely extended through community organizations, private entrepreneurs and individual experiments.

Mabale Primary School in Busia District was one of these projects that were realized. The Mabale Primary School project (Fig. 3.3) consisted of a one block of two classrooms. For this project implementation, one teacher amongst the staff was trained during a workshop on low cost building materials and building technologies at Sega Youth Polytechnic, for two weeks. This teacher further trained a team of 8 people and set up Busia Work Group which has since collapsed, following completion of the project in 1994.



**Fig. 3.3:** *Mabale Primary School*

For Mabale project, a new structural concept was attempted - a design which tried to combine the traditional post and beam concept and the load-bearing capacity of SSB walls. The result was L-shaped load bearing columns in combination with SSB walls - which is not necessarily a more economical solution in terms of construction costs. For the roof trusses, spacing was designed to correspond to the grid of the columns. This was however not achieved, hence making the columns redundant. One of the successes of this structural design is lateral stability that has been achieved especially for the gable end - to the extent that when the building was struck by lightning in 1996, it still remains intact.

The most critical climatic requirement for school buildings (classrooms mainly) in this climatic zone is the need for a cool enclosure during the heat of the afternoons. Since it is often unpleasantly hot during the day, it is not desirable to have the sun shining directly into the classroom except perhaps in the very early mornings when a little bit of sunshine is probably welcome - particularly during the wet season. As for the forms, this is principally determined by the requirements that all habitable rooms should be cross ventilated and adequate natural lighting provided for. In Mabale, a fairly open, well ventilated and adequately lit classroom blocks were provided.

Orientation is in the North-West and South-East directions in order to minimize on direct solar radiation to the interiors. Although verandahs were initially designed as part of the buildings, they were never realized. However, relatively large overhangs have been provided to shade walls from direct sun as well as protecting them from the torrential rains that are a characteristic of this climatic zone.

Since wide diurnal temperature ranges and cool nights are the norm in this zone, it is usually advantageous for walls to be constructed of medium or heavy weight material like the SSBs. The stabilizing effect that massive walls have on internal temperatures is particularly good for houses, houses that are by their nature responsive and hence vulnerable to wide daily temperature fluctuations. The school classrooms, however, do not strictly require this stabilization because they are essentially used in the day (Mabale is a day school). The lower courses have been protected from driving rain by plaster.

The 10mm FCR tile roof was well laid and was in good condition. Wind damage to the buildings, particularly the roofs, is probably more critical in the Lake Zone than in any of the climatic zones in Kenya. There have been several recorded instances of lightweight roofs (especially GCI sheets and thatch) being swept by gusts that are associated with severe thunderstorms. In Mabale, attention was paid to careful laying and tying of FCR tiles to the battens.

In Mabale, strong winds and thunder storms rather than earthquakes cause lateral loading of buildings. The main gable walls have an SSB load bearing columns and ring beam. As indicated earlier, the building was subjected to a severe lightning in 1996 but no cracks have been observed.

In general, the SSB wall is resistant to erosion as observed in Mabale - even on the gable ends, which are extremely exposed. However, base courses have been plastered. The 10mm FRC tile produced in Mabale is adequate and no serious problems were observed.

The walls and roofs in Mabale do not ask for any special finishing and require very little maintenance. However, the base courses and the SSB columns which have been plastered do require some periodic maintenance.



**Fig. 3.4:** SSB Rental Houses at Marachi Estate with GCI roof - Expansion of Technology

A number of cases of expansion of the alternative technology in Busia were observed. These included shops of SSB walling and some residential houses in Marachi Estate (single family detached houses in SSB as shown in Fig. 3.4 above). There are also institutional buildings that have been completed, utilizing the low cost building materials and building technologies, such as the Young Men Christian Association (YMCA) training center that was consisted of a block of 5 classrooms and offices.

### *3.3: Savannah Climatic Zone*

The Savannah zone is located between the semi-arid and highland zones, and comprise most of the land that lies between 500 and 1,250 meters in altitude. The zone includes the dry and sparsely populated parts of Kajiado District that lies slightly above 1250 meters, but excludes the drier hotter parts of the area that lie below 1,000 meters. The predominant forms of vegetation are dry woodland, bush land and Savannah grass. The dry landscape is only broken by the Kitui and Taita Hills which are wetter and greener than their surroundings.

