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A review of the use of lateritic soils in the construction/development of sustainable housing in Africa: A geological perspective

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ABSTRACT

Lateritic soils have been described as highly weathered tropical or sub-tropical residual soils with varying proportions of particle sizes ranging from clay size to gravel, usually coated with sesquioxide rich concretions. It is sometimes referred to as brick earth based on its use. The use of laterite and lateritic soils have been found to promote the realization of decent housing and bridging the housing deficit, especially in Africa.

The author has attempted to review available information on the recent trends in building bricks and housing development with the aim of identifying a suitable soil material that will meet the present challenge of sustaining the environment without costing too much and maintaining a high standard of strength, durability and aesthetics. A critical review of laterite and lateritic soils from a geological point of view indicated these soils to be one of the best natural materials used in the production of compressed earth bricks. Lateritic soils are mostly well graded, comprising both cohesive (silt and clay) and cohesionless (sands and gravels) soil fraction, it contains sesquioxides and clay minerals which are very useful in the natural binding process as well as in the presence of most chemical binders.

Compressed earth bricks are mainly composed of raw earth materials (soil) with their cohesion due principally to the clay fraction present in both humid and dry states. CEB's promote building in a 'sustainable' way and offers a good prospect to using our resources in an efficient manner while creating dwellings that improve human health, well-being and preserving a better environment, with an affordable and natural alternative.

Contents

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1. Introduction

Earth has proven to be man's best friend, companion and solution to most of his problems. Humans live on the earth, food is produced from the earth and earth seems to be the only friendly habitat for safe living.

Earth within the above context refers to soil which is uncemented mineral grains, usually formed by weathering of rocks and includes organic matter and water.

Growing environmental concerns have led to the realization and appreciation of the usefulness of natural earth material to many environmental and construction problems facing humankind. The use of earth material, if managed correctly, does not lead to the same scale of depletion of resources, increase in pollution and waste generation or biological changes as compared to conventional building materials (Bachar et al., 2014).

In order to preserve and sustain the environment, the use of environmental friendly building materials, commonly referred to as green building materials must be encouraged to promote the idea of sustainable building. One such green building material that meets the standards of achieving sustainable housing developments is compressed earth bricks.

Sustainable building was defined by Meriani (2008) as structures that are designed, built, renovated or operated in a resource-efficient manner. It is designed generally for the well-being of the environment as well as the occupants, using resources (energy, water, and other construction materials) in a more effective way. This should lead to a reduction of environmental impacts without compromising standards and aesthetics.

The building industry has been reported to cause increased levels of pollution during the extraction, processing and transportation of raw materials. For instance in the United Kingdom, it has been reported that dwelling and household usage accounts for 50% of all energy consumed and about 8% (350 PJ per year) is used to manufacture and transport building materials. (Adalberth, 1996 in Morel et al., 2001). Waziri et al. (2013) compared energy consumed as well as the amount of carbon emissions between Compressed Earth Bricks (CEB) and other conventional bricks. CEB was reported to generate about 22 kg CO_2/tonne with concrete blocks producing, 143 kg CO_2/tonne, burnt clay bricks, about 200 kg of carbon dioxide (CO_2) per tonne and perforated concrete blocks 280–375 kg CO_2 per tonne. This implies that CEB uses about 10% of the input energy compared to the production of burnt clay and concrete masonry units. Earth bricks have numerous advantages both for man and the environment. With the present global concern about the environment and its sustainability, attention is beginning to shift to energy efficient and environmentally friendly construction materials. Based on this fact, earth construction remains the best and the most effective way of addressing the housing deficit and simultaneously reduce the environmental impact of building construction, as well as reducing the housing energy needs.

According to UN Habitat Report (2011), *"much more can be done in Africa to reduce the cost and increase accessibility of building materials whilst harnessing their ability to contribute to local economies and provide employment opportunities. Increasing affordable housing supply must equally be achieved in a way that is environmentally sustainable and does not affect local, international, and continent's ecosystems and natural resources in adverse manner"*.

Earth bricks, especially compressed earth bricks, are naturally available, economically viable, environmentally friendly and above all energy efficient to produce. It is an ideal material for sustainable construction, but despite the environmental advantages and cost benefits, it is frequently regarded as a building material for the underprivileged and often considered as second class building material for low income earners. This perception and non-acceptance by some governments are due to the inappropriate use by the so-called poor people. Low income communities use earth materials in its simplest, natural form without any improvement. This has led to low acceptability amongst most social groups and resulted in earth materials not being widely recognized by authorities in many countries. Standard building codes and regulations for the use of these natural materials have therefore not been fully developed. With the recent trend in reviving the use of sustainable materials in construction, coupled with the research work in this regard and the aggressive promotion of this style of construction by international organizations (e.g. UN, UNIDO, WHO, CRATerre-EAG) earth material is now more acceptable for use in the realization of decent housing, especially in Africa. This is with an aim of bridging the housing deficit that exists in the world and this new trend and aesthetically pleasing architecture utilising earth materials are now acceptable as a viable construction material in modern housing developments. It is now realised that the past negative perception is not necessarily about the material, but rather, how it is being used by different levels of society. Fig. 1 shows a poorly constructed earth building and the new faces of modern earth construction, (compressed earth and fired bricks).

2. Definition of compressed earth blocks/bricks (CEBs)

Stulz et al. (1993) defined compressed earth blocks (CEBs) as *"masonry elements, which are small in size with regular and verified characteristics obtained by the static or dynamic compression of earth in a humid state followed by immediate demoulding"*.

Compressed earth bricks are mainly composed of earth materials (soil) with their cohesion due principally to the clay fraction present in both humid and dry states. Earth strength characteristics and cohesion could however be enhanced by the addition of a stabilizer.

The final feature of CEBs are dependent on the kind/quality of raw materials utilised (e.g. the kind of stabilizer, soil) and on the steps and expertise in executing various stages of manufacturing i.e. the preparation of materials, addition and mixing of stabilizers and compaction or compression up to curing stage.

In this paper, the term "Compressed Earth Bricks" would be adopted implying the commonly used terms "Compressed Earth Blocks" or "Compressed Stabilized Earth Blocks".

Laterite or lateritic soil remains one of the best natural materials to be used in compressed earth bricks, because, it is generally well