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**FACTORS AFFECTING USE OF APPROPRIATE BUILDING
MATERIALS AND TECHNOLOGIES (ABMT) IN KENYA**
A study in reference to Compressed Stabilized Earth Blocks (CSEB)

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DECLARATION

This Research project is my original work and has not been presented for a degree in any other university.

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This research has been submitted for examination with my approval as a university supervisor

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My brother Lameck, who took on the role of parenting me early in his career as a teacher and has not ceased to pray for me and encourage me towards completing my Masters programme and possibly embark on further studies thereafter. Having people who believe in you makes a world of difference in life and no less in academics.

DEDICATION

This work is dedicated to my immediate family, who have always encouraged me to aspire for better and higher in life, which culminated in the accomplishment of my studies. Particularly noteworthy are the enquiries from my wife Carol, my children Nikita, Nathan and Natalia as to the date of my graduation that kept me working towards the goal.

Also to all of you who, in various fields, are involved in making technology that means well for all humanity this project is dedicated to you too.

ABSTRACT

This research project examines Appropriate Technology (AT), which has been popularised in Kenya for well over thirty years apparently without meeting the desired results of exponential increase in uptake of its products among the target population. It first examines the rationale and need for AT in construction generally and in Kenya in particular. It then looks at the prevalence of factors that have contributed to the adoption of the technology on the one hand and those that have inhibited its growth on the other hand.

The study utilises the Compressed Stabilised Earth Blocks (CSEB), one of the best known products of AT locally to demonstrate the kind of challenges the technology has encountered in the Kenyan context. It discusses literature pertaining to the materials under study starting from the global to the local context, giving an understanding of the material itself and its merits and demerits. The literature also gives a pointer as to the likely areas to be examined in the local context to be able to pinpoint weak points to sustained growth in use of CSEB.

The study employs research methods, tools and instruments relevant to the kind of study to give insight into the material itself and its uptake. Through a survey of the identified stakeholders that can influence the uptake of AT products, the study reveals perceptions as to which category stands a chance to have a great influence in the growth or stagnation of use of CSEB. It also employs techniques of direct observation, interview of key participants and questionnaires to sample populations of stakeholders to give a holistic picture pertaining to the situation analysis of the materials technology in question.

The findings from the study are examined against the background of what has been gained through literature. Some findings seem to be in line with available literature whereas some appear to deviate from what is known. Through these, the researcher contributes to the body of knowledge concerning the object of study and opens up the

subject for study by others. Findings point to public awareness of the material being low given that mass media is not the main sources of information concerning the material, perhaps the reason why the target population is yet to be tapped into.

Based on the findings from the study, recommendations are drawn first and foremost as to whether the technology needs to be promoted any more or abandoned altogether. The study reveals that AT is still relevant to the national aspirations, based on practical considerations of the impact it can have on the supply of materials for construction to a large sector of the population. Also, the study recommends what needs to be done to enhance growth of ABMT in Kenya, how it is to be done and who exactly is to carry it out. The national and county governments are still perceived as not doing enough to promote use of ABMT and, by use of resources at their disposal, they can positively influence the use of CSEB and other forms of ABMT in construction.

It is the hope of the researcher that the conclusions that are reached within this paper will have the impact of enlightening current and intending users of products of this technology. Further, by implementing recommendations contained herein, it is probable that the full potential of ABMT will be realized, bringing with it the economic benefits envisioned by the founders of the Appropriate Technology movement.

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ABBREVIATIONS AND ACRONYMS

AT	- Appropriate Technology
ABMT(s)	- Appropriate Building and Materials Technology (-ies)
BEP(s)	- Built Environment Professional(s)
BMTPC	- Building Materials & Technology Promotion Council (of India)
CCEB	- Composite Compressed Earth Block(s)
CSEB	- Compressed Stabilised Earth Block(s)
CSSB	- Compressed Stabilised Soil Block(s)
CSLB	- Compressed Stabilised Laterite Block(s)
DRC	- Democratic Republic of Congo
HABRI	- Housing and Building Research Institute (University of Nairobi)
HDC(s)	- Highly Developed Country(ies)
HRDU	- Housing Research Development Unit (University of Nairobi)
ICSB	- Interlocking Compressed Soil Block(s)
ISSB	- Interlocking Stabilised Soil Block(s)
JBC	- Joint Building Council
LEEDS	- Leadership in Energy and Environmental Design
LDC(s)	- Lowly Developed Country(ies)
MCR	- Micro Concrete Roofing [Tiles]
NGO	- Non Governmental Organisation
SSB	- Stabilised Soil Blocks
UNCHS	- United Nations Commission for Human Settlements (UN-Habitat)

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background and Context of Study

“The impact that appropriate technology can have on people has the potential to make the difference between prosperity and poverty, even between survival and death.” Wicklein and Katchmar, in Wicklein 2001

The Kenyan construction industry has been characterized as the most dynamic and rampant in nature, with ever changing material choices flocking from various part of the earth (*daily nation newspaper*) April 2015. The article portrays those materials as having been made under special environmental and economic conditions different from the Kenyan ones, thus leading to disregard Kenya-made materials and resulting in structures that seem to be out of place

The materials supply situation has led to the government encouraging state corporations and private institutions to come up with alternative affordable, cheap and locally available materials for the construction, with a view of cutting down the cost of transportation, energy and the carbon footprint in the construction industry.

For different building elements materials range in a given scale, some are deemed as foreign while others are said to be traditional. On the issue of walling materials for instance there are limited options available in what is called the ‘traditional’ pool of materials in what is often referred to as *Architecture for the poor*. These include mud walling, fired bricks, unstabilised earth blocks, compressed stabilized earth blocks (CSEB), adobe and wattle and rammed earth among others

These materials have long ago been deemed outdated and thus not suitable for the modernized communities. The building codes and regulators of the construction industry have not helped either. According to Gichunge (2001), the building codes in Kenya do not cater for ‘appropriate and indigenous’ building materials thus inhibiting their use in the provisions of low-cost housing.

CSEB materials have long been propagated as an avenue of curbing the situation of materials importation as well as cutting down the cost of energy in use. This research was conducted with a chief aim of finding out the main reasons as to why there is either reluctance or slow speed in adoption of this material for walling solutions and what can be done to ensure proper utilization of this abundant resource.

Before embarking on discussions pertaining to appropriate building materials and technologies (ABMT), it is worthwhile understanding what these materials are and the motivation behind the drive for adoption of appropriate technologies. It would also be beneficial to trace the history of this technology in Kenya to date to give clearer understanding to the reviewer of this dissertation.

Hazeltine and Bull (1999) indicate that the terminology ‘appropriate technology’ has evolved over the years beginning with the works of Dr Schumacher (1973) through his book ‘Small is beautiful’ where he discusses what is commonly referred to as ‘Intermediate Technology’. Other well known figures cited by the same authors in relation to this technology include Mahatma Gandhi of India, Mao Zedong of China and Julius Nyerere of Tanzania.

According to Willoughby (1990), a synthesis of E. F. Schumacher’s ideas gives a definition of AT as “a technology tailored to fit the psychosocial and biophysical context prevailing in a particular location and period.” While that kind of definition is general enough to cater for ideas that founders of AT had in mind, it again ends up too wide to

the extent any technology could easily be characterised as “appropriate”, even what the founders and proponents of AT would deem not to be.

Auroville Building Centre (one of the proponents of appropriate technology) defines appropriate technology as ‘building processes and tools that are appropriate to the climate, socio-economic conditions and natural resources of an area, and which contribute to sustainable development’

Hazeltine & Bull, (1999) give the following characteristics for ease of identification of appropriate technology: small-scale, decentralized, labor-intensive, energy-efficient, environmentally sound, locally controlled, people-centered and capital saving. Accordingly, a technology that produces materials while meeting most or the listed characteristics would be deemed “appropriate”. It is also instructive that appropriate technology stands in contrast to the high technology of mass production which is more mechanised and less labour intensive

Willoughby (1990) gives two approaches to defining “Appropriate Technology” that are worthy noting, these being the general-principles approach and the specific-characteristics approach. The former implies that ‘{the technology} is specially fitting, suitable, proper or applicable for or to some special purpose or use’; it places emphasis on technology as a means to certain ends and on the importance of articulating the ends in each case. The general-principles approach creates many loopholes to the extent of one author using it to brand a nuclear reactor system as AT. The latter approach assigns specific and tangible operational criteria to the definition thus eliminating ambiguity.

From the foregoing, we get the following definition along the general-principles approach: “The concept of appropriate technology was [is] viewed as being the technology mix contributing most to economic, social and environmental objectives, in relation to resource endowments and conditions of application in each country.

Appropriate technology was [is] stressed as being a dynamic and flexible concept which must be responsive to varying conditions and changing situations in different countries.”

Going by the specific-characteristics approach, the definition seems to be all-encompassing: “An appropriate technology is relatively inexpensive and simple to build, maintain and operate; uses renewable resources rather than fossil fuels, and does not require high energy concentrations; relies primarily on people's skills, not on automated machinery; encourages human scale operations, small businesses and community cohesion; is protective of human health, and is ecologically sound.”

For purposes of this project, the author chose to lean towards the specific-characteristic approach since it is a means by which AT can be readily identified for the intended discussions herein.

CDI (Compressed Earth Blocks, 1998) defined compressed earth block as “masonry elements principally made of raw earth, which are small in size and which have regular and verified characteristic obtained by the static or dynamic compression of earth in a humid state followed by immediate demoulding”.

According to the National Centre for Appropriate Technology (2011), and Akubue (2000), there is a wide divide as to the reasons for adoption of appropriate technologies between the developed and developing world. In the Highly Developed Countries (HDCs) it is largely due to adoption of ‘green’ policies arising from the 1970’s energy crisis and environmental concerns. In the Lowly Developed Countries (LDCs), it is due to actual need for more affordable and readily available solutions to current situations with the environmental concerns being secondary. Schumacher (1973) also gives the energy perspective where he propounds ‘soft’ energy leading to low per capita energy consumption in the LDCs whereas in the HDCs the motivation is seen in the need to do away with reliance on fossil fuels as sources of energy.

Walker and Stace (1997) also indicate that over the past 40 to 50 years, there has been an increasing interest in the use of stabilized compressed earth blocks for residential construction due to their technical characteristics, ease of use, cost and environmental advantages associated with their use. The phenomenon is not limited to the Third World but in First World countries such as Germany, France, Australia and New Zealand, the technology has been used to come up with luxury homes

Debouch and Hashim (2010) argue that to provide affordable housing, building materials based on natural resources are often used. Examples cited include the use of clay for making bricks, and river sand for making cement sand blocks. However, the commercial exploitation of these resources often leads to various environmental problems.

One of the main approaches to low-cost or affordable housing is the use of low-cost materials and what is referred to as ‘appropriate technologies’. According to the Building Materials & Technology Promotion Council (BMTPC) of India, building materials account for approximately 60% of the total building costs and the situation is not expected to be any different in any other developing country. The fact that materials often constitute 60-70% of the total construction costs for any building project in Kenya, lends credence to the emphasis on low-cost materials.

Butenhuis et al (2011) and Pearce (2012) indicate that appropriate technologies are applicable to a wide range of fields, such as: agriculture, transport, energy, water, medicine, and construction among others. Childress (2012) also argues that the appeal of AT is reflected by the wide range of fields that embrace it and apply it including energy conversion, agriculture, and water systems, but others range from sustainable manufacturing to women’s health. The breadth of knowledge required to fully understand such localized, small-scale technology needs to be focused, yet general. AT is best accomplished from a broad range of knowledge that transcends the technical and

addresses the sociological and anthropological factors of the users. This broad range of knowledge and application helps characterize AT as a field that is multidisciplinary in nature. The reasons are as numerous as its applications and as numerous as the factors that interact among the cultures involved, the needs of the people involved, and the technologies applied to solve their problems.

The materials and technology referred to as Compressed Stabilised Earth Blocks (CSEB) are also referred also to as Stabilised Soil Blocks (SSB), Interlocking Stabilised Soil Blocks (ISSB), Compressed Stabilised Soil Blocks (CSSB), among other similar terms. The technologies and materials are invariably inseparable because technology is the process and materials are the products.

Minke (2006) indicates that even presently the number of people housed using earth technologies is more than one third of the world population and in Lowly Developed Countries (LDCs), the proportion is more than half. He also points to the use of locally available material and self-build techniques as solutions to housing in developing countries. He traces earth technologies to some 9000 years ago, mud brick to 6000 to 8000 years ago, while rammed earth is traceable to 5000 years ago. According to Minke (2006), the earth was used not only for domestic but also for public and religious buildings, which often are of relatively larger spans. He gives the scientific name of the soil used for building as 'loam', this being a mixture of clay, silt, sand and even gravel in various proportions. He cites various advantages and disadvantages of the use of earth from different standpoints. He also discusses prejudices against earth as a building material.

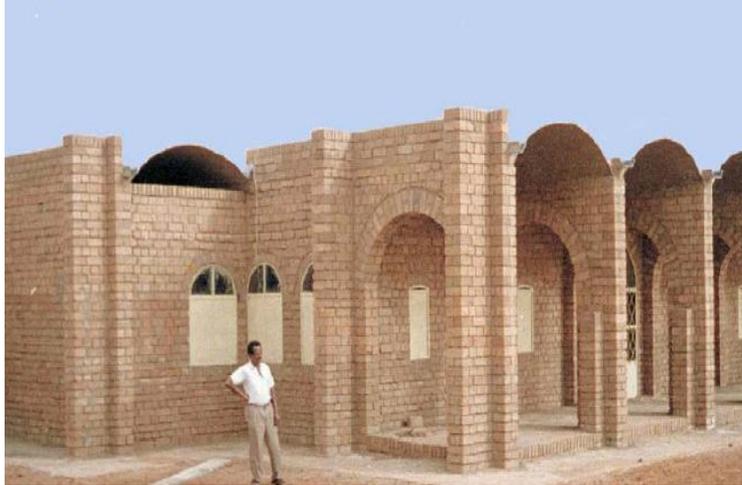


Figure 1 – El Haj Yousif experimental school in Sudan (Adam, 2001)

There are some early challenges encountered in the adoption of appropriate technologies. One is regulatory where building codes outlawed their use (in Kenya). The then Ministry of Housing approached some of the local authorities to alter codes to partially permit usage of the technology and this has since been effected according to the ministry (ministry website). On technical considerations, Egenti *et al* (2013) from their Nigerian experience demonstrate that the ordinary CSEB may need large overhangs to protect against rain thus resulting in higher overall cost than for cement/ sand blocks. In the same discourse, they propose a modification to Composite Compressed Earth Blocks (CCEB) as a possible future alternative. On cost – effectiveness, Egenti *et al* (2013) also indicate that for some soils, the level of stabilization required may be as high 8%, which leads to loss of the cost advantage

In addition, UNCHS (1985) in “The Use of Selected Indigenous Building Materials with Potential for Widest Application in Developing Countries” cites some factors limiting widespread use of indigenous materials (of which appropriate technologies are a subset). These are:: technology of production, investment requirements, quality of output, demand for indigenous products and; inappropriate use of materials in construction

From the website of the Ministry of Land, Housing and Urban Development (MLHUD), there are some generally accepted materials and technologies in the construction industry in Kenya. Soil Stabilization is the process of giving strength to soils by infusing it with additives such as cement. It is used in both road and in building construction. In the former, it is used for road sub-bases and bases whereas in the later, it is used in the manufacture of walling materials such as stabilized soil blocks among others. Other materials and technologies listed include: Micro-Concrete Roofing (MCR) Tiles, Pozzolana / Rice Husks Cement. The National Housing Corporation is also currently promoting and applying AT in the form of reinforced concrete panels and prefabricated panels. One may contend whether these are truly forms of AT since the intention is to have mass production at one point and then transport to where required. Their argument for AT lies in the decentralized production of such products

Most of the above mentioned technologies have been adopted in the country to some extent and they do meet acceptance or resistance to some measure. The reinforced concrete and prefabricated panels are more recent in Kenya, with promotion of their widespread use for housing solutions having started from about 2010; it is thus expected that little data may be available regarding them. However for the materials that have been promoted over a longer time, it is possible to get more information regarding their adoption.

Soil stabilization takes three different but interrelated forms. Mechanical stabilization is the compaction of the soil resulting in changes in its density, mechanical strength, compressibility, permeability and porosity. Physical stabilization modifies properties of the soil by acting on its texture e.g. the controlled mixing of different grain fractions. Other techniques can involve heat treatment, drying and freezing, electrical treatment, electro-osmosis to improve the draining qualities of the soil, and giving new structural qualities. In Chemical stabilization other material or chemicals are added to the soil thus modifying its properties, either by a physic-chemical reaction between the grains and the

materials or the added product, or by creating a matrix which binds or coats the grains. A physic-chemical reaction can lead to the formation of a new material, such as a pozzolana resulting from a reaction between clay and lime.

There are many advantages of the ABMT. On-site materials can be used, which reduces cost, minimizes shipping costs for materials, and increases efficiency and sustainability. The wait-time required to obtain materials is minimal, because after the blocks are pressed, materials are available very soon after a short drying period. The uniformity of the blocks simplifies construction, and minimizes or eliminates the need for mortar, thus reducing both the labor and materials costs. The blocks are strong, stable, water-resistant and long-lasting.

In matters of speedy availability, CSEB can be pressed from damp earth. Because it is not wet, the drying time is much shorter. Some soil conditions permit the blocks to go straight from the press onto the wall. A single mechanical press can produce from 800 to over 5,000 blocks per day, enough to build a 1,200 square feet (110 m²) house in one day. The production rate is limited more by the ability to get material into the machine, than the machine itself. Shipping and transportation costs are minimal since suitable soils are often available at or near the construction site. Adobe and CSEB are of similar weight, but distance from a source supply gives CSEB an advantage. Also, CSEB can be made available in places where adobe manufacturing operations are non-existent.



Figure 2 Building a CEB project in Midland, Texas in August 2011 (source: internet)

CSEB can be manufactured to a predictable size and has true flat sides and 90-degree angle edges, enabling uniformity. This makes design and costing easier. This also provides the contractor the option of making the exteriors look like conventional stucco houses. Materials for CSEB are completely natural, non-toxic, synthetic chemical-free, and do not out-gas. Other characteristics include sound resistance and insulation, fire resistance, insect resistance, mold-resistance, strengths of up to 3.2 kN/mm^2 at 28 days which have been achieved in India among other countries. If practically implemented, use of CSEB has the potential to revolutionize the construction industry by addressing all environmental concerns of sustainability while delivering added benefits.



Figure 3, Mixing of soil and stabilizers



Figure 4, Compressing & retrieving blocks

Photographs of workmen making CSEB- in Mavoko (source: author)

According to Syagga (1993), in the Kenyan context, research into ABMT was motivated by the need to provide decent and affordable housing for more than 70% of the urban population who did not have access to the same. He also talks of such materials being climatically adaptable, socially acceptable and relatively cheaper than existing alternatives. Statistics from the Kenya Population and Housing Census (2009) indicate the materials used for provision of housing as those that can be stabilized to improve the quality of shelter.

Approaches to improving the housing situation in Kenya have ranged from slum upgrading to low-cost housing. These are often very loosely defined terms and give rise to various interpretations which, however, are not the subject of this research.

Among the commonly used building materials are natural stone and timber, the quarrying / harvesting of which continues to pose environmental hazards that will in time cripple the whole country. Indeed, with the rise of green architecture concepts and LEEDS (leadership in energy and environmental design) certification, the use of such materials may give one poor rating in terms of carbon footprint. The search for better and locally available sustainable alternatives continues to be the subject of research by the Kenyan government, non-governmental organizations and academicians.

Progress has been made by the UN Habitat, the University of Nairobi Housing and Building Research Development Institute (HABRI), non-governmental organizations and other government research units to arrive at solutions that are at the same time cheap and readily amenable to the general Kenyan Populace. The technology of soil stabilization, which was pioneered in the 1960s, got into Kenya in the 1980s with the assistance of the German government on a cooperation project. A range of suitable products and processes have been arrived at since then.

A stakeholder is an individual or group, inside or outside the construction project, which has a stake in, or can influence, the construction performance (Toor, & Ogunlana, 2010).

A conceptual framework is a diagrammatical research tool intended to assist the researcher to develop awareness and understanding of the situation under scrutiny and to communicate this (Premchand, 2004).