The temperature differences across the zone are closely related to altitude. Annual mean minimum temperatures are 19.4°C and 30.5°C at Voi (altitude 560 meters). The diurnal temperature range is 11.1°C at Voi. Nights are cold over most of the zone during the Mid-May to October dry season; while days can be very hot.

The mean annual rainfall, which varies according to the topography, ranges from 538mm at Voi to 1031 mm at Kitui. There is hardly sustainable rainfall over long periods of time. Mean annual relative humidity at 1500 hrs is about 45% at Voi.

Due to considerably low humidity, the discomfort caused by Maximum temperatures is much less than in the Coastal zone. However, discomfort caused by the high day time temperatures that prevail during most of the year can be critical. Comfort conditions at night vary considerably over the year. On many nights, it is likely to be uncomfortable.

For this climatic zone, Bondeni project was evaluated. This was built as a residential unit, but serves as offices for the Bondeni Women Group. Training for this project started towards the end of July, 1993 and ended in Mid-August of the same year. Altogether, there were ten people (mainly women and the youth) who were trained on the use of the low cost building materials and building technologies. Actual building works started soon after the training and the project was completed in April, 1994. Major equipment used was the Block Presses and a manual tile vibrator.

Although the intention was to have this unit as a demonstration for other buildings, there had not been any follow-up expansion of the technology. A number of factors contributed to the lack of sustained productivity, among them: the group dynamics had not been successful - the youth from the community felt that they gained less, compared to other groups (especially the women's) and therefore either sold or stole the equipment; and production of tiles that had high failure rates, despite those that were used for the demonstration building being intact. This low quality production of roofing tiles in particular, greatly discouraged would-be users of the material.

The structural concept at Bondeni was that of load-bearing walls and also non-load-bearing SSBs infill for a post and beam structure - just as any other building block. In this project, the columns were cast insitu. The problem of non-conformity of column grid to basic module of the SSB was also encountered here. This non-conformity could largely be attributed to the construction of the post and beam structure prior to the infill of the walls, and lack of adequate skill and attention in the proper use of SSB/FCR as in-fill materials.



The design for this unit has a fairly satisfactory layout, and wide overhangs to ensure good environmental performance as well as protection of the materials from ravages of weather. In particular, the SSB/FCR structure is quite appropriate for human comfort - offsets hot days and cold nights satisfactorily.

In some cases, the low cost building materials and building technologies in this climatic zone as an alternative building technology has been expanded for the building of water tanks and flower boxes and for decorative wall elements besides the main building. A good example for the latter two uses was seen at the Sagana View Lodge (Fig. 3.5).

The highland zone, which lies between 1250 and 2000 meters in attitude, consists of Western highlands west of Rift Valley, and the Eastern Highlands, east of Rift Valley. Annual mean maximum temperatures in this zone range from 23.4°C, at Kabete, to 25.6°C, at Nakuru, while the mean minimum range from 8.2°C, at Nakuru, to 13.6°C, at Kabete. Annual relative humidity at 1500 hrs vary from 46%, at Nakuru, to 53%, at Kericho, while at 0600 hours they vary from 86% at Kabete, to 94% at Nakuru. High relative humidity is rare at day time, but is the norm at night.

The mean annual rainfall in this zone, which generally increases with altitude, ranges from 739 mm at Nanyuki to 1450 mm at Kericho. The intensity of rainfall can be high, thus giving rise to *flash floods*; heavy rain is seldom continuous over long periods.

Although breezes are frequently fresh during the day, persistent high winds do not occur in the Highlands and wind speeds only rarely exceed 10m per second.

In terms of human comfort, the climate of the Highland zone is exceptionally agreeable and is the most favorable in Kenya. Radiation is the most significant climatic factor in this zone, from the point-of-view of human comfort, and it is the strong solar radiation during the day and the rapid outgoing radiation at night that differentiate the equatorial highland climate of this zone from the climates of temperate regions.



**Fig. 3.5:** Sagana View Lodge (Other Uses of SSBs and FCRs)

### 3.4: Highland Climatic Zone

In so far as ventilation is concerned, air exchange is necessary for the corrective cooling of interiors that is often required to counteract the build up of internal heat that results from the intense solar heating of the building fabric, cooking and human activity.



