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Alternative Building Materials for Sustainable Development in Ethiopian Construction

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ABSTRACT

The building construction industries are boosting globally and consuming huge amounts of resources. Ethiopian government has identified construction industry as one of the three sectors of the economy to accelerate the country's economic development. Usually, conventional building materials such as iron, cement and concrete are not produced in sustainable ways. The production and transport of such materials lead to relatively high levels of greenhouse gas emission. Alternatively, there are also locally produced and used building materials that do not cause substantial CO_2 emissions. Low cost housing become must in civil engineering. In this report some methods of low-cost housing are discuss in brief. The materials discussed in the study are available or can be arranged easily around Ethiopia.

Keywords: Alternative building materials; Low cost construction; Ethiopian construction.

I. INTRODUCTION:

The construction industry in Ethiopia is an area that opens the door for the growth of many additional industries. Construction industry is one of the three sectors of the economy identified by the Ethiopian Government for special consideration to accelerate the country's economic development.

Now a day's building construction industries are boosting globally and consuming huge amounts of resources. Usually, conventional building materials such as iron, cement and concrete are not produced in sustainable ways. The production and transport of such materials lead to relatively high levels of greenhouse gas emission. Alternatively, there are also locally produced and used building materials that do not cause substantial CO_2 emissions. Moreover, they create local employment and promote local craftsmanship, which can be truly sustainable. In this study, some examples of sustainable building materials including bamboo and wood, as well as earth and adobe blocks are discussed. With these materials, new technologies based on traditional building methods can be developed for the construction of housing that at the same time is sustainable and affordable for the urban poor. [1]

II. STATEMENT OF PROBLEM: Housing is a basic need of human being. But this is not affordable for low-income people who constitute majority of the population in the country. Low cost housing has become prime focus in civil engineering. In this report some methods of low-cost housing are discussed. [2]

Construction projects in developing countries consume high amount of resource during the execution of the work due to the improper management of the construction resource. Like most of African countries, Ethiopia is one of developing countries, that depends on the improper resource management on construction projects. In this system there is a barrier to achieve good way to manage resource on construction project. There are many factors that lead the improper resource management in construction project.

The vast majority of Ethiopians live in poorly built, dilapidated and cramped houses which lack even the basic facilities, such as toilets and ventilation. Only 30% of the current housing stock in country is in a fair condition, with the remaining 70% in need of total replacement. Access to safe drinking water is 49% countrywide, only 20.7% of the population has access to adequate sanitation according to UNICEF, 2011.

According to the Human Development Report (2014) Ethiopia ranks number 173 of 187 countries in the

world. This low ranking reflects poverty and harsh living conditions of the vast majority of the people in the country. To improve this situation, a number of important measures must be taken. One is to give the Ethiopian people the opportunity to get better housing. The need for this can be identified over large parts of the country; both rural and urban. This need has to be addressed in relation to the large, general problems which country is facing. Of these problems, a high population growth, an increasing deforestation and an uncontrolled urbanization process can be regarded as the most serious. [10]

III. SIGNIFICANCE OF STUDY: The goal is to aware all Ethiopian population, specifically the stratum with very low incomes, the possibility to get affordable and decent housing. In addition to this, the houses must have a healthy indoor climate by using types of alternative material without polluting the environment, that must be safe, durable and sustainable.

IV. SUSTAINABLE CONSTRUCTIONS: The construction involves reducing the environmental impact of the building over lifetime, while optimizing its economic viability. Some of the factors which are considered in sustainable design are Energy efficient buildings, re-use existing structure, efficient using of land, the most important using of renewable products or materials, and reduce or eliminate pollution. [6]

V. REASONS FOR NEED OF SUSTAINABLE CONSTRUCTION

- Sustainable construction used in social progress i.e. which recognizes the needs of everyone.
- Used for environmental protection effectively.
- Extensive use of natural resources.
- Maintenance of high and stable levels of economic growth.
- Reducing the overall cost.[6]

VI. COMMON SUSTAINABLE MATERIAL AVAILABLE AROUND ETHIOPIA

A) ***Bamboo*:** Ethiopia has an estimated one million hectares of natural bamboo forest, the largest in the African continent. Despite the versatile resource base and advanced bamboo utilization at a global scale, its great potential to enhance socio-economic and ecological development remains unrealized in Ethiopia. [3]