1. 2 Problem Statement

One of the well-researched appropriate materials technologies is the compressed stabilized soil blocks that were at one time thought to be the clear solution to low income dwellers and other housing crises around the country. This material is well researched and documented by the University of Nairobi Housing Research Development Unit (HRDU), currently named Housing and Building Research Institute (HABRI) which has developed, among other things, the technology for manufacture of the blocks, the structural and general performance of the material, and associated costs. It has also been promoted by the NGO world for use in developing new housing in areas that have just come out of conflict such as Somalia, Northern Uganda, DRC, South Sudan, etc. Compressed Stabilized Earth Blocks (CSEB) is a form of earthen 'brick' that came into existence in the 1950s and was somewhat popularized in the 1980s. The block is comprised of cement or lime stabilizer, depending on the soil type; for example, cement will mix better with sandy soils, while lime is more appropriate for clayey soils. Once the earthen inputs are combined, the mixture is put into a manually operated compression machine.

According to Deboucha and Hashim (2010), this kind of technology has been shown to have numerous advantages. For one, soil is available in large quantities in most regions. Secondly, in most parts of the world soil is easily accessible to low-income groups. In some locations it is the only material available. Soil is also easy to use - usually no specialized equipment is required. Soil is suitable as a construction material for most parts of the building. Soil is non-combustible with excellent fire resistance properties. Soil has good climatic performance in most regions due to its high thermal capacity, low thermal conductivity and porosity, thus, it can moderate extreme outdoor temperatures and maintain a satisfactory internal temperature balance. Soil has low energy input in processing and handling soil only about 1% of the energy required manufacturing and processing the same volume of cement concrete. This aspect was investigated by the

Desert Architecture Unit which has discovered that the energy needed to manufacture and process one cubic meter of soil is about 36 MJ (10 kwh), while, that required for the manufacture of the same volume of concrete is about 3000 MJ (833 kwh). Similar findings were also reported by Habitat (UNCHS). Soil is also environmentally appropriate the use of this, almost unlimited in its natural state involves no pollution and negligible energy consumption, thus, there is further benefit of the environment by saving biomass fuel.

According to Syagga (1993) the incidence of usage of ABMT in buildings in general and to low-cost housing in particular cannot be compared to the more conventional and more expensive options in the market leading to an increasing gap between supply and demand for housing in Kenya. Put differently, the gap in supply of housing in Kenya can be reduced by the adoption of appropriate technologies; construction costs would also be reduced by choosing adopt AT.

Going by the Kenya Population and Housing Census (2009) the potential for appropriate technology to contribute to improvement of shelter is immense. For example, the percentage of households built using mud and wattle and similar structures is 56% on the national scale. In a major urban centre like Nairobi this percentage is even higher standing at 66% perhaps due to the huge demand for housing. These could directly benefit from the soil stabilisation technology to improve shelter. Further, the supply of housing units (limited by availability of walling materials) could improve should AT be adopted as a recognised method for producing standard building materials

It is the purpose of this study to investigate knowledge, attitudes and practical application by professionals, artisans and clients pertaining to ABMT in the context of Nairobi Metropolitan region with a view to generalising the most prevalent factors leading to the apparent slow adoption of appropriate technology. The professionals specify materials, the artisans build and the clients use the buildings either directly or by renting them out.

By searching amongst them, the researcher believes it is possible to find answers that will contribute to the body of knowledge and unlock the potential of ABMT. The promoters of the technologies will be sought to give expert knowledge as pertains to ABMT and the challenges they have encountered with the technology.

This research therefore seeks to unlock the reasons behind the slow progress in usage of the material in question in Kenya in general and within the Nairobi Metropolitan Region in particular, with a view to suggesting solutions that will add vibrancy to the development of low-cost building materials and possibly revolutionize the production of low-cost housing stock within the country.

1.3 Research Questions

The research questions are closely related to the objectives of this research project. There may be more than one research question required to achieve a specific objective. The questions that need to be answered are:-

Does the material in question (CSEB) meet the intended threshold of the requirements of a good building material?

Has there been growth, stagnation or decline in the use of AT and CSEB in particular when correlated with the growth in the population of potential users?

Is information concerning the stabilized soil blocks well understood by the general Kenyan public?

Does the level of awareness among built environment professionals (BEP), constructors and general populace affect the use of CSEB as a walling material?

Does the material have a potential to grow and be adopted for use in large scale within the Kenyan building industry?

Is the government doing enough in promoting the technology in question or rather the product (CSEB)?

1.4 Research Objectives

The main objective of this study is to establish the major factors behind the slow progress in the use of the Compressed Stabilized Earth Block (CSEB) technology (among other appropriate building material technologies) as part of the building materials supply line in Kenya. The knowledge of such factors may then lead to decisions as to whether improvements need to be made to the technology or it is just institutional frameworks to be put in place to propagate AT.

The following will be the specific objectives that need to be attained towards the realization of the overall objective:-

First, identify through situation analysis of the construction industry in Kenya the stakeholders of CSEB and their role in adoption appropriate technology (AT)

Second, establish factors affecting the adoption of Compressed Stabilised Earth Block (CSEB) technology

Thirdly, identify and propose solutions to technical or institutional hitches in the adoption of CSEB

1.5 The Significance of This Study

Those that stand to gain from this study include the following:-

The developers of housing stock ranging from individuals in rural and urban areas, and non-governmental organizations

The Government of Kenya which will gain momentum in achieving the vision 2030 pillar of environment, water and sanitation, housing and population which is a significant component of the overall vision

The specifiers of building materials i.e. the architects and their fellow professionals in the building industry who stand a chance of offering more cost-effective and environment friendly walling solutions to their clients as a result of the findings of this study

Research institutions engaged in the development of the Compressed Stabilized Earth Block (CSEB) and other Appropriate Technologies

Academicians who may find new frontiers opened up as a result of the research gaps that may come up as a result of this study

The general populace as they will be in a position to make more informed choices as pertains to ABMT and resort to materials that do not result in environmental degradation

Newly created county governments in their ambitious projects to improve housing in their communities will find good avenues if ABMT is adopted in their localities

1.6 Research Hypotheses / Assumptions

One is that there is general lack of knowledge among key players in the building materials industry in Kenya concerning ABMT

Two is that professionals, who are the main specifiers of the material, have found major limitations of the applicability of the material hence their reluctance to specify it

User attitudes towards the materials are negative due to how they perceive them.

That there are technology transfer challenges with the materials and they may not be as easy to produce as envisaged by the proponents

The supply of these materials through small-scale production does not meet the demand in the Kenyan situation, since the country is in a rapid growth mode.

Major industry players have not taken up the material since it is not profitable business or not sustainable

Some expenses relating to the CSEB have not been properly documented resulting in misleading figures from the proponents pertaining to the cost of the products. In other words, the material could be much more expensive than we are made to believe

The material has to be used in combination with other materials that are not low cost and that the proportion of saving when compared to other readily-available walling solutions is insignificant

1.7 Scope of Study

The general area that the study covers is construction materials and technology. It seeks to address itself specifically to what has been termed as Appropriate Building Materials and Technology (ABMT), which is an approach to address the need for affordable building materials that are environment friendly by use of earth technologies which, while being more affordable than ‘conventional’ materials, are at the same time readily available to a wide section of the populace.

Geographical: the study will confine itself to the areas where low cost housing stock is required. It will dwell on the low cost housing projects within the Nairobi Metropolitan Region where these have been used and documented, Kisaju in Kajiado and Machakos. (These have been arrived by review of literature on usage of the product). In these areas, the study will examine the existing housing stock that has been developed using the stabilized soil blocks. Areas of extensive use are likely to have more documentation and could also provide adequate randomness in sampling.

The study will also involve desk study into existing documentation available at the UN Habitat offices, Housing and Building Research Institute (HABRI) of the University of Nairobi and Joint Building Council (JBC) who will provide the information required to verify any statistics or assertions. All of these have offices in the Nairobi Metropolitan Region. As the study will also be making use of expert informants in particular areas, it will entail visits to such people’s offices. Selected experts from the foregoing institutions

will offer insights that may corroborate or repudiate existing knowledge pertaining to the technology that is the subject matter of this research.

To make the research attainable, it was necessary to concentrate on getting clearer understanding of the subject of study from those already involved in research into this technology, large scale producers or manufacturers, if any, as well as the end users of the products. The study also relied on past research in the same area of interest and the approaches taken, with appropriate adaptation to the subject matter of study.

1.8 Research variables

There were many research variables investigated in this study. For purposes of clarity these were grouped as listed hereunder. Some variables however were singled out.

Variables pertaining to physical aesthetical nature of CSEB

Variables pertaining to durability of the material

Structural characteristics and strength of the material

Variables relating to awareness of AT among professionals and lay persons

User perceptions pertaining to usage of the ABMT

Measures of uptake of CSEB and ABMT in Kenya

Extent of institutional framework for the promotion of use of ABMT and CSEB

1.9 Limitations of the Research

The following are the foreseeable limitations of this study:-

First, CSEB has been in use in Kenya for a period of about 30 years and the body of information concerning it is not very large in comparison to other widely used walling materials. There are few written books concerning the material so most citations are from

journals and publications by organizations that have pioneered on usage the material. Sometimes the secondary sources of data may not be available.

Secondly, the time required to go through existing literature and other documentation of interest in the area of study plus that required to collect and analyse data from the field is relatively long given the original set of specific objectives of the study. This led to the need to narrow down the number of specific objectives while keeping in mind the overall objective

Third, the data collection exercise involved travel within the Nairobi Metropolitan Region and upcountry. Due to limitation of funds, there was need for prudent planning to maximize on the time spent in the field

Fourth, lots of research is in progress concerning many aspects of CSEB and AT; the possibility of duplication of at least some aspects of the research is high.

Fifth, experts on AT and CSEB are few and far between. Very few of them were available for interviews during the period of the study. Using other building industry professionals' views, in the opinion of the author, would have rendered the information less authoritative and conclusions drawn less reliable. Hence the decision to stick to the few who have lots of knowledge of the subject matter.

Lastly, shortage of personnel trained to assist in the research could have an impact on the overall output and quality of the research. The author had to give training on the administration of questionnaires where it was not possible to do the work directly. Such short training was useful and it is expected that it would not have impacted the outcome of the study in any significantly negative way.

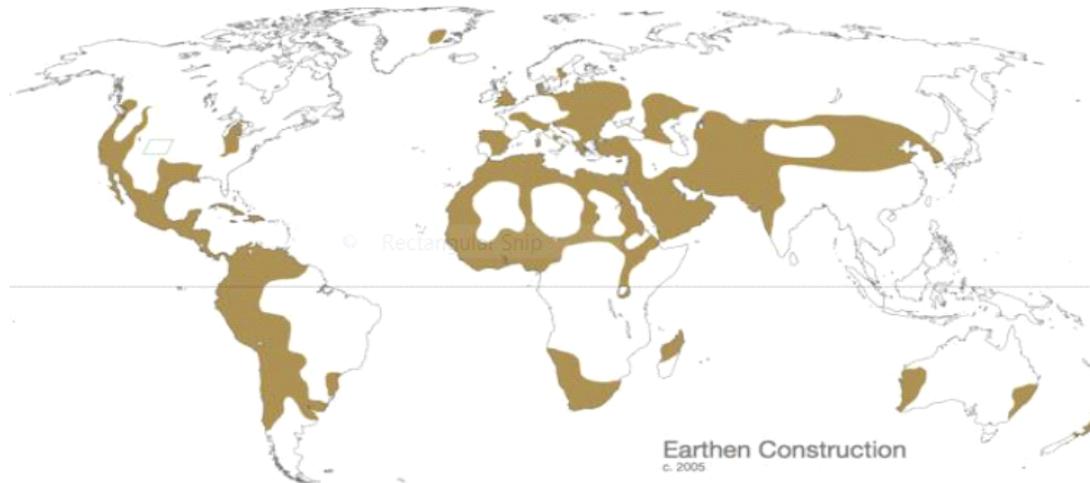
CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

Literature review is a survey and discussion of the literature in a given area of study. It is a concise overview of what has been studied, argued, and established about a topic. The literature review in this study gives understanding pertaining to knowledge on appropriate technologies and particularly as concerns buildings. It also gives insight into some recent studies have found out about factors hindering adoption of appropriate technology (AT) from a global perspective in general and in particular Kenya. The chapter specifically covers the theoretical discussions, empirical review, and the conceptual framework.

Earthen building techniques are not new concepts and their application has been known for over 9,000 years according to Keefe (2005); and Minke (2006). Earthen structures throughout history are evident around the world. Several traditional options include: rammed earth, fired clay/mud, earthen blocks, adobe, etc. Structures including the Great Wall of China, the Temple of Ramses in Egypt, and the Sun Pyramid in Mexico are all founded on earthen building technology (Minke, 2006). Approximately 30-40% of the world's population currently resides in earthen structures and 25% does not have access to decent housing (Keefe, 2005; Auroville Earth Institute, [no date]). Figure 2.1 illustrates the regions of the world where earthen construction technology is utilized. Using soil as a building material is a practical alternative because it is: economical, proven to work when implemented correctly, more sustainable than many modern options, and often readily available when other materials are not.



World map showing zones where earthen construction is applied.
 Courtesy of Matthew Jelacic

Figure 5, (source Matthew Jelacic)

2.2 General Information on Building Materials in Developing Countries

UNCHS (1985) indicates the importance of building materials sector as regards to national development in the developing countries. They are used in the construction of all capital projects i.e. roads, railways, harbours, bridges, dams, factories and other building and civil engineering infrastructure works on which the rest of the national economies depend accounting for about 80% of total capital assets in developing nations. Construction of shelter provides a place of abode for labour and also space for manufacturing of goods and offering of services essential to the economies

Under-provision of physical infrastructure, shelter and other related amenities would indicate underdevelopment and the converse is true for adequate provision. Given the critical role of construction in national development, building materials come out as the single largest input in the building industry accounting for roughly 50% in high end, buildings, 80% in low income and 100% of the costs in self-build for construction in

developing countries, where labour is relatively cheap and in the event of self-build, the sweat equity is not taken into account

UNCHS (1985) further outlines trends in the building materials sector. There are materials considered 'modern' and modern-based production technologies. These are referred to as 'conventional'. Examples of these are bricks, glass, concrete and steel. They are often imported into developing countries or produced locally using imported inputs. These materials can be prohibitive in cost, scarce or intermittently in supply, not appropriate, but they happen to be so popular that they are viewed as the only available materials in building construction. Some of these views are biased given that most of these materials are cheap due to economies of scale in production that makes them relatively cheap. It is also disputable whether materials like concrete would be having a high level of imported inputs in the production, especially if one is referring to Kenya. Traditional building materials: these are said to be produced using rudimentary technologies on a small scale and are often times characterised by low performance. They are said to be not popular despite having been the predominant type used in low-income settlements. Examples of such materials are: earth, stone, bamboo and thatch. Depending on the quarrying and cutting of stone, it may not fall in this category because in Kenya for example, natural stone is used for high end building production. Innovative building materials: simply put these are an improvement on the traditional building materials through research and development in a bid to reduce dependence on import-based materials or technologies. Earlier examples included stabilised soil blocks and pozzolanas though more are being developed. Whereas some of such materials are still under study, even those that have met the threshold of success in research have yet to make an impact in the building materials market. The researcher is in agreement with this view and it actually forms the basis of this study

Some problems of cited with regard to building materials sector include availability of materials: Insufficient quantities of available materials, non-availability of materials and

when available materials can be extremely expensive. These factors lead to delays in completion of essential buildings or if completed, the final cost of such buildings is very high. Importation also depletes foreign exchange reserves and devalues the Third World currencies. Where there is local production, there will still be lots of imported inputs and technologies, which makes little difference with importation of finished products. The advantages of large-scale production in lowering per-unit cost is often not realised due to scarcity of production factors resulting in under-utilisation of installed capacities. The cost of transportation and wear and tear due to poor transportation network in lowly developed countries (fuel and spare parts are both imported) results in a very high cost of the site-delivered product, thus compounding the forex paradox.

There is also lack of alternatives to ‘modern’ or ‘conventional’ building materials leaving the low-income sector without supply of shelter from the private sector investors. When ‘conventional’ building materials like cement are used in low-income shelter production, demand for the product goes up resulting in rapid increase of its price, driving the price of the finished product beyond the income group that was initially targeted. This is true and the industry is replete with example of low-income housing that ended up being bought by a higher class of populace than that for which they were originally designed

The building material industry is said to be unable to benefit from the opportunity to expand output of the sector through a vast array of underutilized indigenous resource inputs. These may include: small-scale raw material deposits, agricultural residues, industrial wastes, low-cost and renewable sources of energy, unskilled and semi-skilled labour. Also there are established technologies which can be readily applied to the local production of low-cost building materials; despite local and international research findings, there remains a wide gap between experimental innovations and their wide-scale adoption in construction.

UNCHS (1985) defines indigenous building materials in context of variations in national resource capacities as material produced within the resource limitation of a country for use in construction. Thus there are variations as to what constitutes indigenous materials from country to country and even within regions of the same country. Developing countries differ in terms of raw materials available and their technological advancement. Suitability of materials is dependent on climatic and soil characteristics since these vary from country to country and even within the same country. For example, using timber for external walling in a wet environment may be unsuitable, but the use of soil construction in arid and semi arid areas will be recommended

In terms of level of technology, it can be seen that developing countries with highly developed technological capabilities can promote the use of most primary raw materials as indigenous building materials whereas in other developing countries, even the conversion skills for the raw materials have to be imported making the materials as expensive as imported ones. When one examines the ability of India to propagate new materials and technologies, it is not comparable to the situation back home in Africa which makes this point more pertinent

For indigenous building materials to be suitable for low-income shelter they have to be both accessible and affordable. Emphasis is on those materials with the greatest impact on costs. For example there is great emphasis on the walling material as opposed to the finishes and fittings, hence orientation to the construction needs of the majority of the population, since they only require basic shelter. Indigenous building materials just like other building materials require these for production: raw materials, labour, machinery and energy. Thus these factors have to be available at the local level to meet the objective of indigenization.

2.3 Literature Pertaining to the Need for Appropriate Technologies

According to the Kenyan Vision 2030, Kenya will be a predominantly urban country by year 2030 if the current demographic trends hold true, and envisages an adequately and decently housed populace by 2020 in what is called a ‘sustainable environment’. Accordingly, the annual production of housing units from 35,000 in 2010 to over 200,000 by 2012. It proposes a planning and development starting with cities and towns while concurrently catering for the rural settlements. The quality of urban planning will take into cognizance the need to provide adequate housing for current slum dwellers. The vision includes access to finance for builders and buyers of homes, reforms targeted at exploiting potentials for housing through public-private partnership. It proposes to increase annual production housing through the Housing Developing Initiative that will lay and emphasis on low-income housing

Literature regarding Housing Supply / Statistics from KNBS indicate that as per the 1999 Population and Housing Census (the 2009 one was awaited then), the total housing stock in Kenya stood at 10.4 million dwelling units – 19.5% of these were in urban areas. 77% of the households in urban areas lived in rental housing, whereas in rural areas 87.3% of households owned their houses. The rural-urban disparity in homeownership patterns reflects the relative high cost of housing in urban areas. It also reflects the importance many Kenyans place on investing whatever limited resources they have to housing construction in their ancestral home areas, where most would like to retire. An additional factor is the uncertainty of temporary and informal employment, the need to relocate within close proximity to employment, and hence the preference for rental options as opposed to home ownership. By 2009 the statistics indicated that the proportions of owned homes had the rural at 81.5% while the urban one was at 18.5%. In terms of rental, the rural had 20.8% while the urban had 79.2% of the renters. Overall nationally in 2009, 59.8% of the housing stock was in rural areas, whereas 40.2% was in urban areas.

The same statistics indicated Kenya’s demand for new housing units at 150,000 against a supply of 25,000 annually, giving an ever widening shortfall of at least 125,000 units by then. At the same time more than 50% of the existing structure in urban areas were in need of repair/rehabilitation. while 300,000 units would require improvement in the rural areas

As pertains to the general area of study, it is instructive that Nairobi is a metropolis that fairly represents the whole country, being the source of roughly half of the GDP of Kenya. Currently, Nairobi is the 13th largest City in Africa in terms of population. This growth is remarkable given that there were only 8,000 people living in the year 1901 and as at 1948, the population increased to 118,000. Further to this, the population increased to 343,500 in 1962, and by 2009, the population overwhelmingly shot to about 3.1 million people (Kilili, 2012).

What is defined as the Nairobi Metropolitan comprises of four regions which cover approximately 32,000 square kilometres as indicated in Figure 4

S/NO	REGION	AREA COVERAGE
1.	Core Metro	City of Nairobi (684 square kilometres)
2.	Northern Metro	Municipal councils of Kiambu, Limuru, Ruiru, Thika, and Karuri, the Town councils of Kikuyu and the County Council of Kiambu;
3.	Southern Metro	Town Council of Kajiado and the County Council of Olkejuado;
4.	Eastern Metro	Town Council of Kangundo/ Tala, the Municipal Councils of Machakos and Mavoko and the County of Masaku

Figure 6 Nairobi Metropolitan Regions; modified from Kilili (2012)

While states are defined by geographic and political boundaries, Metro areas are shaped by economic activity, sometimes across states and national borders. As such, Nairobi is characterized by a single major employment centre composed of the central commercial

area (CBD) and adjacent industrial area which together hold a majority of the city employees. Beyond the CBD, several distinct residential areas are located; to the North and west are predominantly low density and high income areas; to the south and east they comprise areas of high density accommodating middle and low income households ranging from the relatively prosperous Nairobi South area to the more modest Neighbourhoods of Eastlands and Umoja. Further to this, a substantial part of the population reside in high density clusters of low income housing in Dagoretti, Riruta and adjoining low income neighborhoods.