**Fig. 3.6:** *Ndalú PAG Church*

Ndalú Pentecostal Assemblies of God (PAG) Church in Tongaren division, Bungoma district (Fig. 3.6), represents the Highland Climatic Zone. Site identification for the project commencement was done in the month of August, 1991, and consisted of a Pastor's house and the church.

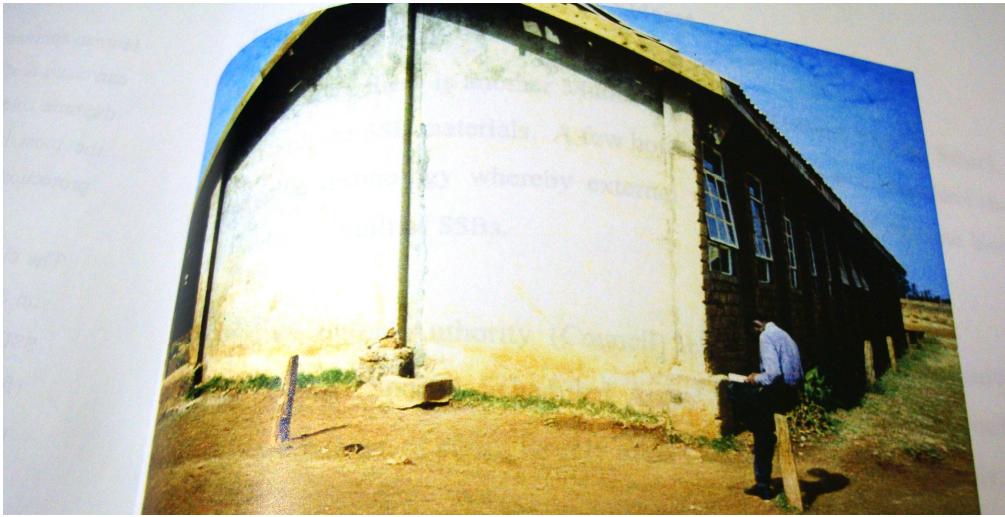
In promoting the alternative technology in Ndalú, a structural design which combined 'post and beam' concept was applied in further testing the efficacy of SSB's load bearing capacity. The result was a T-shaped non reinforced load bearing column and wall. The columns in Ndalú were well executed, and the roof structure which required trusses for clear internal spaces. The problem of modular co-ordination, that was rampant in other case that was evaluated, was well taken care of especially for the arched windows.

The SSB blocks and FCR tiles used in the church building and the Pastor's house were still in very satisfactory condition. However, the SSB columns did show abrasions that would have benefitted from some plaster rendering in order to protect them.



**Fig. 3.7:** *Mogotio Youth Polytechnic*

Expansion of this alternative technology had been well embraced within the highland climatic zone, mainly for schools and churches (as exemplified by Mogotio Youth Polytechnic (Fig. 3.7) and Kipkaren Road Primary School (Fig. 3.8)).



**Fig. 3.8:** *Kipkaren Road Primary School*

The regional training program for the Youth Polytechnic instructors at Mogotio Youth Polytechnic, in Baringo District, took place between July and August, 1988. Besides HABRI, AMREF was also involved in the training.

Kipkaren Road Primary School is located within Kipkaren Site and Service Scheme in Eldoret Municipality. Site identification and project implementation was done in 1989, and completed by the end of 1990. Here in Kipkaren, was another case where a structural design system which combined the traditional post and beam concept with load-bearing SSBs. The result is a non-reinforced T-shaped load bearing column. The roof structure was based on a simple truss, with the same module as the SSB load bearing columns with a reinforced concrete beam all around the external walls.

Expansion of the alternative technology is gaining ground nationally, from the support of major players in the housing sector, for example, the Housing Finance Company of Kenya (HFCK), a housing mortgage company that been aggressively promoting the use of low cost building materials and building technologies through model houses (as in Fig. 3.9 below) at the Annual Agricultural Show Grounds in major towns of Kenya.



