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"Kuyyussu" as a Construction Material

Dejen fayisa[1*]

[1]*Department of Architecture and Urban Planning, Ambo University, Ethiopia.*

Abstract

The material and procedures presented in the study that can be applied in Ethiopia are briefly discussed in this report to reduce greenhouse gas emissions in the building industry. The usage of sustainable materials in the past, as well as related durability difficulties and the effects of today's energy-intensive materials on carbon emissions and sustainability, are all to be examined.
It's becoming difficult to meet the fast-rising demand for low-impact construction materials. The introduction of innovative construction materials is critical in reducing carbon emissions and ensuring that everyone has access to affordable homes. The finding of the present-day study revealed that conventional building materials such as Iron, Brick, Concrete blocks, and cement components have high carbon emissions. The production and transportation of such material lead to a relatively high level of greenhouse gas emission. producing the material at the construction site to reduce transport and greenhouse gas emissions. Examples of low embodied energy materials are provided. The goal of this research is to develop acceptable building materials and easy construction systems for eco-friendly kuyyuusu block construction in Ethiopia. Finally, conclusions and recommendations will be generated based on the findings. Furthermore, a material suggestion for zero-emission materials and procedures was made.

Keywords: Kuyyuusu; sustainability; local material; environmental impact; building materials

1. Introduction

Building materials technologies and building practices have evolved through the ages [1]. The art and science of building construction commenced with the use of natural materials like stones, soil, thatch/leaves, unprocessed timber, etc. [2]. Hardly any energy is spent in manufacturing and use of these natural materials for construction. Some problems associated with the durability of natural materials like soil, thatch/leaves, timber, etc. led to the exploration of durable building materials ever since man started construction activity [3]. Brick burning represents one of the earliest examples of using thermal energy to manufacture durable building materials. Metal products, lime, and lime-based products represent the other manufactured energy-consuming materials used for the construction. The discovery of natural inorganic binders like pozzolanic materials resulted in lime-pozzolana cement and this paved the way for the invention of Portland cement in 1824 [4]. Portland cement and steel brought revolutionary changes in construction practices since the early part of the twentieth century. Later on, plastics and plastic products entered the construction industry. Thus, the journey through the developments in building materials and technologies is traced as we moved away from zero energy materials to more modern materials for construction activities, it became imminent to spend more energy and natural resources. These modern materials are energy-intensive and are hauled over long distances before being used for construction.

Climate change is among the most important issues of our time Rising global temperatures, have severe effects on the earth's natural systems and human society disrupting the economic system, shortage of clean living conditions, and increase in disease. Weak and unstandardized construction techniques, deforestation, use of uneconomical and energy inefficiency materials, are the major problems this research is going to solve [5]. Almost all the traditional construction materials in Ethiopia depend on wood as the main construction material of walling, roofing, and flooring which leads to the over-deforestation of trees.

The objective of this research proposal is to analyze the application of kuyyuusu block as a sustainable construction material and to investigate alternative material provisioning techniques to address concerns about current greenhouse emission approaches to assessing the availability of environmentally friendly building materials in Ethiopia. Also, to transfer the knowledge about kuyyuusu block to the construction industry. The goal of this study is to apply kuyyuusu block construction materials in the

construction sector by making good use of readily accessible and efficient materials. And also, has been to study and analyze different factors affecting the spread of the kuyyuusu block-building technology in Ethiopia.

The long-term aim of the project is to show how we Ethiopians can use the kuyyuusu block material to build climate-smart buildings economically. The study will focus on sustainable and impact Building materials that is sourced and manufactured locally to the building site Earthen materials especially mainly focus on kuyyuusu block use as plaster, paint, flooring, wall, etc., where possible to minimize the energy used through transportation. The goal of this research project is to design an alternative and low-impact sustainable construction material building prototype that can be used in both urban and rural areas of the country.