The high population growth coupled with increased coverage of the Metro areas is bound to increase the demand for housing services with large areas witnessing competition between investment in housing provision and other sectors of the economy. This fact has been witnessed before especially in areas such as Kiambu County which was predominantly an agricultural area but at present experiencing influx of both posh homes as well as gated residential areas that threatens the survival of the Coffee and tea production in such areas. In addition to this, the areas around Kitengela and Ngong regions has also witnessed high concentration of people which at times settles around the migratory corridors of wild Fauna thus aggravating the wildlife-human conflict especially, while extracting forest products to facilitate provision of homes. Further, most of the population within the Metropolitan area comprises of poor households who mostly occupy precarious areas and utilize temporary materials which are susceptible to fire and flooding in such areas thereby increasing their vulnerability to hazardous effects.

From the literature on the subject of study, there are several strategies adopted in the promotion and dissemination stages of the ABTs in Kenya. Accordingly, these strategies included among others:- advertisements; ASK shows exhibition; education and awareness creation; community and leaders Barazas; collaboration and partnership; community groups (CBOs, FBOs, self -help groups); community mobilization, demonstration and trainings; construction of ABMT training centers in each constituency;

construction of demonstration units; display of institutional service charter; distribution of brochures; exhibitions and home expos; fliers and brochures; individual applications; and institutional linkage. The technology promotion also adopted: application of research papers; involvement of youth polytechnics; issuance of machines at a free cost to serve as an incentive for increased use of the technology; office based information dissemination; production and distribution of pamphlets on ABTs; Hydraform machines sourcing and distribution to local sites by the Government of Kenya; and website based information

Bush (1994) in his technical paper “Understanding Stabilized Earth Construction” indicates that stabilized soil, a product of scientific research, offers medium- and high-technology soil options. He cites local conditions as determinants of its applicability. He indicates that earth may not be ‘appropriate’ unless stabilizing additives, technical assistance, and machinery are available and affordable in which case adobe or rammed-earth may be a better option. Bush thus tends to limit the applicability of the technology for stabilized soil blocks to various localities in developing countries perhaps on the premise that most of them have no technology for manufacture and assembly of the block forming machines nor the required additives. My take on this is that the machines used to manufacture CSEB are not that complex and with a little innovation can actually be made in developing countries. Cement and lime are also readily available in most of those countries so they may not present a major challenge

According to a Habitat for Humanity Kenya Document (2009) {Kenyan} families live in inadequate, overcrowded homes, typically with only one room and no windows. The houses are said to have mud walls, cow dung and dirt floors and thatch roofs. Habitat argues that this is poor home construction which may mean that the accommodation serves as breeding grounds for diseases including malaria, amoebic disorders and respiratory conditions, which are commonly life-threatening. What habitat sees as ‘poor’ homes may, with a little hygiene as is often the case in many rural areas of Kenya be very comfortable homes. What becomes complex is when such shelter is put up in the urban

centres by merchants who want to exploit the gap in housing supply in the country and they cause degeneration into squalor. These kind of houses are among the types that can benefit from soil stabilization and AT in general

The same document indicates that investigations into new building methods that keep building costs as low as possible have benefitted thousands of families in western and central Kenya that are now able to obtain their own simple, decent and permanent homes with the concomitant benefits of improved living conditions and good health. Those kind of house will often have concrete foundations and floors and galvanized corrugated iron sheet roofing. The only question one would pose is whether the other elements of the building do not necessarily require materials that are ‘appropriate’

A booklet produced by GTZ (1994) described a technical co-operation project initiated in 1980 between the Government of the Federal Republic of Germany and the Government of the Republic of Kenya. It reviewed several low cost housing projects in Kenya. In chapter two it described soil stabilization and the use of a range of different presses.

2.3.1 Suitability tests of soils for CSEB making

In selecting a suitable soil, optimizing the soil mix, and evaluating strength, deformability. The procedure is a systematic series of processes evaluating potential soils at every phase of production. Readily available potential soils are classified and then methodically evaluated through the sequence of tests.

If at any point during the process, the proposed soil or soil mixture does not satisfactorily satisfy the requirements, a step back is taken to reconsider further action through selection of a new soil or soil amendments (Kronsnowski 2004)

2.3.2 Testing process flow chart

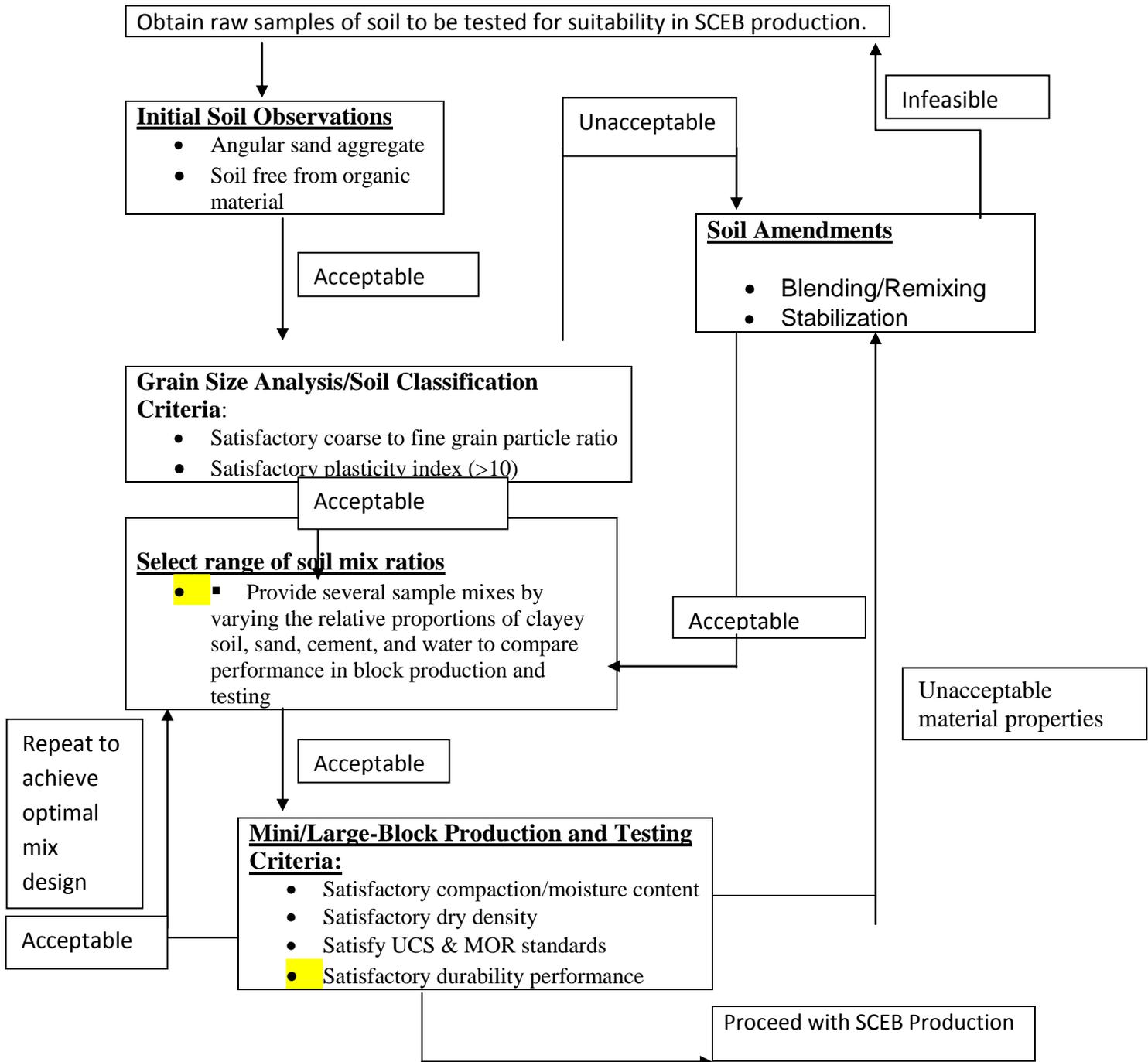


Figure 7 SCEB Testing Methodology

2.3.3. Initial Soil Observations

New soil samples undergo an initial visual inspection when received in the laboratory. The amount of organic material in the sample is observed and noted. The shape and angularity of the soil particles in the sample is observed and noted. The sample's in-situ moisture content is determined. Any irregularities or inconsistencies in the sample are also noted.

Presence of organic material should be of high concern when detected. Section 14.7.4.23 of the 2009 New Mexico Earthen Building Code addresses SCEB production directly (NMAC, 2009). In Section G, a mineral soil is specified, suggesting a material free from any organic constituent. Due to weaker strength and higher compressibility, organic soils containing roots, moss, sticks, leaves, etc. are not suitable for SCEB production (Coduto 1999). As the organic material breaks down, it is possible that it creates additional void space within the block, allowing for water seepage and augmenting freeze/thaw effects. Excessive organic material content may be the result of improper mining techniques, such as not removing enough of the top-layer of earth on-site.

The shape and angularity of the aggregate material (silt, sand and gravel) can vary from very angular to well-rounded. The more angular particles are, the more difficult it is for particles to move past each other when loaded. This effect creates a matrix of particles capable of increased shear strength and therefore better performance when subjected to loads (Coduto 1999).

The initial moisture content of the soil is determined. The moisture content is the ratio of water mass to solid (dry soil) mass. Samples are generally collected and transported sealed in airtight five gallon buckets to prevent moisture loss during transport. Samples that contain too much or too little natural water content will need to be amended before use in SCEB production.

2.3.4. Soil classification

A grain size analysis is required to classify a soil. A proper classification will correctly identify a soil, thus providing insight to the soil's properties. Soils are tested and classified as per the Unified Soil Classification System – USCS (ASTM D2487). Clay and silt are commonly referred to as fine grained soils, while sand and clay are referred to as coarse grained soils. A sieve test (ASTM D422) is performed to determine the soil grain size distribution. For fine grained soils, a Liquid and Plastic limit tests (ASTM D4318) is carried out (also known as the Atterberg limit test). The Atterberg limit test provides a method for quantifying a soil's plasticity, providing information regarding the amount of clay present. Using the information obtained from the grain size distribution and Atterberg limit tests a soil classification is determined using the process provided by the USCS. Any soil found to contain organic material is unacceptable. The sand used for aggregate must have angular particle characteristics and its gradation must be compatible with that of the clayey soil to be used.

Current literature and applicable building codes do not offer guidelines for selecting an optimal soil for earthen construction based on the soil's USCS classification. The sand aggregate used is ideally well-graded with a USCS classification of SW. The clayey soil used contains a significant amount of clay minerals with a USCS classification of CL. In addition, the clayey soil should achieve a plasticity index which is greater than 10. Sand aggregate and clayey soil that is not classified as SW and CL, respectively, can often be amended to achieve optimal characteristics.

2.3.5. Dry Soil Grain Size Analysis

For coarse grained soils, a grain size analysis is performed by shaking a raw soil sample in a Gilson Testing Screen Model TS-1 shown in Figure 3.2. Samples are first air-dried for several days to achieve maximum separation during sieving. The dry sieve analysis

passes a dry soil through sieves of decreasing opening sizes and measures the gravitational amounts passing each sieve size. The amount passing each sieve is plotted against the sieve opening size and a best-fit grain size distribution curve is constructed. Samples are shaken for a minimum of 30 minutes or until desired separation has been achieved. The grain size analysis provides a way to classify the soils using a standard procedure (ASTM D 422 and ASTM D 2487). For SCEB application, fine grained soils are also tested in this manner in order to provide an understanding of the gradation of the coarse-grained particles present in the soil and also to provide information regarding the effort that would be needed to prepare the soil for SCEB production.



Figure 8, Gilson Testing Screen Model TS-1

2.3.6. Wet Sieve Analysis for Fines Content

Based on grain size, the USCS delineates the division between fine and coarse grained soils by determining the amount of soil that passes through a #200 sieve (particle diameter of 0.075 mm). For instance, if more than 50% of a soil sample passes through a #200 sieve, then the soil is referred to as fine grained. Due to the high levels of cohesion often present in clayey soils, it is difficult to accurately determine this information with the Gilson model soil shaker. A wet sieve procedure is performed on the soil sample to make this determination. Water is used to expedite the sieving process and the retained soil is dried and weighed to complete the test. It should be noted that this process does not give any information regarding the specific amount of clay or silt content in the soil. This process is illustrated in Figures 9-12 below



Figure 9 - #200 Sieve; Original Sample



Figure 10 - #200 Sieve; mixing with water



Figure 11 - #200 Sieve; And more mixing



Figure 12 - #200 Sieve; Retained soil

2.3.7 Characteristics of soils with different plasticity indices

Table 1: Soil Classification on Plasticity Index

Plasticity Index	Classification	Dry	Visual-Manual ID of Dry
0-3	Non plastic	Very Low	Falls apart easily
3-15	Slightly Plastic	Slight	Easily crushed with fingers
15-30	Medium Plastic	Medium	Difficult to crush with fingers
>30	Highly Plastic	High	Impossible to crush with fingers

2.3.8. Selection of Soil Mix Ratios

The soils to be used for SCEB production contain primarily angular sand, clay and silt. Larger aggregate particles such as gravel and rocks may also be present in the mined soil and are typically removed by screening. Soil samples vary widely from region to region and the composition of the samples from one site may also vary. This makes the selection of a proper soil mix a “trial by error” process. Ratios for SCEB production typically range from 20% to 40% clayey soil and 60% to 80% sand aggregate, but ratios outside of this range can also produce quality blocks.

The clay component provides the cohesion or binding forces necessary to hold the particles comprising the block together. Silt, sand and gravel particles supply the structural strength by combining to create a compact matrix with little void space

2.4 Advantages of CSEB Technology as a subset of Appropriate Technology

The motivation of this research is the standardization need for widespread use of earth as an alternative building material. Concrete has grown into the most important building material over the last century and in industrialized nations the annual production amounts to 1.5-3 tons per capita (Glivand, Mathisen, Nielsen; 2005). The use of cement in the production of concrete contributes vastly to the construction industry’s carbon footprint.

Cement production is responsible for 10% of global CO₂ emissions; Keefe (2005). Aggregate is often created by mining, and crushing rock to the desired specifications. Building sites are rarely located within proximity to the mining sites, necessitating additional energy requirements to transport the materials. This process requires a huge amount of “embodied energy”. Embodied energy is the sum of all the various processes involved to implement a material into production. Keefe (2005) offers an embodied

energy consumption value for various building materials. “Concrete block” registers 600-800 kWh/m³ while “Earth” registers 5-10 kWh/m³, clearly indicating the advantage of earth building. The addition of cement triggers a chemical reaction which emits noticeable amounts of carbon dioxide into the atmosphere. One mass unit of cement generates approximately an equivalent mass unit of CO₂ emissions (Glivand, Mathisen, Nielsen; 2005). Of course, this looks like a double edged sword since CSEB still uses cement, but the proportion tends to be quite low thus lowering the embodied energy.

To investigate additional advantages of SCEBs, current research is investigating the indoor climate regulating effects of structures built from earthen blocks. Minke (2006) presents data showing that earthen construction materials are able to absorb and desorb moisture more efficiently than any other building material, allowing them to regulate indoor climate. He suggests a range of 40-70% relative humidity as ideal for indoor environments and explains in detail how both high and low levels of relative humidity can lead to health related issues. Minke mentions a case study in Germany in which an earthen structure maintained an indoor humidity range of 45-55% for a five year period. Building with earthen materials thus makes buildings better for occupants’ health.

Morony (2004, 2005, and 2007) performed a series of experiments to support the hypothesis that earthen building techniques create structures which are warmer in the winter and cooler in the summer. Two modules of identical dimensions were constructed, one with earthen blocks (adobes) and one with cinderblocks (concrete masonry units). The flooring and roofs were of the same material. Temperature readings were recorded to investigate the thermal properties of the two materials. On a hot summer day in Del Rio, Texas the outdoor temperature was 98° F (no relative humidity data available). The temperature was 90° F in the earthen block module and 103° F in the cinderblock module. Not only did the earthen block module register an interior temperature below the ambient temperature, it also remained a dramatic 13° F cooler than the cinderblock module. This is a huge advantage that should work in favour of CSEB.

In his discussion, Morony (2004) classifies earthen blocks as a Phase Change Material – PCM, which takes advantage of moisture differentials and latent heat phenomena. Latent heat of condensation results in heat storage in a PCM when relative humidity is high. Excess water vapor is absorbed into the material and stored in the liquid phase, an endothermic reaction. Latent heat of vaporization results in heat being released from a PCM when relative humidity is low. Water stored in the material in the liquid phase is released as a vapor, an exothermic reaction. Morony explains that it is through this mechanism that the earthen block module was able to “lose” 8° F

2.5 As Regards Limitations to Adoption of Appropriate Technologies

UNCHS (1985) lists some of the main factors limiting application of these technologies and especially as pertains to developing countries. These were listed in the introductory portion of this research and are now discussed below.

Technology of production: it is said that the technology has to be tested, proven and widely known at the local level. Despite dissemination of information across the globe as pertains to innovative technologies, replication across countries has been slow. This is partly due to lack of ownership of the technologies, thus enabling distribution in a supply chain across countries. Whereas, for example, India has tasked the Cement Research Institute with distribution of rice-husk-ash-cement and mini-plants for cement production as well as Khadi & Village Industries Commission with establishing lime and lime-pozzolana production units, there is little that can be found of the same in other countries that claim to espouse the same technology. The tendency in the rest of the developing world is to lump together ‘Appropriate Technology’ but it would be far better, in my opinion to have each of the appropriate materials dealt with as a stand-alone. It can also be seen that the commercialization of a newly-introduced technology is complex and resource-consuming

Investment Requirements: sometimes investments in the technology may be high but the returns may not be as envisaged when it fails to catch up as expected. When it comes to quality of output: there may be inconsistencies since AT is not a mass-production and quality assurance will differ from one place of manufacture to another. The soils also differ from place to place hence the need for different ratios of cement in the soil stabilization

On demand for indigenous materials it is evident in many developing countries that people have a preference for imported materials and they do not believe in local products. Misapplication of indigenous materials in areas where they are not suitable has also contributed to delayed uptake since it gives negative publicity

UNCHS are not the only ones to have documented these limitations. From Nigeria, we have literature that details such shortcomings. One of the facts that may limit usage of the blocks, according to literature is the lack of consistency hence because of differences in soil types, CSEB will differ in characteristics from region to region

2.6 Criticism of Appropriate Technology and Materials

According to Willoughby (1990) the criticisms could be grouped into those that concern the ideals and claims of the Appropriate Technology movement on the one hand and those that raise fundamental questions as to the validity of appropriate technology per se on the other hand. The former he terms 'general' and the latter as 'political'

Criticisms against AT abound. They range from technical, to economic, cultural and political. On the technical front, "appropriate technologies" are considered to be technically inefficient and by nature incapable of matching the supposedly superior productive capacity of "high" or "modern" technologies. This however is based on lack of

understanding of AT, which is meant to be readily available and amenable to end users. Another criticism states that there is no need to look for technology options since there is only one viable way of efficiently conducting an activity. This is shown to be a misunderstanding of the reason for existence of AT, this being actually increasing availability of technology in areas that have limited availability.

On the economic front, AT is thought of as not being economically competitive. This is fuelled by the economic theory that increasing the scale of production and increasing the level of gross and per capita capitalization in a production process brings concomitant increases in productivity. There is no evidence that the economies of scale theory holds true in all cases. In any case, the soil stabilization means the biggest raw material, i.e. soil, does not require transportation and this should immensely contribute to lowering the cost of the finished product – CSEB. The second economic criticism postulates that economic growth is incompatible with the use of appropriate technologies; and that a healthy economy requires continual growth. It is however clear that AT has one of its goals economic growth and countries like Kenya see its implementation as a stepping stone to economic greatness. Where it has been embraced, AT has brought transformation an example being in India where even entire cities are built using the same technology. A third economic critique of AT states that it is based upon inadequate or spurious economic theory. To the contrary, AT is grounded on development economics, where technology is seen not only as an engine for development but also in terms of creation of employment. Indeed, creation of employment is one of the measures of a growing economy and use of AT guarantees more job creation. Lastly, it is said that AT requires intervention of public planning to flourish versus the "hidden hand" (Adam Smith) of the market forces. Whereas that may be true in the introductory stages of the technology, the market would take up the technology once it understands it well, removing the need for government interventions.