**Fig. 3.9:** Show House at the Nakuru Agricultural Show Grounds

#### 4.0: Conclusions

Dissemination of low cost building materials and building technologies (as an appropriate and/or alternative technology) in Kenya has mainly been done, and continues to be, through the use of demonstration projects. In these projects, the target group is identified, such as women groups, youth polytechnics, religious groups and school committees. The group is then trained in the production and use of alternative building materials and technologies. The expectation being that the groups can carry out similar projects elsewhere within the community, hence replicating the technology. However, there have not been support structures that have been put in place, in terms of financial, socio-political and technological climate, to favor the desired expansion and embracing of the alternative technology.

In Kenya, just like in many developing countries, existing financial institutions do not readily fulfill the financial requirements needed for critical input in the private sector of the alternative building industry since they view them as being too risky. Thus the norm has been reliance on own finances by the private sector, which are often limited. Even in the public sector, low-income housing development is also vulnerable due to limitations of cash flow. Similarly, in most circumstances, conventional low-income housing programs are provided by the public sector, and thus exposed to severe financial constraints. In addition, there is lack of an enabling environment through well-formulated and well articulated policies on capital and funding, and hence very few financial institutions can be willing and ready to offer capital to potential small-scale producers of low cost building materials. The main reason is that low cost building materials, and their building technologies, are yet to gain general acceptance despite the legal recognition. It therefore constitutes a financial risk to lend to potential producers of building materials that have not gained wider acceptability and have only recently been permissible under the building regulations in only special scheduled areas and therefore the market still remains limited.

Another constraint is that of regulatory measures in form of building acts, regulations and codes by which authorities control building activities to ensure safety and health in the built environment. Also the practice is such that, standards and specifications enshrined in contract documents for building production and use are only for the known conventional materials and hence do not allow for use of the

alternative low-cost materials. Since these regulatory instruments are formulated such that they prohibit the use of any other materials, delivery of low-cost housing is thus limited. The resultant is, therefore, that there are inadequacies in the existing regulations which have negative effects on the provision of basic infrastructure, especially housing, to the low-income households. They stipulate standards which are far too costly for the target group and which, even if they were to be provided, they cannot be maintained with the local resources and know-how.

Equally limiting the popularization of the alternative technology is the issue of social biases and prejudices to do with viewing the technology as being less permanent and inferior. Although this seems to be a widely held view, there is no single proof for it. The groups and individuals who have been courageous enough to utilize the alternative materials and technologies have been quite successful as attested to by the evaluated case studies and documentation from other developing countries. Suffice to say, the single most explanation for the prejudice against alternative materials and technology is solely to do with lack of public knowledge on their efficacy based on numerous research findings - most of which have remained restricted in use only to researchers.

The absence of stable markets, exorbitant transport costs and production hitches resulting from the lack of spare parts for the imported machinery and energy supply (as is the case for FCR electric vibrators) are also some of the reasons for low-capacity utilization and scarcity of the materials in the market.

Innovations in alternative technologies have as yet made very little impact on the low cost building materials industry because most building materials research institutions tend to ignore the component of machinery and equipment component in their activities, and, even where useful innovations emerge, there is no effective means to transfer such know-how to viable local channels for commercial production. While research institutions often collaborate with other governmental agencies, there is hardly any collaboration with the private sector, to the extent that the potential role of the latter remains unexploited. Sometimes lack of popularization of local innovations can be attributed directly to the non-existence of indispensable governmental support.

Despite the advantages of using alternative building materials and technologies, there are constraints that limit the widespread adoption of such technologies and materials by governments of developing countries in general. One typical constraint which hinders their wide adoption is the lack of standards and specifications. Other obstacles include sheer conservatism, unfounded prejudices, lack of information about these materials and their potentialities and also inertia in the building industry. Information exchange, for example, would go along way to improving on transfer of technology between countries that have similar problems.

The experience in Kenya is that, these changed building regulations and standards operate with severe manpower limitations - perhaps it might be desirable to assign the direct responsibility for formulation of codes of practice to professional institutions (Architects and Engineers) involved in construction, while allowing for overall administrative support to be provided by the National Standards Institution, the KBS. This is out of the realization that the standards have been largely promoted as technical guidelines, as opposed to operating as mandatory requirements so as to be as indispensable as the standards governing conventional building materials.