2. Materials and methods

2.1. Data sources

Primary data was collected by observing the sites and taking pictures, and data was collected from construction laborers and men, while secondary data, which comprises the literature review, was collected by reviewing different research works and texts dealing with the concept of environmentally sustainable building. An in-depth study of material describing the environmentally sustainable and affordable house buildings concept and examples of how it has been implemented were consulted to have ideas about how the concept could be adapted to the housing project and will be used in the interpretation of the results. The interviews were conducted with the construction laborers and farmers. This method was chosen as a primary data collection technique/method mainly because of data on several environmentally sustainable building materials.

Site observations were conducted to gather data on whether any environmentally sustainable building concepts and any housing units had been incorporated in the new buildings' construction; whether any environmentally sustainable houses built by locally available construction material concepts had been initiated by the dwellers; whether the buildings were being utilized according to the plan and to verify the dwellers' answers from the interviews.

The primary data was collected through personal observation, laboratory analysis, and questionnaires. The questionnaire was conducted on prepared questions by asking the society in the written ways and persons living in mud / compressed earth block houses were selected randomly for the questionnaires from selected sites. The physical survey was employed to survey the ingredients, block size, constraints, construction techniques, and any metric measurements of the data on the mud/ compressed earth blocks.

The secondary data was collected from written documents master plans and/or Google Earth maps. The written document was used to read and collect the necessary documents about this study. This was performed on the local and international understanding of people's perception toward the mud/ compressed earth block houses. The master plans and/or Google Earth maps were used to indicate the location of the site and site geography, information about the study sites, and the appropriate location, position, amount, and arrangement of the buildings. Besides this, Zonal and regional offices, reports, books, journals, the internet, and other published and unpublished sources were the sources of secondary data collection methods in developing knowledge on the mud block and mud block housing.

2.2. Site

The study will be carried out within 250,000 m2 (500 m x 500 m) at about 30km south of ADAMA town in Dodota Farmers land in Dodota district at about 130 km east of Addis Ababa. The site was purposively selected because of its high termite mound densities and accessibility. Dodota area is characterized by a semi-arid climate and the natural vegetation is composed of sparsely grown acacia trees and shrubs of various species as well as grasses. Generally, the soils of the area range from sand to loam, loam to sandy clay loam with some clay loam and a few clay soils. The soils of the area are characterized by numerous gray-to-gray, brown termite mounds. Maize, haricot bean, teff, wheat, and barley are the major staple food crops grown by large-scale farmers in the area. The study site was in farmlands that had been under cultivation for a long period and most of the mounds looked very old and eroded and new termite mounds were not found on cultivated lands. Whereas, on the narrow stripes of uncultivated land left for demarcation as borders between adjacent farms belonging to neighbors, small and young mounds were observed, and these were always dug by aardvarks. Active and rapidly growing mounds were observed closer to the study site on uncultivated lands along the roadsides of the main road from Adama to Arsi Asela.

2.3. Materials involved

Termite Mound Density, Dimensions, and Status Mound density were determined by counting all the mounds within the study site of 500 m x 500 m and dividing the total number of mounds by the total area (Abdurahman, 1990; Meyer et al, 1999) using the formula d = n/s, where n = number of mounds sampled and s = area sampled. Local people measure farmland by qarxii which is equivalent to 50 m x 50 m (0.25 ha

The soil was crushed to obtain the desired particle size for laboratory investigation. Samples of TMSs. Bricks Production and Characterization Wooden molds prepared to the desired dimensions (L x W X H) were used to make the bricks from the soil. The molded bricks were left in a shed to be dried with air. The time of drying was dependent on the moisture content of the green bricks and the humidity of the production area.

Figure 1 kuyyuusu

Figure 2 Fiber

Thermite soil/ Kuyyuusu is one of the most needed materials for my research. Fiber is used to increase its strength according to what is needed in this project. Fine sand and gravel sand are used. Gypsum (calcium sulfate) powder is used for fast drying, to reduce the weight, and to accelerate its curing process.