Another criticism of AT implies that physical resource constraints make AT impracticable. That for efficient exploitation of scarce resources, high technology is more appropriate than AT since it is deemed to be low on wastage and high in output. This is premised on the thinking that appropriate technologies are neither modern nor efficient in their use of resources, which is erroneous

On the cultural front, the AT movement is seen as replete with anti-technology sentiments. This is because of mix-up on AT ideology to mean alternative technology or anti-technology. AT however, is in the line of modern technology available to a great part of the populace for various applications i.e. technology in the hands of the many. It is also thought that AT is a passing fad rather than a serious or enduring phenomenon. This is attributable to the bandwagon appeal of the movement and some fringe members rather than the mainstream proponents. Others have said that AT represents inferior (or 'second-rate') technology compared to the modern technology of urban industrialized societies. Indeed, inferior technology cannot be 'appropriate' so this argument is invalid. AT essentially meant to be available to the masses and easy to operate. Equally it is said that AT does not require the cultivation of significant scientific and technical skills and that it therefore defeats its own purpose by failing to act as a stimulus for local skill in technological innovation. However, the experience of practitioners has revealed that considerable sophistication is frequently required in the design, development, dissemination and initial deployment stages to produce a technology which exhibits simplicity in its form and operation. Small does not mean lack of innovation.

On the social front, AT is labeled as a social concept rather than a concept about technology. The social dimension implies that social changes are required as a prerequisite to its effective dissemination and that such changes are impracticable. Further, Appropriate Technology is said to embody a social vision which is neither attractive nor commendable. It has been however shown that technology cannot be

socially neutral, a fact that AT does not hesitate to address. AT does not require social revolution but social evolution to better perception of technology.

On the intellectual front, Appropriate Technology is seen as a mixture of incomplete and sometimes incompatible ideas, combined with a collection of ambiguous symbols and poorly defined terms - and hence that it is not a coherent concept. The validity of this statement has its foundations in lack of a concise definition of what comprises AT. Furthermore, some critics imply that there is nothing novel about AT; they charge that many appropriate technologies may be identified which have come about independently of the social movement and without evoking the label "appropriate technology". It can be argued that the existence of appropriate technologies without the social movement proves the need for AT rather than militating against it. Similar to cultural critics, some intellectual posit that AT is symptomatic of an inferior intellectual life because it is anti-science, anti-technology and anti-civilization. This is also based on misunderstanding as to what AT is rather than facts

Local or regional self-reliance runs throughout the Appropriate Technology movement and some people argue that the notion is either unrealistic or patently impossible. However, most advocates of AT make a distinction between absolute self-sufficiency, on one hand, and self-reliance as a general approach, on the other hand

It is factual that the various criteria for deciding the appropriateness of technology are often in tension with one another. For example, maximum use of renewable energy technology or maximum recycling of certain types of waste materials may require the use of highly complicated or expensive technology. It can be argued that trade-offs between principles or forces in tension with each other is not uncommon in technology, social life or in natural settings. Secondly, the existence of contradictory criteria for a given set of circumstances does not mean that innovation may not take place to resolve such contradictions (e.g., improvement in photovoltaic technology to make it more cost-

effective). The need for innovation of this type is part of the reason for existence of AT rather than the grounds for its abandonment.

According to Willoughby (1990) some of the political criticisms of AT include range from problems of dissemination: It is widely claimed, by both antagonists and protagonists, that despite the technical and economic feasibility of appropriate technologies they have been disseminated to only a limited extent. The political constraints to dissemination are listed as follows include narrow technicism in which case AT is often accused of being a narrowly technicist notion which ignores the social and political context of particular technologies. Critics often argue that the fundamental problems which motivate the Appropriate Technology movement are social and political problems rather than problems of technology. Firstly, some assume that technology is "neutral" and thus open to being deployed for either good or evil, violence or non-violence, etc., depending upon the intentions and interests of those people who use the technology. Thus the changes required (to achieve a more humanly or environmentally sound socio-economic system) are seen as "human" problems which have no bearing on the professional activities of engineers, technologists and others whose work bears directly on the design and production of technology. Secondly, some claim that technology is not neutral and that it always embodies the political and social conditions of the society in which it was spawned or in which it is deployed. Thus, the required changes of direction are seen as bearing upon the professional activities of technologists, but in the final analysis are "human" problems - or at least socio-political problems - and not technological problems. Criticisms from either of these two viewpoints are directed at Appropriate Technology implying that because the concept is vitally concerned with technology it is ipso facto flawed in terms of social and political theory. These arguments can be proven to be flawed. Other criticism from the same source include technological determinism and: dependency, inequality and vested interests

2.7 Reasons Given for or Against Adoption of Appropriate Technology

The secondary data on the adoption of ABMT from KNBS and Ministry of Land, Housing and Urban Development (2013) indicates the following in terms of prevalence as reasons for adoption: more economical in the long run – 31.0 % of BEPs, environment friendly – 29.0 %, maximise on use of available natural resources – 24.0%, less time for construction – 11.0%, use of traditional ways [methods] of construction – 4.0 %, other reasons – less than 1%. These reasons given by professionals in the industry for adoption of ABMT during previous surveys are a pointer to the problem being tackled in this research project.

The same secondary data regarding reluctance to adopt ABMT in Kenya published in the Kenya National Housing Survey of 2012 / 2013, the following factors were rated as adversely affecting adoption of ABMT in Kenya (from the viewpoint of BEPs who do not support use of the materials & technology): not readily accepted by the clients – 25.0% of the professionals, not supported by laws (legislation) – 15.9%, expensive – 13.6%, do not understand the technology – 11.4%, materials not durable – 9.1%, challenges in maintenance – 9.1%, other reasons – 9.1% and; other building parts not available – 6.8%

Apart from the built environment professionals, it is necessary to get the viewpoints of other stakeholders regarding the adoption of ABMT in the Kenyan context, which is the purpose of this project. These statistics provide useful insights which will either be corroborated or repudiated in the findings

2.8 General Critique of the Literature on AT and CSEB

There seems to be very varied views from writers concerning AT with a number of convergences and divergences. Appropriate Technology when seen as a movement, more like the non-aligned movement that came up in the cold-war era, has been declared by some including Polak (2000) to be ‘extinct’. What cannot be wished away is the fact that there are success stories and cases of dismal performance in various countries both the highly developed and the lowly developed ones.

There appears to be convergence on what Appropriate Technology connotes but the wording of definitions differs; thus the decision to use specific and general characterization to define the technology.

Most literature on the subject of AT seem to presume that it is a generally acceptable and environmentally sound solution to various fields and especially in energy and construction sectors. What many of the authors fail to address is that any technology that is appropriate tends to strike the right cord with the beneficiaries. For example, mobile telephony, which until the year 2000 was almost unknown in Africa, has in the last decade caught up quite well and grown exponentially in the continent. This researcher contends that there are lessons in the other forms of technology that AT has to learn from to become universally acceptable as being ‘innovative’.

2.8 Research Gaps

In this research paper, the researcher provides an overview of previous research on AT and in particular as refers to CSEB. The latest research of AT practices in construction, while they seem to address the technological issues concerning AT, are inadequate on the sociological and psychological aspects that this technology has to grapple with. The

literature shows a great variety of factors pertaining to the adoption of the technology. From the reading, it does not seem obvious who should be held responsible for unlocking the untapped potential of CSEB and exactly what interventions need to be put in place. Based on this review, it is evident that there is need to carry out a study to establish the prevalent factors working against adoption of AT in the Kenyan building industry context so as to propose concrete steps towards adoption of this technology on a large scale. This is pertinent given that as per Kenya Population and Housing Census of 2009, CSEB as a walling material is mentioned and this research presumes as being classified within the 1.9 % 'other' walling materials. It still occupies a very insignificant place amongst the walling materials which calls for concise explanations and solutions

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Introduction

This chapter explains the methods, tools and techniques that were applied in this study including their procedures and their bases or rationale. The methods are based on a conceptual framework that has been derived from Chapter Two (Literature Review) that reviewed the existing literature and established the theoretical grounding for the research.

Among the issues relevant to research objectives that were interrogated are strength, durability and aesthetic characteristics of the material (CSEB) in the Kenyan context. This pertains to the technical characteristics of CSEB. The research also sought trends and patterns of growth in the use of CSEB in the recent years to determine whether there has been growth, stagnation or decline in the use of AT and CSEB in particular: this was correlated with the growth in the population of potential users. Awareness of appropriate technology in general and CSEB in particular among the cross-section of those sampled was also investigated.

Perceptions regarding the material was also sought from the sample population. This addresses the question of whether the users view it as a material with a potential for use or not. The association of CSEB and AT with poverty and backwardness as opposed to the sound technological solutions was also interrogated.

For this purpose, the study has relied heavily upon analysis of existing documentation concerning the material, expert knowledge on trends in technological innovations in housing solutions and feedback from end users of the material who shed light as to its

worth as a construction material or otherwise. This has refined ideas about the study and gave focus for details to be sought in the field.

This chapter adopted the following structure: Research Design, Target Population, Sampling Techniques, Data Collection Techniques and Analysis that were followed in the research process.

3.2 Research Design

Research design refers to the way the study is designed and the methods used to carry out the research (Kothari, 2004). The research design defines the overall strategy taken to integrate the components of the research and a logical and coherent manner, thereby addressing the research problem. It sets out how data will be collected, measured and analysed

The researcher took the mixed-method research method as propagated by Teshakori and Creswell (2007). This is informed by the research problem having the real-life contextual understanding, multi-level and cultural influences. In addition, quantitative data on magnitude and frequency of factors was needed but qualitative explanations to these factors were required. Thirdly, to get a holistic picture on CSEB, there was need to draw on the strengths of both the qualitative and quantitative data collection techniques to bring about new understanding on AT or give new solutions for implementing the technology

The research design enables complementarities between numeric data and narrative and non-text data. It also enables use of existing data to reach new or more advanced conclusions than those previously postulated. It also allows more tools and flexibility in the hands of the researcher to tackle the research problem at hand. The weaknesses in one

research method is also overcome using the strengths in another. Data triangulation is possible and this provides a clear basis for reaching conclusions. The multiplicity of methods also leads more insights on the research problem than would be the case if a single method was used.

3.3 Scope of the Research

The general area of study is construction materials and technology. Classified amongst construction technologies is Appropriate Technology. The researcher decided to limit himself to the CSEB technology because based on understanding gained from the literature review; CSEB is an adequate representation of ABMT. Products of Appropriate AT may be many, but the motivation and processes are similar, hence the challenges in adoption of any subset of the technologies can be generalized for AT.

The study was confined to the Nairobi Metropolitan Region because it has been the hub for development of the material and there are many examples of application of the materials. The city being cosmopolitan, it was also possible to interview users of the materials who may have applied them from various parts of Kenya. Time constraints on the researcher were also taken into account.

3.4 Target Population

Population is the total group of subjects that meet the designated set of criteria, according to Polit and Hungler (1999). They also distinguish between the target population and the accessible population. The target population includes all the cases about which the researcher would like to make generalization. The accessible population comprises all the cases that conform to the designated criteria and are accessible to the researcher as a pool of subjects for a study

Hence target population in statistics, is the specific population about which information is desired. According to Mugenda (2003), a population is a well – defined or set of people, services, elements, events, group of things or households that are being investigated. This definition ensures that population of interest is homogeneous. Population studies are more representative because everyone has equal chance to be included in the final sample that is drawn according to Mugenda and Mugenda (2003). Construction is a project based industry which involves all project participants such as clients, designers, contractors, constructors, and consultant. Nairobi Metropolitan Region was chosen because it is the greatest consumer of construction materials and has a large population housed in shelters that are targeted for improvement by provision of low cost housing, which could easily benefit by use of AT. The populations that were considered in this research are: registered professionals, registered contractors, manufacturers of products related to CSEB, developers that have used AT and the body of expertise on AT/ABMT

3.5 Sampling

Sampling is the process of selecting a portion of the population to represent the entire population (polit and hungler 1999;714). Exploratory design according to wood and brick (1998;320) calls for small samples that are chosen through a deliberate process to represent the desired population

3.5.1 Sampling techniques

This refers to the method used at getting the sample for purpose of the study. In Simple Random Sampling a simple random sample (SRS) of size n is produced by a scheme which ensures that each subgroup of the population of size n has an equal probability of being chosen as the sample. In Stratified Random Sampling the population is divided into

"strata". There can be any number of these. Then choose a simple random sample from each stratum. Combine those into the overall sample. That is a stratified random sample. i.e. choosing from various array of affordable materials primarily compressed stabilized earth blocks

Various stakeholders were sampled to achieve objectives of this research. First, the promoters of the building material to give insight into what has been done to bring the material to public limelight. Since there are few, the purposive sampling method was used to arrive at those giving out the information. Secondly, the manufacturers and suppliers of CSEB could give insight into the consumption of the material and its progression over a period of time thus to justify or nullify the notion regarding slow adoption of the said technology

The educators, who have the influence of producing the specifiers were also purposively sampled given that they are not many institutions offering such education. The specifiers of building materials were sampled to give an insight into their awareness and understanding of the material under study. This population is fairly large given the number of professionals that could influence the usage of the materials. To get a representative population, the researcher looked at the professional registration bodies, regulators and associations. These have registered professionals of all ages, race, gender and other demographic characteristics

The end users of the products i.e. those that have built using CSEB were sought to give insight into any shortcomings noted of the material that may or may not be in the domain of the technical literature from the promoters. Here the simple random sampling technique was employed but over a small area due to the limitation of time for this study. References were sought for such

3.6 Data Collection

The data targeted for collection including total housing stock developed using the material under study and its growth over a predetermined 10 year interval (specifically the comparison of 1999 and 2009 when there were housing censuses). This is compared to the growth in total housing stock over the same period determined by the census results

Variety of modules of the material available in the market (length, width and height), shapes, patterns and textures was also studied. Production rates of CSEB at various documented ABMT centres in Kenya was also sought. The research also sought local and national statistics on the same on a month-by-month basis comparing between a start year and an end year

Percentage of various stakeholders willing and able to use the material in question was also an issue for interrogation. Specifically, the research also sought professionals' attitudes and understanding of the material in terms of how many are specifying it, especially in the government agencies concerned with low-cost housing. Attitudes of developers and end users who stay in completed houses developed using CSEB. The research also interrogated specific interventions by government or related institutions to promote the use of ABMT

3.7 Methods of Data Collection

The methods used in the collection of data for the study are described by Mugenda (1999). They have been chosen depending on relevance to the type of data required to build a complete picture of what the research intends to unearth. They include:-

3.6.1 Case studies

This involved a detailed description and analysis of an individual subjects gathered from a variety of sources which includes interviews, observations and other already documented sources.

The researcher analysed selected low-cost housings that have adopted the use of the CSEB with a view of understanding in-depth motivations for using the material as well as challenges encountered. Whereas case studies may not serve for generalization, they serve as pointers to what could be pertinent issues of the subject of study. Three buildings that have adopted use of CSEB were chosen on the basis of variety of information that could be obtained due to their diversity of location and soils. The analysis of the case studies helped to establish features common to all, differing but overlapping features, and features unique to a particular case study

3.6.2 Observation

This study entails direct observation of the physical environment where primarily data collection tools are applied. Observation can yield information which people are normally unwilling or unable to provide. This method of data collection was useful in documenting existing projects that have adopted the use of CSEB. Observations were made at points of production of the materials, construction sites where CSEB was in use, completed buildings that had wholly or partially utilized the materials and promotion centres for the technology and materials.

Methods include active participant observation, passive participant observation or non-participant observation. All had their place in this study depending on how they affected the validity and reliability of the data to be collected. The author observed processes of manufacture as non-participant observer

3.6.3 Study of photographs and annotated diagrams

Photographs and annotated diagrams were used in reviewing and documenting both the local and international case studies. These are basically secondary data that were analyzed or manipulated to produce primary qualitative data for use in this study.

3.6.4 Secondary Data Sources

Literature is a source of secondary data that the researcher can manipulate to produce primary sources or use directly for analysis and interpretation. Review of appropriate literature containing the required statistics from the government agencies and any other institutions such as UN-HABITAT, HRDU.

3.6.4 Interviews

Interviews with key informants from HRDU, UN-HABITAT, Ministry of Housing, Joint Building Council, regulators of the building industry among others served as additional sources of information as to what underlies the slow adoption of CSEB. The interviews can be structured or non-structured depending on the purpose of the study. In this case, the study demanded a structured type to be able to assess various factors while at the same time leaving room for the informants to provide additional or new information. (interview guide?)

3.6.5 Use of Questionnaires:

By carrying out detailed questionnaires to both the building owners and the construction experts, the questionnaires carry pertinent issues, informs of questions for the researcher to deduce facts on the causes of either slow adoption of the material or the reverse

Questionnaires to professionals, contractors, potential clients and end users to determine their knowledge and attitude of the material in question. The questionnaires had to be administered in cases where issues of literacy were noted, but in any case care had to be

taken to ensure that the questions asked are framed in a language that the subjects of interview were familiar with

The questionnaires were targeted at three levels of stakeholders who are in direct contact with the materials: the professionals, builders and developers. The regulators were left out of questionnaires since their inputs are covered by other methods.

3.6.6 Use of Tests

Tests could also be conducted on structures made of ABMT in particular the CSEB, these tests are carried out to better understand the suitability of the material in different weather conditions and how the factors such as age, temperature and humidity affect the material in question. Tests could also be carried out inside the factories where these materials are manufactured. Lab tests could also be administered to get their chemical composition of various soils and raw materials.

3.6.7 Methods of data collection chosen

The methods of data collection that were found to be more helpful included;

Observation: This is a direct viewing and recording of a given fact, for my research, observation was paramount in obtaining observable facts e.g. the physical aesthetics of structures made of the CSEB.

Questionnaires: Administration of questions set to either the construction experts, owners of the buildings that have adopted the ABMT in their construction and the manufacturers. Provided crucial information and input to the research process. Ministry of housing for instance answered crucial questions in research.

Review of Secondary Sources: By going through the journals, newsletters, books and magazines secondary data was collected, compiled, analyzed and reported for the research to get its bases.

Study of photographs and annotated diagrams: During observation phase of the research, photographs were taken and annotated diagrams made this helped in the research by providing pictorial evidences and pictures for the research to base its arguments upon.

3.7 Data collection instruments

Data collection instruments are related to the method and type of data to be collected. For example to collect dimensions (L,B,H) of CSEB, the method would be by direct observation and measurement. The tools required is a measuring tape of with a given error margin. Among the instruments incorporated in the research study are: research permits, checklists, writing materials, electronic devices including computers, data storage devices such as flash disks dvds and cds, scanner, printer and photocopy, and laboratory for exhibits experiments

3.8 Data Analysis and Interpretation

Data analysis refers to a process which entails an effort to formally identify theme and to construct hypothesis, as they are suggested by data and an attempt to demonstrate support for those themes and hypothesis (Bogdan and Taylor 1975)

Data analysis in quantitative research begins when data collection commences Streubert and carpenter (1999;28), in addition to the analysis that occurs thought this period, a protected period of emersion occurs at the conclusion of data collection.

It must be noted at this juncture that both qualitative and quantitative types of data are collected in this study. Though the research is primarily quantitative (i.e. enumerating

factors), it is notable that some qualitative data is needed to explain and argue various viewpoints taken by the researcher in order to come to scientifically acceptable conclusions. Though data analysis is the subject matter of the next chapter, the following are some of the common methods of data analysis:-

3.8.1 Comparative technique

This method involves a subjective and qualitative evaluation of data gathered through photography, sketches, annotated diagrams, and library and internet research

3.8.2 Graphs and charts

This method involved an objective and quantitative analysis of the data gathered

Results obtained were treated as follows:

- The implications of the findings, test of validity
- ANNOVA, Chi-square and similar forms of analysis were undertaken

CHAPTER FOUR

4.0 DATA COLLECTION, ANALYSIS, AND DISCUSSION OF RESULTS

4.1 Introduction

This chapter presents the findings that were arrived at using the tools and techniques devised in the Chapter Three and their applicability in meeting the objectives of the research project. The chapter carries the results of the data analysis. The various categories of data was collected and then processed in response to the problems posed in Chapter 1 of this research project.

Moreover, the chapter sets out to present data and discuss the findings of the study as revealed by the content of the respondents' data. As highlighted in earlier chapters, the study was based on the evaluation of performance of Appropriate Building Materials and Technology, specifically the promotion of use of CSEB in Kenya. In an attempt to address the research theme, three sets of interviewees were involved namely; the key informants, the professionals in the building industry and the end users of the CSEB as a material of choice.