Quality control presents a problem also to the alternative building materials in twofold. First, there is the prevalent lack of skills resulting in incorrect production procedures in this sector - in general, labor requirements for the production of the alternative building materials may be taken for granted, but skills are deficient with regard to technology upgrading for production of these materials. Secondly, and more

significant, is the lack of simple standards and specifications for production and use for the alternative materials. Even where such standards and specifications have been formulated, they need to be accompanied by simple field tests for purposes of quality control. Lack of quality control measures for innovative building materials is a major constraint to the widespread adoption of materials because most developers would not easily determine the quality of their products. The existing standards have yet to be adopted by the respective Local Authorities' Building By-laws.

Another factor is that of high cost of equipment, which is a constraint to commercialization of alternative building materials such as FCR/SSBs. In the cases of AAK/ITDG/HABRI, the innovative materials and technologies were introduced through demonstration or pilot projects. The experience in Kenya is that there is a need to make available tools and equipment (e.g. block presses, vibrating tables and moulds) that are affordable by potential users, particularly since the technology arises at community-based institutions. The equipment should be easy to maintain. Imported Equipment and Tools are very expensive. Even though the minimal use of simple equipment can lead to noticeable improvements in the final product for the SSBs, for instance, manually-operated compacting machines, such as the Press machine, can improve the mechanical properties of the soil blocks in comparison to hand-moulded blocks. For the FCRs, the use of a vibrating machine is the key to achieving desirable compaction of the freshly prepared concrete as well as to achieving a relatively thin product. In most instances, these machinery has to be imported - and hence making the technology inaccessible to the majority low-income groups. This is also compounded by lack of awareness by both decision makers and the general public about the existence of low cost building materials and technologies.

Recent developments in Kenya though, such as the formulation of Grade II By-laws and the Building Code (Gazette notice Number 257 on Revised By-laws) do offer promising opportunities for the use of the alternative building materials and technologies (GoK: 2010). The revised By-laws ensure that building regulations and codes would state the basic requirement than particularizing as is the case under the previous building By-laws.

In a recent workshop in Nairobi, it was noted that three Municipalities have taken an initiative to use the existing legal framework (Special Scheduled Areas) and the revised By-laws. However, it is necessary to point out that building regulations and standards are only meant to operate as guidelines. What is crucial is how they are applied in practice.

In order to be more effective, the adopted standards and specifications for these alternative building materials and technologies have to be complemented by corresponding adjustments in building codes and regulations, tendering and contractual documents, and codes of practice. There would be a danger, for instance, if the standards for specific alternative building materials and technologies were to be issued as an independent publication without cross-referencing such standards in other regulatory instruments which support the building industry.

Widespread adaptation of appropriate building materials and technologies is also determined to a large extent by market conditions. So far, the determination and strategies have targeted the low-income groups in society. These people question these materials, for the simple fact that public institutions and high income groups do not use locally available building materials that are low cost. An example of doubts can be seen in Komorock Housing Estate in Nairobi, where a number of households have replaced the original FCR roofing tiles with other materials. It is however important to note that it is not only in Komorock where roof finishes have been changed, in Nairobi West, Tysons and other places in the city, wood shingles, have been replaced. People tend to use a specific technology because it is

economically attractive, socially acceptable and/or technically appropriate. People are also influenced by its symbolic value.

The effective dissemination and widespread adaptation of appropriate technologies and materials is constrained by lack of requisite skills in the usage of innovative building materials. The safety of construction and durability of appropriate building materials is directly dependent on the skills and competence of the labor. As seen from the case studies, innovative building materials can be wrongly used ending in unsound and unsafe construction. Alternative building materials should therefore become an integral part of the syllabus in building construction courses at various levels (professionals, technologists and artisans) in the country as another way of promoting the alternative technology. Also, there is a general lack of awareness among the consumers/users with regard to the quality of building materials and it is imperative to promote consumer-protection rights, for instance, as part of a system of checks and balances in quality production of buildings. This can be largely achieved through a wider utilization of the alternative building materials and technologies.

The failure by Kenyan government to use alternative technologies in building public, or government sponsored housing, developments is a constraint to widespread adoption of such technologies and materials. This failure limits the popularity of such technologies and materials. It is the contention of this article that use of alternative building materials and technologies by the government in public housing developments would go a long way help in dissemination and popularizing the technology for acceptability and universal usage.

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