3. Results and discussion

3.1. Fire test

The ratio selected was 1.5:1:0.5:0.1 or 50%,33%,16%, and 1% for kuyyuusu, sand, gypsum, and Enset fiber (type A), and the ratio 2:1:1:0.1 or 50%,24.5%,24.5% and 1%-kuyyuusu, sand, gypsum, and fiber (type B) respectively.

Observations about type A: Not burnt, No shrinkages, No distortion, No chipped edge, Np fissures, Maintained texture, No scratches. brick/block has good strength, modest weight, and fire resistance.

Observations about type B: Not burnt, No shrinkages, No distortion, No chipped edge, Np fissures, Maintained texture, No scratches, good metallic sound.

Figure 3 Fire resistance test-burning stage

Figure 3 Fire resistance test- after burning process

3.2. Water absorption test

The water absorption testing process was continued for 24 hours. In the beginning, the bubbles could be observed which shows the porosity of the material.

Observations about type A: Good strength, No change in dimensions, absorption less than 15%, no visual difference in the texture.

Observations about type B: Good strength, No change in dimensions, absorption less than 15%, no visual difference in the texture.

3.3. *Drop test*

The test is done by dropping the blocks from 1.5 meters high. The process was repeated three times for both types of blocks. No serious damage could be observed during this test. A slight damage could be observed to the edges and corners of the blocks.

3.4. Compression test

The compression strength was done with a compression test machine. It was observed that the blocks could bear the compression of 4.1 MPa.

4. Conclusion and recommendations

This study briefly discussed the material conditions, construction methods, and local community perception of the kuyyuusu brick/block houses typology and durability in the mentioned different ratios which will be suitable for different climatic zones. The factors that affected the housing condition were moisture, ground soil swelling and shrinkage, lack of structural columns and beams, and surface wash of walls by rain. The kuyyuusu or termite mound soil used, the amount and types of admixtures or components used, and the climate zone in which the buildings are built all have an impact on the environmental resilience and longevity of kuyyuusu block/brick houses.

Excessive uses of HCB, concrete, wood, and fired brick as a building material contribute to deforestation, and air pollution and are energy inefficient, environmentally unsustainable, and uneconomical to use. Kuyyuusu brick/blocks are molded from thermite mound soil and other components like: - gypsum powder, Enset fiber, and sand as in the study ratios. According to the

research and interviewee remark, stabilizers are critical components in increasing the strength of the blocks by improving compressive strength, water resistance, and cohesiveness.

Besides the admixtures, the main input used is thermite mound soil is good for construction due to its compressive strength, water resistance, and cohesion. Even if the strength of kuyyuusu block depends on the amount of kuyyuusu and admixture appropriate ratio.

kuyyuusu block houses are more economical and environmentally sustainable compared to all other construction materials. Termite mounds, the main ingredient for molding kuyyuusu brick/blocks are accessed from the local (Dodota), temperate zone and the cost used for converting thermite mounds and admixture in to block is very too low compared to the cost used for molding concrete block or burned brick. In addition to the main ingredient used, the amount and types of admixture used in molding kuyyuusu block are economical.

In kuyyuusu block constructions the most commonly used admixture is sand, Enset fiber, and kuyyuusu soil which is accessed from local. Enset fiber and gypsum powder as admixtures are used for the production of durable, crack-resistant, and weightless kuyyuusu blocks.

The present study suggests the following recommendations:

- The use of kuyyuusu block houses should be taken and strengthened as alternative walling and flooring material in Ethiopia.
- The local community shall use the locally available, affordable, and environmentally friendly kuyyuusu brick/blocks as construction materials to reduce the ever-increasing deforestation construction cost and environmental problems.
- Due to its high moisture resistance and fire resistance, the kuyyuusu brick/block construction with (gypsum powder, Enset fiber, and sand) is ideal in desert and highland environments. However, the methods for constructing kuyyuusu brick/block dwellings in various climates can be inconsistent. Additional study is required to standardize kuyyuusu brick/block construction techniques and practices.
- The present study also recommends that further studies be performed to select the best kuyyuusu brick/block ingredients that could fit the different climatic zones

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