The study was conducted mainly through personal interviews, photography, observations of ABMTs processes and products, administration of questionnaires, literature review and the study of materials collected from reliable internet websites. Laboratory tests to evaluate the strength of the material in question were carried out to cross-check some of the data given from the field.



Figure 13, Ministry of Housing Machakos County;

Source: (Author)



Figure 14, CSEB storage

The respondents' data and findings from the field formed the basis of the presentation and discussions offered in this chapter.

Two types of questionnaires were administered, and key informant interviews conducted. The responses were collated and categorized into five major points to be analyzed. These main points gave much weight on the insight into the material under investigation. These indicators formulated were:-

First, sources of information to the public and the users of the material in question. The key responsibility of information dissemination concerning the CSEB is one of the aspects interrogated in this research project

Secondly, the scope of the level of awareness to the target group for the material as well as the general public

Third, general levels of performance of the material as perceived by either the end users or the manufacturers of the material. There are areas the targeted group felt that the material needed some improvement

Fourth, the cost comparison with the other so called the 'conventional' building materials

Fifth was the category of clients and end users fit to use the material

Information for the research was collected in the following categories of respondents:-

First, building industry professionals e.g. Architects and engineers. Their lists were obtained from their key respective bodies. They are also referred to as built environment professionals (BEP's)

Second, other construction experts/professionals and the product end users including contractors and the general public.

Third, experts with information regarding the material: by interviewing key informants within the construction industry including Ministry of Land, Housing and Urban Development and the UN-HABITAT. Also, manufacturers of machinery or the CSEB materials, such as Makiga Engineering were contacted to give insights in specific areas of the study.

Fourth, where local authorities had the data, information was gathered on statistics of approvals from approving authorities within the larger Nairobi metropolitan region, on the adoption of the material for walling purpose. (within a period not less than 10yrs span)

4.2 Response Rate

Questionnaires were subjected to the intended and targeted groups to whom were sampled out in order for each group to be represented. The sampling included both the professionals in the building industry and to the lowest level of the craftsmen.

4.2.1 Area of specialization in the construction industry profession

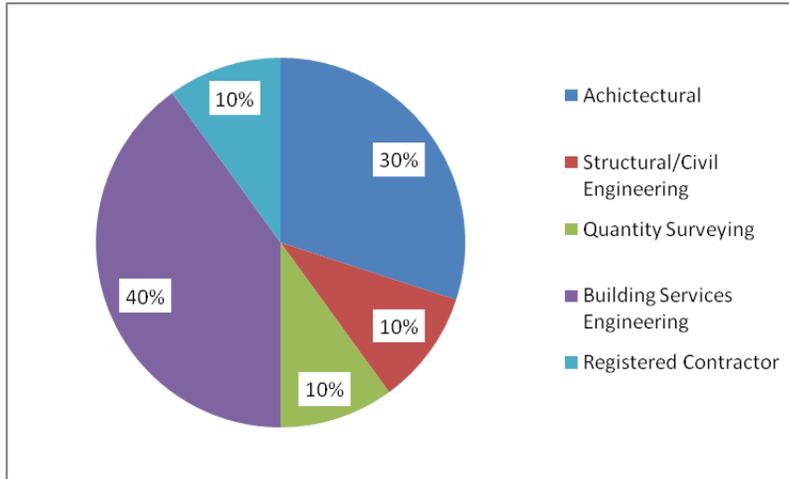


Figure 15: Area of specialization of respondents

According to findings in Figure 15, 40% of respondents were in building services engineering, 30% were in architecture, 10% were structural/civil engineers, quantity surveyors and registered contractors

4.2.2 Highest level of education

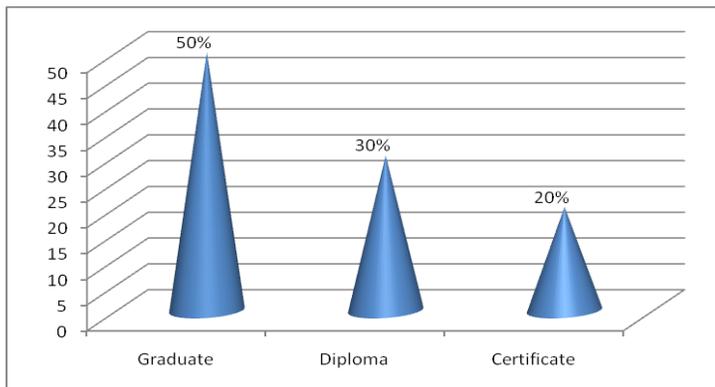


Figure 16: Level of education

From findings in Figure 16, 50% of the respondents were graduates, 30% were diploma holders while 20% were certificate holders.

Respondents organization

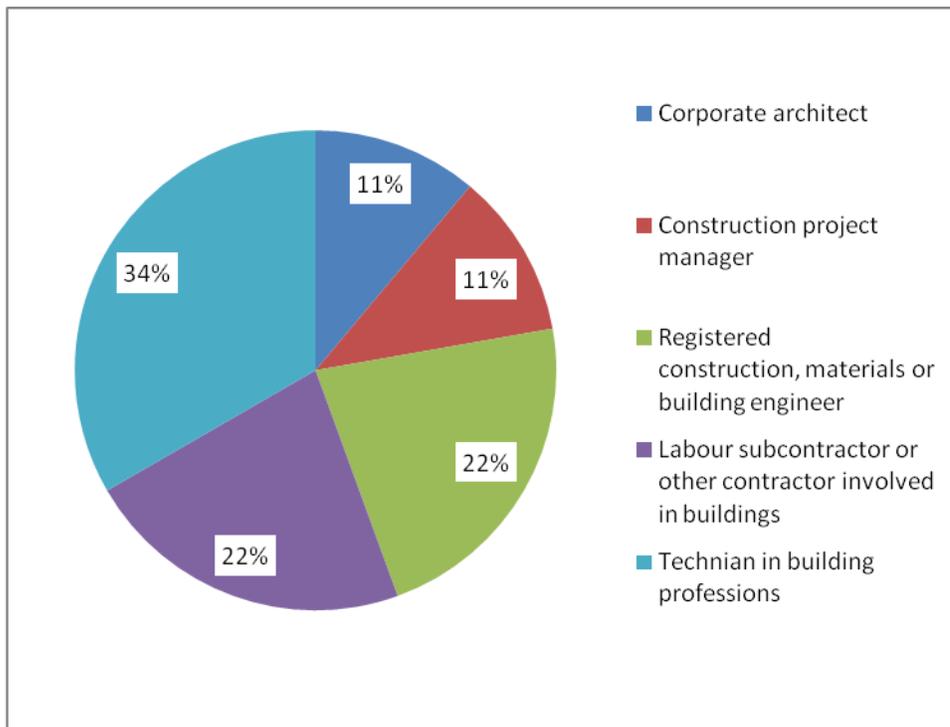


Figure 17: Respondents organization

According to findings in Figure 17; majority of the respondents were Technical in building professions and an equal percentage 22% were registered construction, materials or building engineers and labor sub contractor involved in buildings. An equal 11% were construction project manager and corporate architects.

4.3 Reliability Analysis

This portion of the work was done using the Relative Important Index (RII). The RII is explained in Enshassi et al (2008, 2007) and Holt (2014). The RII values range from 0.2 to 1.0 and at the values are assigned using the following on the Likert scale:

Table 2: Response scales used in data measurement

Item	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Scale	1	2	3	4	5
Item	Never	Rarely	Sometimes	Often	Always
Scale	1	2	3	4	5

The formula for deriving RII for each factor is given as follows:-

$$RII = \frac{\sum w}{AN} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5N}$$

where w the weighting given to each factor by the respondent, ranging from 1 to 5; n_5 number of respondents selecting total strongly agree or always; n_4 number of respondents selecting agree or often; n_3 number of respondents selecting neutral or sometimes; n_2 number of respondents selecting disagree or rarely; n_1 number of respondents selecting total strongly disagree or never; and N the total number of respondents.

According to Patton (1990) value of 0.70 is an acceptable reliability coefficient and this has been adopted in this research.

The responses from the professionals on specific factors derived from literature and subjected to interrogation were analysed using the RII to gauge their importance. They were ranked based on the indices arrived at using the designated formula

The original 37 factors derived from literature review and part of the interviews conducted at early stages of the research project were subjected to interrogation in the questionnaires devised by the author. It should be noted that some of the factors were positive while others were negative. After subjecting them to the RII, they were arranged in order of importance depending on the RII score. An interesting picture emerges of the factors when sorted using the RII.

Table 3: Table showing RII for each of the 37 factors investigated

No.	Description	Agree	Disagree	No opinion	Rating of agreement / disagreement (tick the applicable box)					Total	RII
					1	2	3	4	5		
1	Provide comfort through a good balance of temperature, humidity and noise control	4	4	1	0	0	1	3	5	9	0.889
2	Easy to work with since simple tools and minimal skills are required	8	1	0	0	0	0	7	2	9	0.844
3	Lack of courses in appropriate technology in universities and other institutions of higher learning	3	5	1	0	0	1	6	2	9	0.822
4	Climatic conditions in some localities or seasons do not allow for sun-drying of CSEB thus hindering its manufacture	9	0	0	0	0	2	4	3	9	0.822
5	CSEB manufacture a source of employment in the immediate neighbourhood	9	0	0	0	0	3	2	4	9	0.822
6	Soil is available in large quantities locally	8	1	0	0	0	3	2	4	9	0.822
7	The material is associated with poverty or lower classes of society	7	1	1	0	0	4	1	4	9	0.800
8	Inappropriate soil conditions in some regions rendering CSEB inapplicable	8	0	1	0	1	1	4	3	9	0.800
9	Use of CSEB considerably reduces cost of walling	8	1	0	0	0	2	5	2	9	0.800
10	CSEB production is 80-90% less in use of energy compared to most other walling materials	4	3	2	0	0	2	5	2	9	0.800
11	Strong in compression and its tensile & shear strength can easily be increased through additives	5	1	3	0	0	4	1	4	9	0.800
12	Material is appropriate for the tropical climate experienced in Kenya	5	4	0	0	0	3	3	3	9	0.800
13	CSEB can be used at both interior and exterior walling in various climatic conditions	6	2	1	0	0	2	5	2	9	0.800
14	CSEB does not need secondary industrial transformation since only a compress is needed	7	2	0	0	0	2	5	2	9	0.800
15	More time and labour compared to 'conventional' materials since CSEB has to be made at or near site.	8	1	0	0	1	1	5	2	9	0.778
16	Allows for participation by end users and communities	7	2	0	0	0	3	4	2	9	0.778
17	Low technical performance of CSEB as a walling material	2	7	0	0	0	4	3	2	9	0.756
18	Less respiratory illnesses in buildings constructed using CSEB hence better health	5	3	1	1	0	2	3	3	9	0.756

19	The thickness of CSEB used for walling of houses provides a sense of security to occupants	3	6	0	0	1	2	4	2	9	0.756
20	Since CSEB can use the same moulds used for fired bricks, there is little investment required for new plant and processes	3	3	3	1	0	2	3	3	9	0.756
21	Since CSEB is produced locally, there is no transport cost for the bulk material – only stabilisers need transport	6	3	0	1	0	2	3	3	9	0.756
22	CSEB has excellent fire resistance qualities	8	0	1	0	1	3	2	3	9	0.756
23	CSEB presents less opportunity for the entrepreneur for large profit margins compared to other available walling options	2	2	5	0	1	4	1	3	9	0.733
24	Lack of building codes and policies that allow or promote use of CSEB	5	3	1	0	0	3	6	0	9	0.733
25	Promotion of CSEB as walling material for poor communities by donors sends wrong signals in the market	8	1	0	0	0	4	4	1	9	0.733
26	Houses built with CSEB are cool in the hot season and warm in the cold season due to low thermal conductivity	8	1	0	1	0	2	4	2	9	0.733
27	By allowing building to ‘breath’, CSEB ensures less interior pollution by 5-7 times compared to other materials	2	6	1	0	1	4	1	3	9	0.733
28	CSEB allows for a variety of external and internal finishes and can in itself be a facing	5	2	2	0	1	3	3	2	9	0.733
29	The material is seen as a step backward towards primitive and unhygienic buildings that are difficult to clean	7	2	0	0	1	3	4	1	9	0.711
30	Technology to manufacture CSEB is not readily available	7	2	0	0	1	3	4	1	9	0.711
31	Savings when one utilises CSEB are not significant when compared to other ‘conventional’ materials	2	4	3	0	2	3	1	3	9	0.711
32	With minimal guidance, architects and other building experts can easily incorporate CSEB into current projects	1	1	7	0	1	3	4	1	9	0.711
33	Lack of examples of good quality buildings put up using CSEB	3	5	1	1	0	4	2	2	9	0.689
34	Lack of funding to promote appropriate technology nationwide in Kenya	7	1	1	1	0	4	2	2	9	0.689
35	Professionals make less money when they specify CSEB as their payments are on percentage basis	4	4	1	2	0	1	5	1	9	0.667
36	Lack of knowledge, skills and understanding pertaining to CSEB by professionals, government, donors and users	9	0	0	0	2	5	0	2	9	0.644
37	Lack of policy minimising energy-intensive materials like burnt clay bricks, concrete and steel for housing projects.	9	0	0	0	4	2	0	3	9	0.644

4.4 General Findings Regarding the CSEB in Kenya

4.4.1 Material and Technologies in Use

The study revealed the existence of a number of Appropriate Building Materials and technologies that have been used over time. Some of these materials are provided in Table 4 and include; Interlocking Stabilized Soil Blocks, Stabilized Soil Blocks, Fibre Concrete Roofing Tiles, Micro-Concrete Roofing Tiles, Prefabricated Panels, Tevi Tiles among others.

It is noted that Stabilized soil blocks have been used mostly with response given at 73.3%. This was followed by Interlocking Stabilized Soil Blocks at 40%.

Table 4: Range of Appropriate Materials as per Respondents

SN	Material/Technology	Frequency	Percent	Percent of cases
1	ISSBs	12	24.0	40.0
2	SSBs	22	44.0	73.3
3	FCRs	8	16.0	26.7
4	Micro-concrete roofing tiles	1	2.0	3.3
5	Prefabricated panels	3	6.0	10.0
6	Tevi tiles	4	8.0	13.3
	Total	50	100.0	166.7

According to the information obtained from interviews with the key informants in the ministry dealing with housing most of them gave a list of other walling materials in use alongside the CSEB. From the list of materials it is possible to arrange in descending order from mostly used to the least used ones. The table below shows the preference in choice of the materials for walling:-

Table 5: Range of Materials for Walling Solutions as per Respondents

SN	Commonly used materials	Responses		Percent of Cases
		N	Percent	
1	Hydraform-ISSBs	11	6.9%	19.3%
2	Quarry Stone	37	23.1%	64.9%
3	Bricks	53	33.1%	93.0%
4	Concrete Blocks	20	12.5%	35.1%
5	Timber	20	12.5%	35.1%
6	Mud	18	11.3%	31.6%
7	Iron-Sheets/ Tins	1	.6%	1.8%
	Total	160	100.0%	280.7%

The response rate in Table 5 shows that the use of Quarry Stones and Fired/Burnt Bricks are common in housing delivery in Nairobi County and this stood at 56.2 per cent. The exploitation and use of the two materials poses some harmful effects to the environment. In particular, burnt bricks consume forests and increase carbon foot print: methods should be devised to manufacture bricks in a sustainable way within the area. There should also be concerted efforts to sensitize the residents on the adoption of alternative building materials including the ISSBs and other forms of SSBs.

4.4.2 Sources of equipment / machines used in the making of the CSEB

The majority of the key informants in the ministry of housing had no knowledge of the sources of equipment used in the production of appropriate building materials and this stood at 63.3 per cent. On the other hand, about 26.7 per cent of the respondents indicated local design and assembly with another category at about 10 per cent indicating that they are being imported. This is depicted in Table 6

Table 6: Sources of Equipment for CSEB as per Respondents

SN	Source of Equipment	Frequency	Percent
1	Local design and assembly	8	26.7
2	Imported	3	10.0
3	Don't Know	19	63.3
	Total	30	100.0

4.4.3 Respondents that consider of using CSEB as a walling material

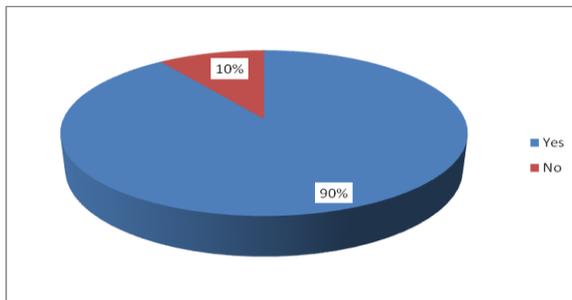


Figure 18: Possible use of CSEB as building materials

From findings in Figure 18, 90% of the respondents indicated they had considered using CSEB materials while 10% had not tried using CSEB materials.

4.4.4 Source of information concerning the CSEB

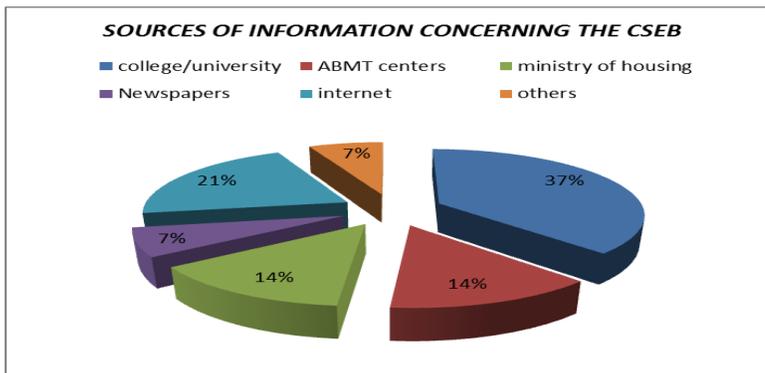


Figure 19: Source of information about the CSEB

According to the findings in Figure 19 above it was evident that institutions of higher learning, universities and colleges are the major sources of information concerning the CSEB, within Nairobi and the environs, contributing up to 37% of the information base. Therefore it can be said that most of the people with the knowledge concerning the material gained knowledge through institutions of higher learning. On the other hand, the newspaper and other sources of information such as apprenticeships are the least contributor with 7%, pointing to a possible unexploited avenue for reaching the masses by using the dailies since they are the mostly read by the people.

4.4.5 Level of understanding of respondents as pertains to CSEB

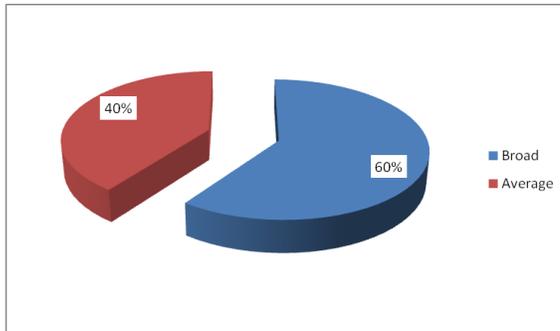


Figure 20: Level of understanding of CSEB

According to findings in Figure 20, 60% of the respondents had broad understanding about CSEB while 40% had average understanding of CSEB.

4.4.6 Level of awareness among general public

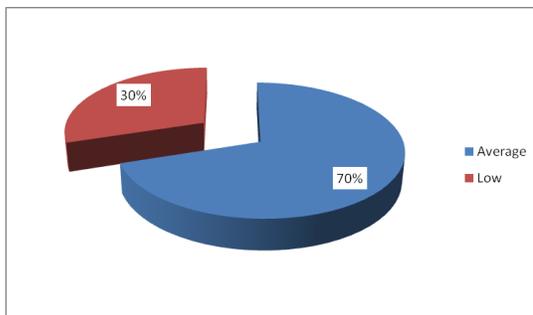


Figure 21: Level of awareness among general public

According to findings in Figure 21, majority of the respondent's 70% had average knowledge of the sources of the locally manufactured equipment for CSEB while 30% had low knowledge of regarding CSEB.

4.4.7 Frequency of using CSEB in the projects handled

Table 7: Frequency of using CSEB in the projects handled

No. of times	Frequency	Percent
On more than 10 projects	3	10.0
on 6-10 no of projects	6	20.0
on 2-5 no. of projects	15	50.0
Only on 1 project	3	10.0
None	3	10.0
Total	30	100.0

The study findings in Table 7, majority of the respondents 50% had used CSEB on 2-5 projects, 20% had used CSEB on 6-10 projects while an equal 10% used the CSEB on more than 10 projects, only one project and 10% did not use the CSEB.

4.4.8 Rating of achievement of expectations in sales of CSEB in relation to projections

Table 8: Rating of achievements

Rating	Frequency	Percent
Exceeded	3	11.1
Attained	15	55.6
Not attained	3	11.1
Far below expectations	3	11.1
Not applicable	3	11.1
Total	27	100.0

From findings in Table 8, 55.6% of the respondents indicated they have attained sales expectation in sales of CSEB in relation to their expectation, 11.1% indicated they have exceeded, 11.1% indicated that they have not attained their expectations, 11.1 indicated they are far below their sale expectations while 11.1% indicated they had no expectations.

4.4.9 Trend of demand for CSEB products

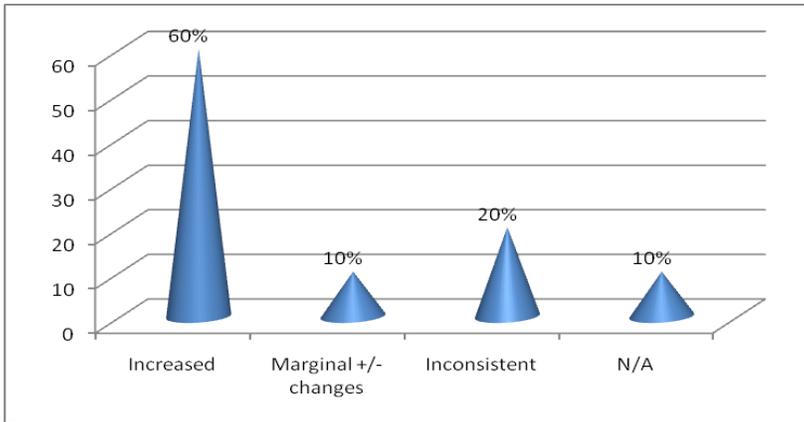


Figure 22: Rate of the trend of demand for CSEB product

From findings in Figure 22, majority of the respondents 60% indicated that the demand of CSEB products have increased, 20% indicated the demand is inconsistent while 10% indicated that their has been marginal positive or negative changes.

4.4.10 Satisfaction with the decision to use CSEB in building development

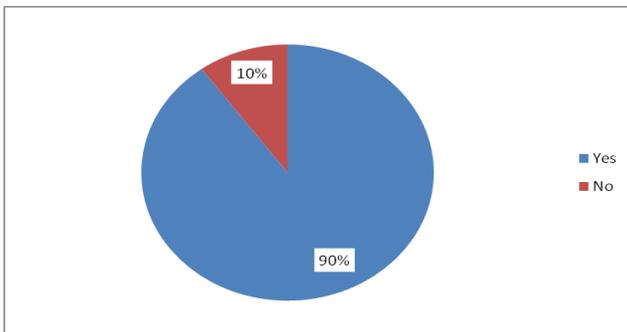
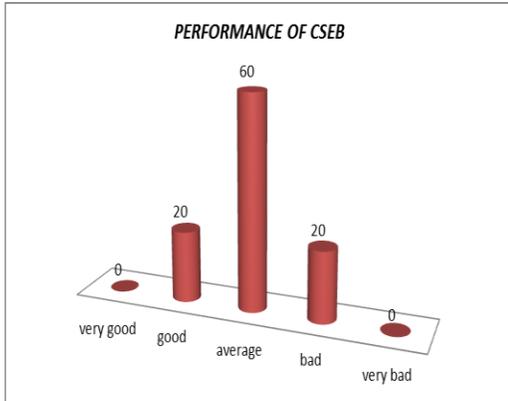


Figure 23: Respondents expressing satisfaction after choosing use of CSEB

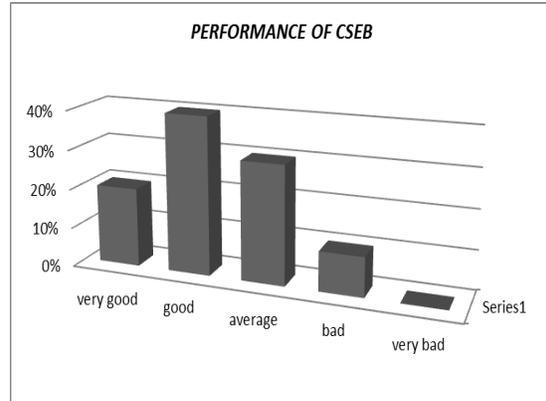
From the findings in Figure 23, 90% of the respondents indicated that they were happy with their decision to use CSEB in building development while 10% indicated they were unhappy with their decision to use CSEB in building development.

4.4.11 Respondents' Rating of CSEB performance



AESTHETICALLY

Figure 24: Rating of aesthetics



STRUCTURALLY

Figure 25: Rating of structural strength

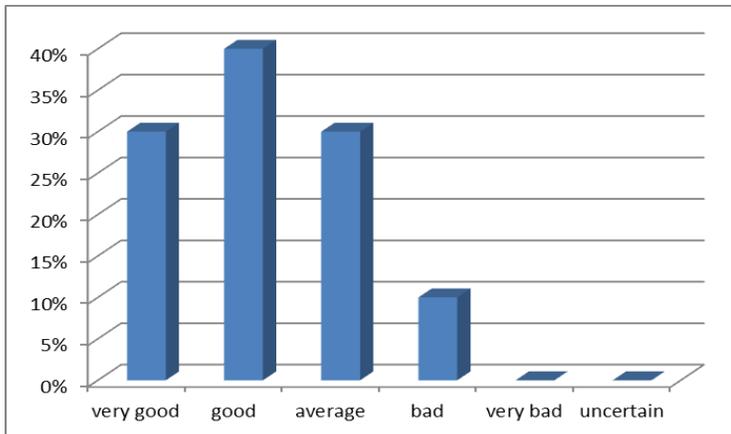


Figure 26: Rating of CSEB durability

According to the data collected most respondents indicated that the material in question i.e. CSEB, is averagely aesthetically appealing that is 60% in the scale of the graph indicator, and 20% of them felt that it's neither very bad nor very good aesthetically.

Such a response that does not seem to have a bias may point to the need to have framed the question differently, as aesthetics may be a loosely defined term for the respondents. On the structural aspect, 40% perceived CSEB as good and while ‘averagely good’ and ‘very good’ were at 20% but none (0%) indicated it to be very bad.

On durability, 35% of the interviewed felt that the structure made from CSEB has a good durability capacity while those who thought it have an excellent durability and average were 30% each. The technical aspects i.e. strength, aesthetics and durability are thus positively perceived and, according to this research may not hinder adoption of the technology.

4.4.12 Respondents’ rating of the economic viability of CSEB vis-à-vis other walling materials

Table 9 : Cost comparison between CSEB and other conventional materials

		NATURAL STONE	CONCRETE BLOCKS	CLAY BRICKS	INDUSTRIAL BRICKS	TIMBER WALL
CSEB	MORE COSTLY	80%	90%	20%	80%	20%
	LESS COSTLY	20%	10%	30%	10%	50%
	INSIGNIFICANT COST DIFFERENCE	0	0	40%	10%	10%
	UNABLE TO COMPARE COST	10%	0	10%	0	10%

When it came to comparison as shown in Table 8, 80% were of the opinion that natural stone and industrial bricks are both more costly relative to CSEB while 20% and 10% felt these materials are less costly respectively. This may point to the fact that CSEB as a material of construction is relatively cheaper as compared to the said conventional

building materials. On the other hand 90% of those sampled indicated that concrete blocks are more costly than CSEB as opposed to 10% who thought the inverse to be true

4.4.13 Respondents' rating on use of ABMT over the conventional technologies and materials in the industry

Table 10: Rating on use of ABMT

Rating of ABMT	Frequency	Percent
Superior	21	70.0
Same level	6	20.0
Unable to compare	3	10.0
Total	30	100.0

According to findings in Table 10, majority of the respondents 70% indicated ABMT were superior over the conventional technologies, 20% indicated the economic viability of ABMT is at the same level with materials built using conventional technologies, 10% were unable to compare the two forms of materials.

4.4.14 Perception of improvements that have occurred in CSEB

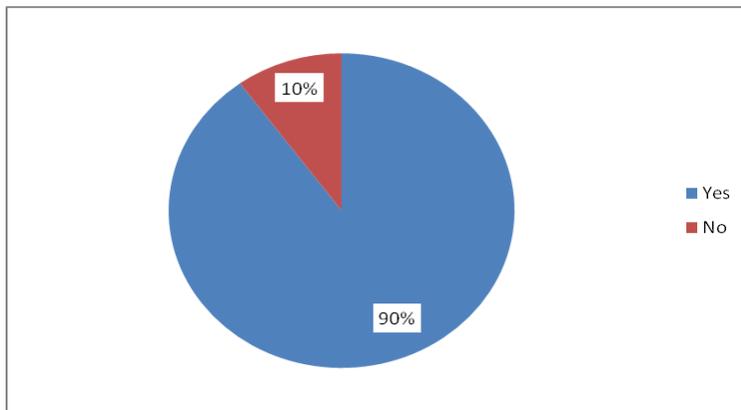


Figure 27: Perceived notable improvements of the product (CSEB)

According to findings in Figure 27, 90% of the users of CSEB products have noted improvements while 10% have not noted any improvement on CSEB products.

4.4.15 Aspects of CSEB perceived as needing improvements

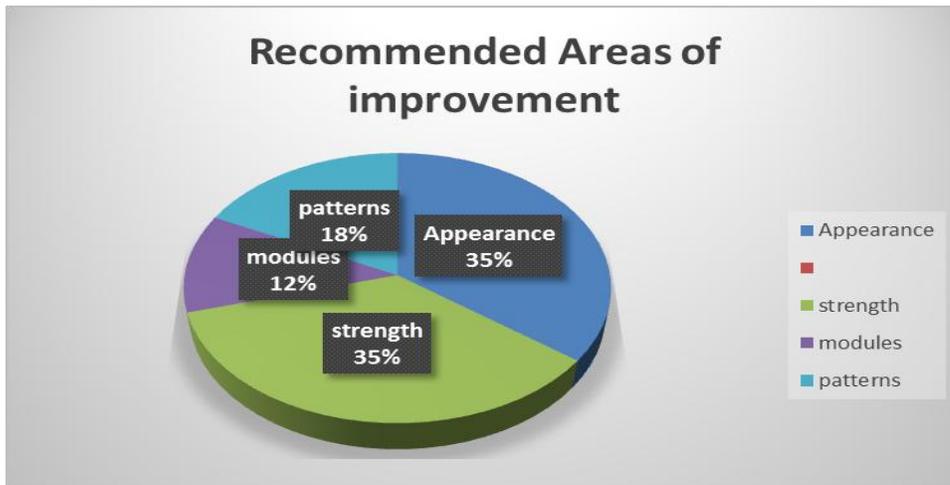


Figure 28: Recommendations on areas of improvement

As shown in Figure 28, the respondents were of the opinion that the CSEB needed improvement in the areas of appearance and strength each scoring 35.3% among the respondents. The need for module size and interlocking patterns improvements scored 11.8% and 17.6% improvement respectively, which could point to them not being a major area of concern relative to the other two factors

Table 11: Aspects that need improvements for the material

Aspects	Frequency	Percent
Appearance	9	30.0
Strength characteristics	15	50.0
Modules/size variety	3	10.0
Interlocking patterns	3	10.0
Total	30	100.0

According to study findings in Table 11, 50% of the respondents suggested that strength characteristics of the materials should be improved, 30% of the respondents felt that the appearance of the CSEB materials should be improved while 10% each were of the

opinion that improvements should be made on module/size variety and interlocking patterns

4.4.16 Rate of adoption of the materials by consumers

Table 12: Rate of adoption of the materials by consumers

Rate of adoption	Frequency	Valid Percent
Very fast	3	10.0
Fast	9	30.0
Average	6	20.0
Slow	6	20.0
very slow	6	20.0
Total	30	100.0

According to the findings in Table 12, 30% of respondents indicated that the adoption of CSEB materials by consumers is fast, while an equal 20% indicated the adoption is average, slow, and very slow. 10% indicated the adoption is very fast.

4.4.17 Respondents' Advice to developers to adopt CSEB as a walling material

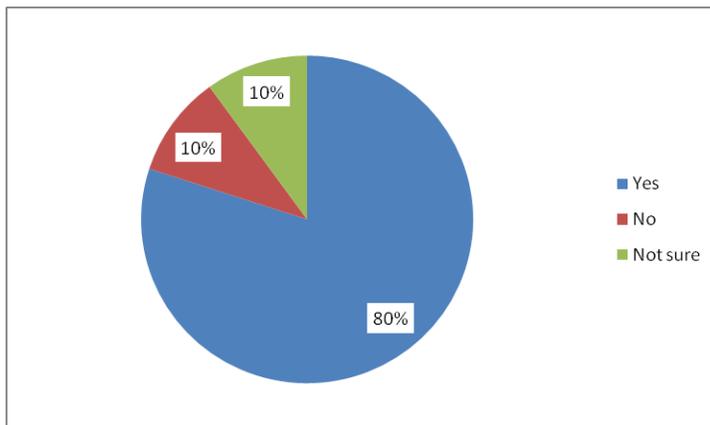


Figure 29: Advice on developers to adopt CSEB as a walling material

According to findings in Figure 29, majority of the respondents 80% can advise the developers to use CSEB materials, 10% indicated they would not advise the developers to use CSEB materials while 10% were not sure on advice to offer.

4.4.18 Perceived Possibility of CSEB replacing other walling materials

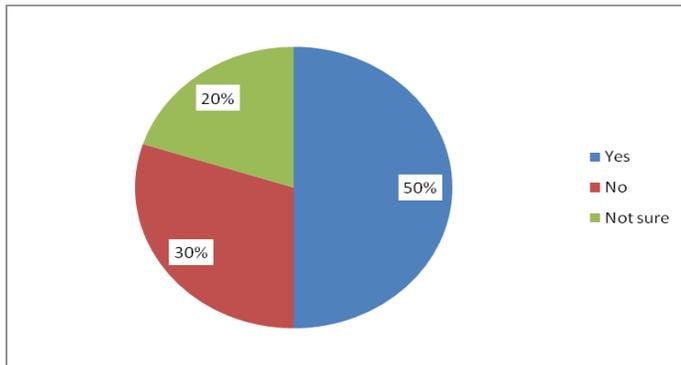


Figure 30: Possibility of CSEB replacing other walling materials

According to findings in Figure 30, 50% of the respondents indicated that there is a possibility of CSEB material replacing normal walling materials. 30% indicated there is no possibility while 20% were not sure.

4.4.19 Perception on type of Clients recommended to adopt CSEB as walling material

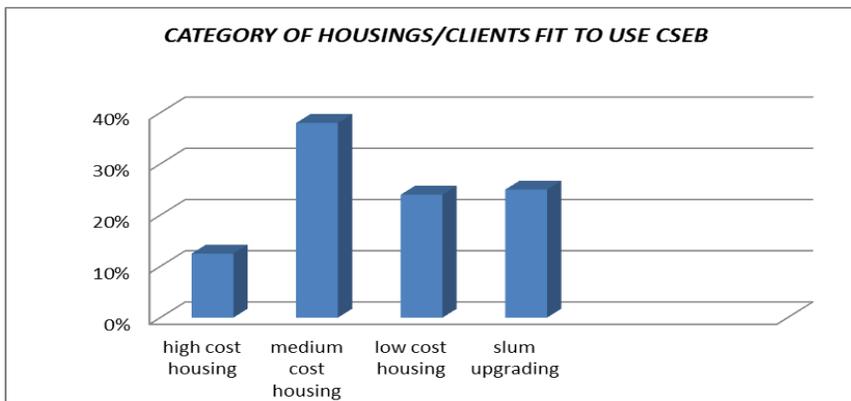


Figure 31: Respondents Perception of Target Users of CSEB (source author)

According to the statistics on the Figure 31, it was established that the material in research is deemed to be fit to be used by the medium cost housing at 38%, followed by the slum upgrading projects and low cost housing with a percentage of about 25%. There

was a low number deeming it fit for high cost housing but nonetheless significant given that there has been a poverty tag given to the material.

4.4.20 Rating of the weight of responsibility for dissemination of information regarding CSEB materials

Table 13: Responsibility for dissemination of information regarding CSEB

	Very low	low	average	High	Very High
Manufacturers/ promoters	20%	20%	20%	40%	0
Built industry professions	20%	10%	30%	30%	10%
Construction workers	20%	20%	30%	20%	10%
Ministry of Housing	20%	10%	20%	20%	20%
NGO s	10%	30%	30%	20%	10%
Institutions of higher learning	0	30%	30%	20%	20%
CLIENTS/ OTHERS	0	20%	0	0	20%

On the matter of responsibility for dissemination of information pertaining to ABMT, the respondents placed least responsibilities on clients and ‘others’. The manufacturers, professionals, government, NGO and institutions of higher learning were given almost equal weight of responsibility by the respondents. Further to these responses some of the key informants indicated that Kenya as a country has not taken the development and promotion of Appropriate Building Technologies with the seriousness it deserves. According to these informants, the stakeholders in the ABMT development and promotion do not work in a coordinated manner, and they see the need to have a structured way through which all the actors can operate for the benefits accruing from the ABMTs use to be realized by the general populace.

In addition, the key informants suggested that the Government should meaningfully support ABMT development initiatives and take lead role in the purchase of the

equipment/machines from local industries/private sector for ease of access by the citizens at the Constituency or County ABMT Centers Countrywide.

4.5 Information and Awareness Related Factors

Table 14: Statements on information of CSEB materials - I

Statements on information	N	Minimum	Maximum	Mean	Std. Deviation
Lack of building codes and policies that allow or promote use of CSEB	27	3	4	3.67	.480
Lack of policy minimizing energy-intensive materials like burnt clay bricks, concrete and steel for housing projects	27	2	5	3.22	1.340
With minimal guidance, architects and other building experts can easily incorporate CSEB into current projects	27	2	5	3.56	.847
Allows for participation by end users and communities	27	3	5	3.78	.801

According to study findings in Table 14, the respondent agreed that there is lack of building codes and policies that allow or promote use of CSEB as indicated by a mean of 3.67 and standard deviation of 0.480; the respondents were neutral on statement that there is lack of policy minimizing energy-intensive materials like burnt clay bricks, concrete and steel for housing projects with a mean of 3.22 and standard deviation of 1.340.

The respondents agreed that with minimal guidance, architects and other building experts can easily incorporate CSEB into current projects as indicated by a mean of 3.56 and standard deviation of 0.847; they also agreed that CSEB's allow for participation by end users and communities as indicated by a mean of 3.78 and standard deviation of 0.801.

Table 15: Statements on information about CSEB materials -2

	N	Minimum	Maximum	Mean	Std. Deviation
Lack of knowledge, skills and understanding pertaining to CSEB by professionals, government, donors and users	27	2	5	3.11	1.121
Lack of courses in appropriate technology in universities and other institutions of higher learning	27	3	5	4.00	.679

According to findings in Table 15, the respondents were neutral on the statement that there is lack of knowledge, skills and understanding pertaining to CSEB by professionals, government, donors and users indicated by a mean of 3.11 and standard deviation of 1.121; the agreed that there is lack of lack of courses in appropriate technology in universities and other institutions of higher learning indicated by a mean of 4.00 and standard deviation of 0.679.

Perception of government efforts to promote the CSEB products

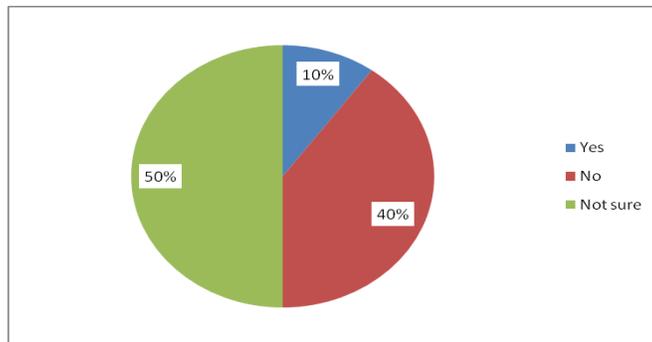


Figure 32: Perception of government efforts on promoting CSEB products

According to findings in Figure 30, majority of the respondents (50%) indicated they were not sure as to whether the government is doing enough to promote use of CSEB and ABMT, 40% indicated ‘no’ while a small proportion 10% indicated that the government is doing its best in promoting CSEB products.

Information in the realm of the public pertaining to CSEB or ABMT

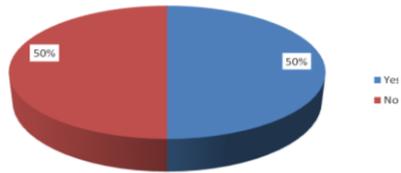


Figure 33: Information about CSEB or ABMT that respondents would disclose

From findings in Figure 31, 50% of the respondents indicated they new something about ABMT not disclosed in the research questionnaires while 50% indicated that they had nothing to share. The responses of the former were very varied and not analysed herein

4.5 Technology and Performance Related Factors

Table 16 : Statements on performance of CSEB materials

Statement on performance	N	Minimum	Maximum	Mean	Std. Deviation
Low technical performance of CSEB as a walling material	27	2	5	3.67	.961
Inappropriate soil conditions in some regions rendering CSEB inapplicable	27	2	5	4.00	.961
Climatic conditions in some localities or seasons do not allow for sun-drying of CSEB thus hindering its manufacture	27	3	5	4.11	.751
Strong in compression and its tensile & shear strength can easily be increased through additives	27	3	5	4.00	.832
Provide comfort through a good balance of temperature, humidity and noise control.	27	3	5	4.44	.698
Houses built with CSEB are cool in the hot season and warm in the cold season due to low thermal conductivity	27	1	5	3.67	1.177
Material is appropriate for the tropical climate experienced in Kenya	27	3	5	4.11	.892
By allowing building to 'breathe', CSEB ensures less interior pollution by 5-7 times compared to other materials	27	2	5	3.67	1.074
Less respiratory illness in buildings constructed using CSEB hence better health	27	1	5	3.78	1.251
CSEB can be used at booth interior and exterior walling in various climatic conditions	27	3	5	4.00	.679
The thickness of CSEB used for walling of houses provides a sense of security to occupants	27	2	5	3.56	.974
CSEB allows for a variety of external and internal finishes and can in itself be a facing	27	2	5	3.67	.961
CSEB has excellent fires resistance qualities	27	2	5	3.78	1.050

According to findings in Table 16, the respondents agreed that there is low technical performance of CSEB as a walling material as indicated by a mean of 3.67 and standard deviation of 0.961; they agreed that inappropriate soil conditions in some regions render CSEB inapplicable indicated by a mean of 4.00 and standard deviation of 0.961.

The respondents agreed that Climatic conditions in some localities or seasons do not allow for sun-drying of CSEB thus hindering its manufacture indicated by a mean of 4.11 and standard deviation of 0.751; they also agreed that CSEB tensile & shear strength can easily be increased through additives by a mean of 4.00 and standard deviation of 0.832. The respondents agreed that CSEB provide comfort through a good balance of temperature, humidity and noise control by a mean of 4.44 and standard deviation of 0.698; they agreed that Houses built with CSEB are cool in the hot season and warm in the cold season due to low thermal conductivity with a mean of 3.67 and standard deviation of 1.177.

The respondents agreed that CSEB material is appropriate for the tropical climate experienced in Kenya by a mean of 4.11 and standard deviation of 0.892; they also agreed that by allowing building to 'breathe', CSEB ensures less interior pollution by 5-7 times compared to other materials as indicated by a mean of 3.67 and standard deviation of 1.074.

The respondents agreed that there is less respiratory illness in buildings constructed using CSEB hence better health as indicated by a mean of 3.78 and standard deviation of 1.251; they agreed that CSEB can be used at both interior and exterior walling in various climatic conditions indicated by a mean of 4.00 and standard deviation of 0.679.

From the findings, respondents agreed that, the thickness of CSEB used for walling of houses provides a sense of security to occupants as indicated by mean of 3.56 and standard deviation of 0.974; they also agreed CSEB allows for a variety of external and internal finishes and can in itself be a facing indicated by a mean of 3.67 and standard deviation

of 0.961 and agreed that CSEB has excellent fire resistance qualities as indicated by a mean of 3.78 and standard deviation of 1.050.

4.6 Cost Related Factors

Table 17: Statements on cost

Statement on cost	N	Minimum	Maximum	Mean	Std. Deviation
Technology to manufacture CSEB is not readily available	27	2	5	3.67	.832
Savings when one utilizes CSEB are not significant when compared to other 'conventional' materials	27	2	5	3.56	1.188
More time and labor compared to 'conventional' materials since CSEB has to be made at or near site.	27	2	5	3.89	.892
CSEB presents less opportunity for entrepreneur for large profit margins compared to other available walling options	27	2	5	3.56	.974
Professionals make less money when they specify CSEB as their payments are on percentage basis	27	1	5	3.78	1.155
Lack of funding to promote appropriate technology nationwide in Kenya	27	1	5	3.44	1.188
Use of CSEB considerably reduces cost of walling	27	3	5	3.89	.751
CSEB production is 80-90% less in use of energy compared to most other walling materials	27	3	5	4.11	.751
Easy to work with since simple tools and minimal skills are required	27	4	5	4.22	.424
Since CSEB can use the same moulds used for fired bricks, there is little investment required for new plant and processes	27	1	5	3.67	1.177
Since CSEB is produced locally, there is no transport cost for the bulk material only stabilizers need transport	27	3	5	4.00	.679
CSEB does not need secondary industrial transformation since only a compress is needed	27	3	5	4.00	.679
Soil is available in large quantities locally	27	3	5	4.22	.801

According to research findings Table 17, the respondents agreed that Technology to manufacture CSEB is not readily available as indicated by a mean of 3.67 and standard deviation of 0.832; they also agreed that savings when one utilizes CSEB are not significant when compared to other 'conventional' materials with a mean of 3.56 and standard deviation of 1.188.; the respondents agreed that CSEB requires more time and labor compared to 'conventional' materials since CSEB has to be made at or near site with a mean 3.89 and standard deviation of 0.892.

The findings indicates that the respondents agreed that CSEB presents less opportunity for entrepreneur for large profit margins compared to other available walling options with a mean of 3.56 and standard deviation of 0.974; they also agreed that professionals make less money when they specify CSEB as their payments are on percentage basis with a mean of 3.78 and standard deviation of 1.155, the respondents were neutral that there is lack of funding to promote appropriate technology nationwide in Kenya indicated by a mean of 3.44 and standard deviation of 1.188.

They agreed that use of CSEB considerably reduces cost of walling with a mean of 3.89 a standard deviation of 0.751; also they agreed that CSEB production is 80-90% less in use of energy compared to most other walling materials with a mean of 4.11 and standard deviation of 0.751. From the findings the respondents agreed that Easy to work with since simple tools and minimal skills are required with a mean of 4.22 and standard deviation of 0.424; they agreed that, since CSEB can use the same moulds used for fired bricks, there is little investment required for new plant and processes with a mean of 3.67 and standard deviation of 1.177; also they agreed that, since CSEB is produced locally, there is no transport cost for the bulk material only stabilizers need transport with a mean of 4.00 and standard of 0.679.

From the findings the respondents agreed that CSEB does not need secondary industrial transformation since only a compress is needed with a mean of 4.00 and standard deviation of 0.679; the also agreed that Soil is available in large quantities locally with a mean of 4.22 and 0.801.

4.7 Perception Related Factors

Table 18: Statements on categories of CSEB materials

Statements on categories	N	Minimum	Maximum	Mean	Std. Deviation
The material is associated with poverty or lower classes of society	27	3	5	3.89	.892
The material is seen as a step backward towards primitive and unhygienic buildings that are difficult to clean	27	2	4	3.44	.698
Promotion of CSEB as walling material for poor communities by donors sends wrong signals in the market	27	3	5	3.67	.679
CSEB manufacture a source of employment in the immediate neighborhood	27	3	5	4.11	.892

According to findings in Table 18, the respondents agreed that the material is associated with poverty or lower classes of society as indicated by a mean of 3.89 and standard deviation of 0.892; they also they were neutral on statement that the material is seen as a step backward towards primitive and unhygienic buildings that are difficult to clean indicated by a mean of 3.44 and standard deviation of 0.698.

They also agreed that promotion of CSEB as walling material for poor communities by donors sends wrong signals in the market with a mean of 3.67 and standard deviation of 0.679; the respondents agreed that CSEB manufacture a source of employment in the immediate neighborhood as indicated by a mean of 4.11 and standard deviation of 0.892.

4.8 Competition from other available walling alternatives

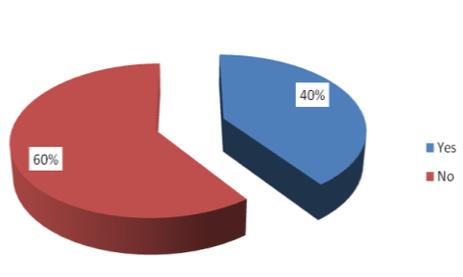


Figure 34: Perception of availability of new materials that could compete with CSEB within Kenya

From study findings in Figure 34, 60% of the respondents indicated that there are no new materials threatening the CSEB market segment while 40% indicated there are.

4.9 Population and Coverage of the Study Area

In research statistics, a population is a complete set of items that share at least one property in common that is the subject of a statistical analysis. A statistical sample is a subset drawn from the population to represent the population in a statistical analysis. If a sample is chosen properly, characteristics of the entire population that the sample is drawn from can be inferred from corresponding characteristics of the sample. For example the built environment professionals all have some knowledge concerning building materials, of which CSEB is a subset. It is therefore statistically correct that interviewing a cross-section of such professionals would be representative of the whole range of knowledge by the whole lot of them.

4.10 Reasons Given as Affecting Speed of Adoption of CSEB

4.10.1 Response rates.

4.10.1.1 The key informants.

The key informants included the specialists within the construction fraternity which included; Ministry of housing, NCA and the UNHABITAT and the ABT information centres. These teams provided important insights of the research topic and important data on the subject matter.

4.10.1.2 Statistics on ABMT from information centers

(Literature review)



Figure 35, CSEB; source author)



Figure 36: CSEBS IN SERIES; source; ministry of housing data

4.10.1.3 The professionals

Their valid lists were collected from their respective umbrella bodies, these professionals interviewed and analyzed included; Architects, Engineers, Quantity Surveyors and

construction managers; they were involved since they are the initial heads of the construction process, and thus they give either specifications or quantification of the construction materials.

4.10.1.4 Approval bodies and authorities

Some statistics were collected from approval bodies; these bodies gave information on the nature of curve formed by the material over a period of ten years and how various clients have adopted the material within their projects. It is however noteworthy that very limited data is available pertaining to walling material approvals by the county governments and the previous local authorities.

4.10.1.5 General public and end users

The end users of the material i.e. the public, users, constructors and the craftsmen also gave their insight on the material, a questionnaire for them was also administered and tangible information was instructed from them.

4.11 Prevalence of Causative Factors for Adoption of the Technology

From this research, causative factors enhancing the adoption of the CSEB as a material and ABMT as technology have been evaluated as hereunder

First, as compared to other building materials e.g. machine cut stones CSEB was found to be less expensive.

Secondly, the materials used in making of the material in question i.e. CSEB are locally available thus lesser embedded energy is attached to the material

Thirdly, the time frame of completing a structure made CSEB is shorter as compared to the 'conventional' building materials.

Fourth, technology for manufacture of CSEB is readily available within immediate environment of users

Fifth, when using CSEB, additional material in the making of walling is limited when compared to other materials such as stone and bricks, where cement and mortar are consumed in large quantities.

Sixth, the government and the Ngo's are making considerable amount of effort in promoting the product by using it to provide housing solutions to the homeless citizens, thus making the product known to the entire populace.

Seventh, population increment has led into demand of alternative building materials; this has significantly increased the demand of CSEB within the construction industry.

Lastly, CSEB does not need secondary industrial transformation since only a compress is needed

4.12 Prevalence of Reasons Given for Reluctance to Adopt the Technology

Also some strong issues came into lame light concerning the reluctant nature of adoption of the material in question.

First of all there is lack of knowledge, skills and understanding pertaining to CSEB by the developers hence reluctance to adopt it for walling solutions

Secondly, the material is associated with poverty or lower classes of society

Thirdly, the material is seen as a step backward towards primitive and unhygienic buildings that are difficult to clean

Fourth is there are very few examples of good quality buildings put up using CSEB

Fifth is a perception of low technical performance of CSEB as a walling material

Sixth is that inappropriate soil conditions in some regions render CSEB inapplicable

Seventh is that climatic conditions in some localities or seasons do not allow for sun-drying of CSEB thus hindering its manufacture

As the eighth reason, promotion of CSEB as walling material for poor communities by donors sends wrong signals in the market. It creates stigma towards use of CSEB
 Lastly, lack of funding to promote appropriate technology nationwide in Kenya

4.13 Challenges Encountered in Data Collection

The researcher encountered some challenges during data collection phase of the research and they are enumerated herein

First, the geographical spread of the data collection area was quite wide, thus tiresome for the researcher to cover i.e. Nairobi (university of Nairobi, ministry of housing, AAK, JKUAT, Kenyatta University and clay works and products), Kajiado, Mavoko, and Machakos

Geographical area of research

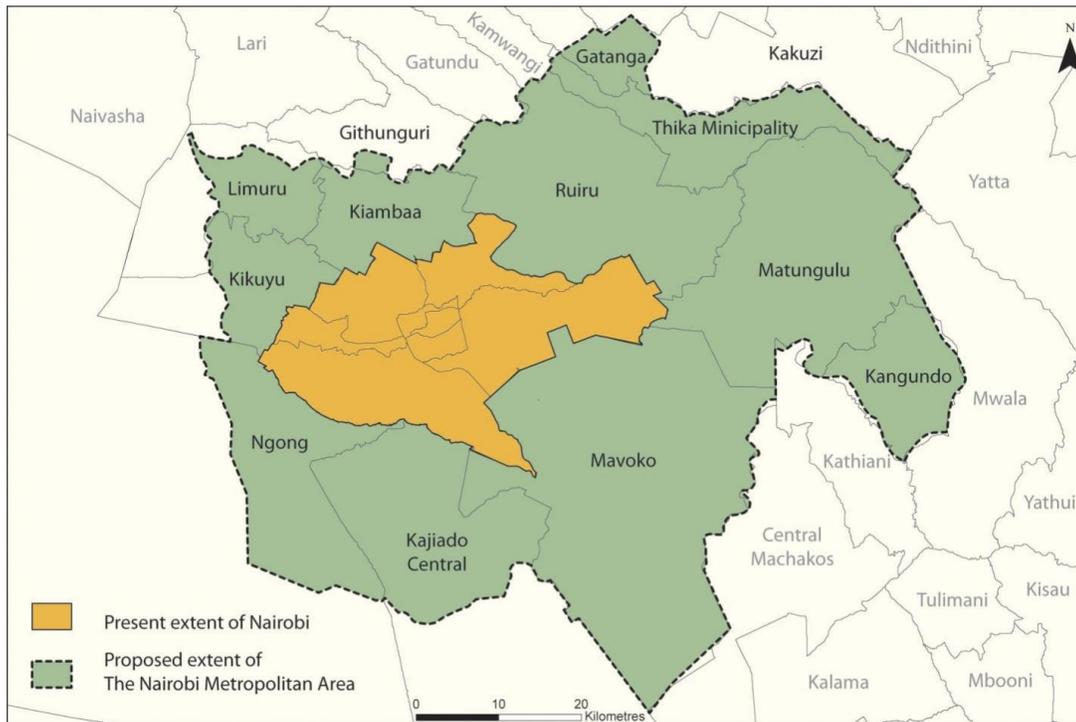


Figure 37 Map of Nairobi Metropolitan Region. Source: Google

Secondly, the time-frame to cover the entire place of research was quite minimal. However, this is a common limitation of research projects of this nature. The type of data and duration of collection had thus to be carefully chosen

Third, the questionnaires had to be edited after the pilot study that found out various constraints in the phrasing and the type of questions posed. However, there was need to triangulate some responses and this informed the decision on the final set of questionnaires and list of interview questions for the key informants. Whereas they may appear to duplicate, the intention was to corroborate factors from more than one view-point. Fourth, the questionnaires to the professionals centred on thirty-seven factors impacting either positively or negatively on the adoption or otherwise of ABMT's and CSEB in particular. These were many and some of the respondents to the questionnaire claimed to be too busy to complete the questioning session thus leading to postponements or cancellation of interviews or administration of questionnaires

Fifth, in some place illiteracy on the path of the respondents was a major barrier to the research process. For illiterate people, the questionnaire had to be administered for the required data to be collected

Sixth, language barrier served also as another source of distress during data collection phase. Some mother tongue translators had to be used by the researcher in a few cases and this may have had minor impacts on the reliability of the data collected.

Finally, there were financial constraints to cater for the assistants used during research to collect data. Travel and accommodation had to be arranged and this was a financial strain to the researcher that had to be met to realize this research project

CHAPTER FIVE

5.0 SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary of the findings concerning Compressed Stabilised Earth Blocks (CSEB) as a subset of Appropriate Technology in the context of the research objectives listed in the introductory chapter of this research project. The objectives included the need to find the prevalent factors that have the greatest influence for or against the adoption of ABMT and propose solutions that will enable adoption of this technology for solutions in the building industry. Having specifically picked CSEB as a subset of this technology, the research looks at how it can be better adopted as a solution in the supply of walling materials in Kenya.

The findings have been presented in terms of how they address the research questions that were to be addressed to meet the research objectives.

5.2 Question 1: Whether Use of CSEB has Grown, Stagnated or Declined

Results from the foregoing chapter point to a marginal growth in use of CSEB when compared to the growth in potential users of the product. It would appear that many of the potential users of the material still have areas of uncertainty that, unless dealt with, would continue to be a hindrance to adoption of AT. Given that most of the manufacturers of the material attained or exceeded their expectations in terms of sales volumes and returns, reasons for the apparent stagnation must lie outside the cost and technological realms.

5.3 Question 2: Whether CSEB Meets the Threshold of a Good Walling Material

Empirical tests on CSEB show that it does meet the crushing strength and durability thresholds and even rates higher than burn brick on these characteristics. There was convergence among respondents on the CSEB as being positively perceived in terms of strength, aesthetics and durability as seen by general public, professionals and key informants. Whereas there are some suggested improvements to the product, this has to do with enhancing the present characteristics. There is also the perceived need to increase the variety of modules available to enable more widespread application. An obvious paradox with that is that unless consumption of the product goes up exponentially, it would not be easy to tell which other sizes or varieties would be suitable.

There is good potential for growth in the use of CSEB if the manufacturers of the manual presses take upon themselves the responsibility of making known the merits of the product. Some of those that have taken up the popularising the product, e.g. Makiga Engineering Ltd, have seen growth in the sale of machines and the consumption of CSEB as well

5.4 Question 3: Whether Information Concerning CSEB is Well Understood by the General Kenyan Public

From the research, it is apparent that the general public and the professionals all seem to be well aware of the existence of ABMT in general and CSEB as a walling material. It is apparent that CSEB is the best known among the ABMT's in use in Kenya and its use to represent the technology is thus seen to be scientifically sound. Interviews from key informants also seem to corroborate the same. However, it was notable that most respondents did not seem to know the sources of equipment for making of CSEB, which

would point to a need for something to be done since ABMT relies on the use of simple tools and equipment in both philosophy and practice

It also came out the number of people that would consider using CSEB for walling is very high but most of them have an average to low understanding of the product. Those that have chosen to use the product also generally indicated being satisfied with it. The key to widespread adoption lies in a deeper understanding of the product being available to these potential users

From the findings, it appears that the universities and other tertiary educational institutions are doing their work in disseminating information on ABMT and CSEB. Indeed it came out that they have included these in their curricula.

Despite differing levels of knowledge of the material, it is apparent that many would still recommend the use of CSEB for walling and ABMT's in general. There is still a lot of untapped potential in CSEB that can be realised mostly through information and awareness campaigns. The stakeholders should not adopt a wait-and-see attitude but aggressively address the marketing aspect of the material

However, much needs to be done by the government because the role it plays in promoting ABMT is hardly felt at the grassroots as evidenced in the responses obtained in the research. If lots of resources are being channelled in the direction of ABMT, then it needs to assess whether those efforts are impacting positively if at all.

5.5 Question 4: Whether Awareness Among Professionals and Users Translates to Widespread Use of ABMT's

From the professionals and key informants, it emerges that soil and climate are major challenges in the adoption of CSEB. Since different soils require different amounts of stabilisers, there is a point where the cost benefit is eradicated – thus awareness to some extent may be seen as hindering the use of CSEB for some soil conditions. It may do well to have a map of the country zoning the soil types, recommended stabilisers and quantities as a quick guide to professionals and entrepreneurs. The same map one could even show some of the areas where manufacture of CSEB is not economical. Maps such as solar maps or wind maps have been seen to help investors interested in renewable energy development. Most people would not invest in a product that has many unknown variables and the importance of such high-level guidance on soils cannot be ignored.

On the positive side, the tropical climate experienced in Kenya, with most of the seasons being dry, is seen as suitable for curing of CSEB which is normally done outdoors. In the rains, it may necessitate some form of protective structure and this may contribute to higher than normal costs for the CSEB.

Furthermore, there seems to be a consensus that houses built using CSEB have a stable internal climate, being relative cool in the hot seasons and relatively warm in the cold seasons, with a small range of temperature realised when compared to other walling materials.

5.6 Question 5: Commercial Potential of CSEB as Supply Line for Construction Materials and Substituting Other Materials

It also emerged that CSEB is generally perceived to be cheaper than natural stone, home-made bricks, industrial bricks and concrete blocks among other materials. If this is seen in the context of savings on mortar when the interlocking type of CSEB is used, then major savings are likely to be realised by using the material. The cost calculations from manufacturer of CSEB materials and machinery point to substantial cost savings.

It also emerges that those that go into the manufacture of CSEB will mostly attain or exceed expectation in sales, it can be argued that the product is commercially viable. Given the number of blocks that can be realised from the use of one bag of cement with most of the soils in the country, there is need for entrepreneurs to venture into its manufacture and distribution at local centres. Apart from benefits to the entrepreneurs, manufacture of CSEB is seen a source of employment to the general public with the concomittant trickle down effects

Due to local production of CSEB, it can be seen that major savings on transport are realised where it is used. For most bulk materials (blocks and the like) up to 35% of the landed costs goes to transport. This may be an immediate benefit to be realised by using CSEB since only cement or other stabilisers need to be transported to site.

It can be seen that there are other products in the market likely to compete with CSEB. Even with ABMT, there are emerging competitors that are likely to take attention away from CSEB. Competition cannot be wished away and is there to stay. However, if the merits of CSEB are looked at critically in terms of environmental benefits, then there would be no comparable options from either traditional or emerging products in the market.

Despite its advantages, it emerges that CSEB is still perceived as a step backward towards ‘dirty’ and ‘less permanent’ structures. Whereas this is not an accurate perception, in a country where people are moving out of houses made of soil, mud and wattle, to what is perceived as ‘permanent’ and ‘modern’ structures with natural stone or concrete block walling, a lot needs to be done to overcome such stigma being attached to CSEB. Whereas it goes back to the information bit, it will take a paradigm shift to accept CSEB as a modern material. This is one of the factors that needs to be critically examined if CSEB has to find its rightful place in the building industry

5.7 Question 6: Findings Pertaining to Effectiveness of Government in Promoting ABMT

From the study, it emerges that the government role in promoting ABMT is well understood by the general population and BEP’s. However, much is still expected from most stakeholders that the government should do more to promote use of ABMT generally.

5. 8 Conclusion and Recommendations

This section hereby highlights the conclusions and recommendations made by taking cognizance of the study findings

5.8.1 Conclusions:

The conclusions emanating from this study relate to the objectives which were included viz-: establishing the factors affecting the adoption of Compressed Stabilized Earth Block (CSEB) technology in the Kenyan context; identification through situation analysis of the construction industry in Kenya the stakeholders of CSEB and their role in adoption

appropriate technology (AT) and recommending practical solutions that can be taken to foster the adoption of AT for building solutions in Kenya.

This study has established that the existence of Appropriate Building Materials and Technologies in Kenya is gaining recognition and a number of strategies have been put in place in their promotion.

The failures of fast adoption of CSEB activities could be attributed to several factors notably: inadequate funding; inadequate personnel; negative cultural perception on soil products; inappropriate dissemination strategies; ineffective legislations on use of appropriate technologies; lack of technological capacity development; lack of enough government support; lack of interest by policy makers and implementers; and low pick up rate of technology use by end users.

The role of the built environment professionals was rather prominent as disseminators of knowledge concerning materials. They also are the specifiers of the materials and with their understanding of environmental and technical issues that surround CSEB in particular and AT in general, they stand at a vantage point to advance use of this material and others of similar nature.

The various institutions involved in the technology development right from the research to product development as well as harmonization of legislations and regulatory measures applicable to the construction industry lack adequate capacity to effectively perform the functions. The government at both national and county levels can play its role in facilitating the transfer of ABMT to every corner of the nation.

The strategies that have been employed in the promotion of the ABMTs in Kenya over the years are also inadequate and do not comprehensively aid the promotion and adoption of the ABMTs programmes and projects in the country. In order to make the CSEB a

material of choice to the builders within the construction industry, there is need to embrace a number of strategies including:-

Conducting adequate research to determine the technologies that are working within specific areas;

Creation of adequate facilities to sustain ABMTs development and economic empowerment of local trainees and technology beneficiaries;

Proper equipping of training centers to enable effective on-site training on ABMTs;

Enhanced awareness creation;

Enhanced capacity building

Legislation at national and county levels that allows and promotes CSEB as a walling material and opening way for other ABMTs

Manufacturers building the capacity for producing CSEB on a large scale to compete well with other walling materials

5.8.2 Recommendations

For there to be a significant part of the Kenyan population that utilizes CSEB as walling material in their projects, the following policies ought to be put in place:-

First, adopt use of the Appropriate Building Materials and Technologies especially CSEB as a walling material in Government projects in order to create confidence on viability of the materials and technologies

Secondly, develop linkages for collaboration and partnerships between technical institutions and industry entrepreneurs for training of artisans and technicians as well as development of adequate equipment. From the research it emerges that knowledge on AT comes through these institutions. Availability of machinery across the country would go help meet, grow and sustain demand for CSEB and other ABMT's

Thirdly, the Government should accelerate the process of operationalizing the regional ABMT centres at Mavoko, Narok and across the whole republic in all counties to act as advisory centres on ABMT development in the Country and the Region.

5.8.3 Suggested further research

There are a number of aspects that emerged in the course of this research project that opened up areas of further study. This study recommends further research on the following aspects: -

The performance of various ABMT's that are potentially viable for adoption in walling solutions in Kenya in comparison with CSEB.

The role of Built Environment Professional in the promotion of Appropriate Technology
Development of capacity of key institutions in the adoption of Appropriate Technologies in Kenya

Geological mapping of soils in terms of suitability for stabilization as a quick guide to manufacturers of stabilized building blocks

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APPENDIX 1 – QUESTIONS FOR KEY INFORMANTS

FACTORS AFFECTING USE OF APPROPRIATE BUILDING MATERIALS AND TECHNOLOGIES (ABMT) IN KENYA

Researcher: Festus Marita Mariera

REGISTRATION NO: B50/76637/2009

UNIVERSITY OF NAIROBI

*A RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILMENT FOR THE
REQUIREMENTS OF MASTERS OF ARTS IN CONSTRUCTION PROJECT
MANAGEMENT.*

KEY INFORMANT QUESTIONS FORMAT

As part of a research project into the use of Appropriate Building Material Technologies (ABMT), I have chosen to use the Compressed Stabilized Earth Blocks (CSEB) as specific area of focus. CSEB is a generic name that should be construed to include the Interlocking Stabilized Soil Blocks (ISSB) or any other variant of earthen blocks made using the stabilization process, which is adding stabilizers (cement, lime, etc) to soil in various proportions and compressing in a manual or mechanical press to produce blocks that are usable in building walls.

The various stakeholders in the usage of the material will therefore be requested to give insights into what facilitates or hinders the use of the said technology in filling the supply gap of materials for the building construction industry in Kenya. The last question requests the key informant to freely share what they think of the materials and technologies

The information you give as a respondent will be treated with utmost confidence in line with the ethical requirements of this kind of research. It's my request that you give responses honestly and without any prejudice to any opinion. I request the informant's permission for audio recording and pledge that it is for purposes of capturing information only. It will not be played out anywhere or shared by any means with any third parties

To the Key Informant

I want to sincerely thank you for taking time off your schedule to share your very useful insights into this topic of research. I'll try to be as objective as possible

1. How long have you worked in the Department of Housing?
2. Could you describe some of the appropriate building material technologies (ABMT) available in the country?
3. Briefly outline the history of ABMT in Kenya
4. What is the extent of roll out of ABMT in Kenya so far?
5. Briefly describe the processes involved in manufacture of CSEB?
6. What equipment is required?
7. Where is such equipment procured from?
8. What kind of documentation is available at your department regarding Compressed Stabilized Earth Blocks (CSEB)?
9. How current is that documentation?
10. How is that kind of information collected and compiled?
11. What do the statistics in the ministry indicate concerning adoption of CSEB as a walling material?
12. Please give examples of projects that you know of that have made use of CSEB as walling material, some in rural and others in urban settings
13. Can you name any areas in Kenya where CSEB is inapplicable due to technical reasons?
14. What are some of those technical reasons?
15. What research is ongoing as pertains to making improvement to CSEB technology?
16. Who funds that kind of research?
17. How much money is expended annually on the research at various levels?
18. What challenges have been encountered in the field pertaining to use of CSEB for walling?
19. What is currently being done to overcome those challenges?

20. Is there anything important that you think I may have missed?

Thank you for your time.

APPENDIX 2 – QUESTIONNAIRE TO CONSTRUCTION EXPERTS

FACTORS AFFECTING USE OF APPROPRIATE BUILDING MATERIALS AND TECHNOLOGIES (ABMT) IN KENYA

Researcher: Festus Marita Mariera

REGISTRATION NO: B50/76637/2009

UNIVERSITY OF NAIROBI

*A RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILMENT FOR THE
REQUIREMENTS OF MASTERS OF ARTS IN CONSTRUCTION PROJECT
MANAGEMENT.*

QUESTIONNAIRE

As part of a research project into the use of Appropriate Building Material Technologies (ABMT), I have chosen to use the Compressed Stabilized Earth Blocks (CSEB) as specific area of focus. CSEB is a generic name that should be construed to include the Interlocking Stabilized Soil Blocks (ISSB) or any other variant of earthen blocks made using the stabilization process, which is adding stabilizers (cement, lime, etc) to soil in various proportions and compressing in a manual or mechanical press to produce blocks that are usable in building walls.

The various stakeholders in the usage of the material will therefore be requested to give insights into what facilitates or hinders the use of the said technology in filling the supply gap of materials for the building construction industry in Kenya. Under additional information section, I have requested each respondent to freely share what they think of the materials and technologies

The information you give as a respondent will be treated with utmost confidence in line with the ethical requirements of this kind of research. It's my request that you give responses honestly and without any prejudice to any opinion

PART 1:

1. What is your area of specialization in the construction industry professions?

- Architectural
- Structural / Civil Engineering () (*tick appropriately*)
- Quantity Surveying
- Construction Project Management
- Building Services Engineering
- Registered Contractor
- Construction Artisan
- Other (please specify)

2. Indicate highest level of education attained:-

- Post-graduate
- Graduate
- Diploma
- Certificate
- Other (please specify)

3. Have you ever heard of CSEB as a walling material? Yes / No (*tick appropriately*)

4. Have you ever considered using CSEB as a walling solution in any project?

- Yes / No N/A (*tick appropriately*)
-

5. Kindly indicate below your source of information concerning ABMT or CSEB (*You may tick one or more sources if applicable*)

- College/University

- ABMT Centres
- Ministry of Housing
- Newspaper
- Radio
- Internet
- Other (please specify)

6. Please rate your level of understanding as pertains to CSEB as a walling material

- Very broad
- Broad
- Average
- Limited
- Very limited
- N / A

7. How do you rate the level of awareness among the general public regarding CSEB?

- Very High
- High
- Average
- Low
- Very Low
- N/A

8. For how long have you been using / developing/ promoting this material?.....
 years (*indicate '0' if you have not used, manufactured or promoted CSEB*)

9. What motivated you to get into production of CSEB?

- a)
-

- b)
-
- c)
-

10. How would you rate your achievement of expectations in sales of CSEB in relation to your projections? (*tick appropriately*)

- Exceeded
- Attained
- Not attained
- Below expectations
- Far below expectations
- N/A

11. How often have you used CSEB in the projects that you have handled?

- a. On more than 10 no. Projects
- b. On 6-10 no. projects (*tick appropriately*)
- c. On 2-5 no. Projects
- d. Only on 1 no. Project
- e. None

12. How would you rate the trend of demand for your product, CSEB since you started production / use / recommending the product?

- Highly increased
- Increased
- Marginal +/- changes
- Inconsistent (*tick appropriately*)
- Decreased
- Highly decreased
-

N/A

13. Is there anything you have discovered about CSEB that was totally unknown to you had a close encounter with it? Yes/No (*tick appropriately*)

If yes, briefly explain:

14. Are you happy with your decision to use CSEB in your building development? (*tick appropriately*)

Yes	No	Not sure	N/A
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

15. What do you perceive to be the merits of using CSEB?

- a)
-
- b)
-
- c)
-

16. How do you rate its performance?

(a)	Aesthetically	Very good	<input type="checkbox"/>	<i>(tick appropriately)</i>
		Good	<input type="checkbox"/>	
		Average	<input type="checkbox"/>	
		Bad	<input type="checkbox"/>	
		Very Bad	<input type="checkbox"/>	

(b)	Structurally	Very strong	() <input type="checkbox"/>	<i>(tick appropriately)</i>
		Strong	() <input type="checkbox"/>	
		Average	<input type="checkbox"/>	
		Weak	() <input type="checkbox"/>	

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
--------------------------	--------------------------	--------------------------	--------------------------

		Very Weak	<input type="checkbox"/>	
(c)	Durability	Very high	<input type="checkbox"/>	
		High	<input type="checkbox"/>	
		Average	<input type="checkbox"/>	(tick
		<i>appropriately)</i>	<input type="checkbox"/>	
		Low		
		Very Low	<input type="checkbox"/>	
		Uncertain	<input type="checkbox"/>	

17. How do you rate the economic viability of the product vis-à-vis other frequently used building materials? (tick appropriately in the 2nd , 3rd ,4th or 5th Column

	More costly than CSEB	Less costly than CSEB	Insignificant cost difference with CSEB	Uncertain / unable to compare costs
Natural Stone				
Concrete block				
Locally manufactured clay bricks				
Industrially produced clay bricks				
Timber walling				

18. In your experience how do you rate the use of ABMT over the conventional technologies and materials in the industry? (tick appropriately)

Superior	<input type="checkbox"/>
Inferior	<input type="checkbox"/>
Same level	<input type="checkbox"/>
Unable to compare	<input type="checkbox"/>
N/A	<input type="checkbox"/>

19. Have you noted any improvement the product (CSEB) since the time you started using it? Yes / No / N/A (*tick appropriately*)

If yes, what aspects of the product have undergone improvements? (*tick 1 or more options*)

- Appearance
- Strength characteristics
- Modules / size variety
- Interlocking patterns
- Other (please specify).....
- N / A

20. Would you advise other developers to adopt CSEB as a walling material?

Yes / No / Not sure N/A (*tick appropriately*)

Kindly give reasons for your answer above

- a)
-
- b)
-
- c)
-

21. How do you rate the level of adoption of the materials by consumers?

- Very fast
- Fast (*tick appropriately*)
- Average
- Slow
- Very slow

22. What do you perceive to be the demerits of using CSEB?

- a)
- b)
- c)
- d)
- e)

23. In your opinion which of the following aspects needs improvement for the material (CSEB) to gain widespread acceptance? (tick appropriately)

- Appearance
- Strength characteristics
- Modules / size variety
- Interlocking patterns
- Other (please specify)
 - 1.
 - 2.
 - 3.

24. Kindly list three (3 no.) inconveniences / challenges that you consider greatest in using the technology and material i.e. ABMT and CSEB

- a)
- b)
- c)

25. Please give three main reasons why you would not recommend use of CSEB for walling solutions

- a)
- b)
- c)

26. Do you foresee a possibility of CSEB replacing other walling materials e.g. local fired bricks, tin, iron sheets, etc now or in the near future? Yes No Not sure

N/A

(tick appropriately)

Briefly explain your answer

27. Please indicate what should be done to make CSEB more acceptable in the building industry as an alternative walling material

a)

.....

b)

.....

c)

.....

28. For what category of clients / developers do recommend adoption of CSEB as walling material (You may tick one or more options if applicable)

High cost housing

Medium cost housing

Low cost housing

Slum upgrading projects

Other (please specify)

Please give reasons for your answer

29. On a scale of 1 to 5 (1 being least and 5 being the most) please rate the weight of responsibility for dissemination of information regarding CSEB for each of the following:-

- Manufacturers / promoters
- Building industry professionals
- Construction Workers (contractors/artisans, etc.)
- Ministry of Housing / Government agencies
- NGO's
- Institutions of higher learning
- Others (specify).....

30. Are there other new materials coming into the market that threaten your market segment? Yes / No / Not sure? *(tick appropriately)*

If Yes, please name a few:

31. Do you think the government is doing its best to promote the product (CSEB)?

Yes / No / Not sure N/A *(tick appropriately)*

32. Is there any other information about the CSEB would like to divulge?

.....

.....

.....

.....

.....

.....

APPENDIX 3 – QUESTIONNAIRE TO BUILT ENVIRONMENT

PROFESSIONALS

State the number of years of work experience in the building industry

Which of the following best explains you or your organization?

- | | |
|---|--------------------------|
| 1) Corporate architect | <input type="checkbox"/> |
| 2) Corporate quantity surveyor | <input type="checkbox"/> |
| 3) Construction project manager | <input type="checkbox"/> |
| 4) Registered construction, materials or building engineer | <input type="checkbox"/> |
| 5) Registered building contractor NCA 1 to NCA 8 | <input type="checkbox"/> |
| <i>(tick appropriately)</i> | <input type="checkbox"/> |
| 6) Labour subcontractor or other contractor involved in buildings | |
| 7) Technician in building professions | <input type="checkbox"/> |
| 8) Artisan/mason | <input type="checkbox"/> |
| 9) Other professional category (specify) | <input type="checkbox"/> |

Main question

Have you ever heard or read about CSEB as a method or material of choice for walling through any means?

Yes

No

Main question

Have you ever used of Compressed Stabilised Earth Blocks (CSEB) in any of your designs or construction? Yes No

Underlying idea: To determine the reason of reluctance/ speed of adoption of the ABMT, especially the CSEB, in the Kenyan building industry.

Prompt A- Can you tell me what helps or hinders the speed adoption and utilization the CSEB within our construction industry?

Please indicate whether you agree or disagree with the following statements about what affects the adoption of Compressed Stabilised Earth Blocks (CSEB) for walling solutions in Kenya. Please also indicate the extent of agreement or disagreement on a scale of 1 to 5 where 1 is least and 5 is greatest

No.	Description	Agree	Disagree	No opinion	Rating of agreement / disagreement (<i>tick the applicable box</i>)				
					1	2	3	4	5
1	Lack of knowledge, skills and understanding pertaining to CSEB by professionals, government, donors and users								
2	The material is associated with poverty or lower classes of society								
3	The material is seen as a step backward towards primitive and unhygienic buildings that are difficult to clean								
4	Technology to manufacture CSEB is not readily available								
5	Lack of courses in appropriate technology in universities and other institutions of higher learning								
6	Lack of examples of good quality buildings put up using CSEB								
7	Low technical performance of CSEB as a walling material								
8	Savings when one utilises CSEB are not significant when compared to other 'conventional' materials								
9	More time and labour compared to 'conventional' materials since CSEB has to be made at or near site.								
10	CSEB presents less opportunity for the entrepreneur for large profit margins compared to other available walling options								
11	Inappropriate soil conditions in some regions rendering CSEB inapplicable								
12	Climatic conditions in some localities or seasons do not allow for sun-drying of CSEB thus hindering its manufacture								
13	Lack of building codes and policies that allow or promote use of CSEB								
14	Professionals make less money when they specify CSEB as their payments are on percentage basis								
15	Lack of policy minimising energy-intensive materials like burnt clay bricks, concrete and steel for housing projects.								
16	Promotion of CSEB as walling material for poor communities by donors sends wrong signals in the market								

17	Lack of funding to promote appropriate technology nationwide in Kenya								
18	Use of CSEB considerably reduces cost of walling								
19	CSEB production is 80-90% less in use of energy compared to most other walling materials								
20	Easy to work with since simple tools and minimal skills are required								
21	Allows for participation by end users and communities								
22	Strong in compression and its tensile & shear strength can easily be increased through additives								
23	Provide comfort through a good balance of temperature, humidity and noise control								
24	Houses built with CSEB are cool in the hot season and warm in the cold season due to low thermal conductivity								
25	Material is appropriate for the tropical climate experienced in Kenya								
26	By allowing building to 'breathe', CSEB ensures less interior pollution by 5-7 times compared to other materials								
27	Less respiratory illnesses in buildings constructed using CSEB hence better health								
28	CSEB can be used at both interior and exterior walling in various climatic conditions								
29	The thickness of CSEB used for walling of houses provides a sense of security to occupants								
30	CSEB allows for a variety of external and internal finishes and can in itself be a facing								
31	Since CSEB can use the same moulds used for fired bricks, there is little investment required for new plant and processes								
32	Since CSEB is produced locally, there is no transport cost for the bulk material – only stabilisers need transport								
33	CSEB does not need secondary industrial transformation since only a compress is needed								
34	CSEB manufacture a source of employment in the immediate neighbourhood								
35	With minimal guidance, architects and other building experts can easily incorporate CSEB into current projects								
36	CSEB has excellent fire resistance qualities								
37	Soil is available in large quantities locally								