According to, Bamboo Senior Expert and Technologist, Mulatu Teshale agrees upon the aforesaid statement. He says bamboo in Ethiopia is not well utilized beyond construction of a houses, boats, fencing, house furniture and equipment. Thus, its huge economic contribution is underestimated and unable to play its stake in generating foreign currency accordingly. [8]

Bamboo, a grass, is widely available in tropical climates and has been used by generations for construction purposes and as artefacts. However, until lately, it has been considered a Constructional material for 'poor' settlements. Bamboo is a superior construction material as Compared to timber because it has excellent mechanical (tension and bending) and anatomical properties for its low weight. [4]

B) ***Manufactured Sand***: The consumption of natural river sand is very much high, because of more usage of concrete. As Ethiopia is one of the under developing countries, rapid construction is going is on around the country, and the shortage of first-class concrete is the problem. Due to more construction, river sand is becoming very much expensive and demanding.[7]

Manufactured sand is one of the good alternative materials to replace natural river sand. The term Manufactured sand is nothing but the aggregate material whose size is less than 5.0mm. The supply of m-sand is from crushing plant, where the hard rocks and over size stone used to crush in smaller particles. [9] Manufactured sand offers important economic advantages in regions where the availability of natural sand is scarce or in cities where transportation cost is high as in the case of Addis Ababa and Jimma. To minimize cost of manufactured sand transportation, more advanced mobile plants might be a solution.[5]

The use of manufactured sand in the construction industry helps to prevent unnecessary damages to the environment and provide optimum exploitation of the resources. [5]

C) ***Straw Bales:*** Agriculture is the mainstay of the Ethiopian economy, contributing 41.4% of the country's gross domestic product (GDP), 83.9% of the total exports, and 80% of all employment in the country.[12]

Straw is the dead, dried stems of cereals. It is left over after the grain is removed in the harvesting process. Wheat, sorghum, sesame, rice, and some herbalists are the most commonly grown cereal crops around the country. Some of their straw is currently used for animal. A certain amount would still be required for these purposes. The straw when bundled together into a bale with various shapes and sizes, it becomes a solid block that is highly resistant to decomposition beside it is flexible and easy to work with. [11]
Straw bale is a rectangular compressed block of straw, bounded by ties after harvesting using mechanical baling equipment, at moisture contents of less than 20%. [11]

Straw bales have a good insulation property i.e energy efficient, which helps in reducing cost of cooling in summer and heating in winter, good sound insulation property, and provides high fire resistance when combined with plaster. It also has ability to withstand the vertical and lateral load in addition to seismic loads. Finally, it's a low-cost material with relative to its availability. It is considered as recycled materials from remnants of the harvest, this contribute to the conservation of the environment. [11]

D) ***Ferrock Cement:*** Cement in concrete, the second most used entity after water in the world today, is the fourth largest source of anthropogenic carbon emissions. It's been called the foundation of modern civilization. For each ton of cement produced more or less eight ton of CO_2 is released. It is terrifyingly polluting the environment. [13]

In recent times this problem is addressed by the use of Ferrock. The name Ferrock is a reflection of its composition – largely iron-rich ferrous rock. It's actually created from waste steel dust which is normally discarded from industrial processes and silica from ground up glass. The iron within the steel dust reacts with CO_2 and water to form iron carbonate. It is this that is fused into the matrix of Ferrock and, like concrete, after it is dried, it cannot be melted back into a liquid form but retains its hard, rock-like qualities. [14]

Currently, there are around 241 small, medium and large factories involved in steel and iron production. After looking at the high demand and supply gap in the steel market, a South Korean based company, Ekos Steel Plc. came here and built a steel factory in Dukem. By the Ethiopian new year, they should begin manufacturing steel. Capital's Tesfaye Getnet went to Dukem and talked with Shell H. Choo CEO of the company to learn about the plan of the factory, according to capital Ethiopia (august 2018).

The study found that the strength of Ferrock concrete is twice that of conventional concrete. Since Ferrock, being Environmentally friendly and all the raw materials used are from waste metal powder, by using these to make concrete is an efficient concreting technology both in terms of strength and environmental efficiency. [14]

E) ***C & D Waste***: "Sustainable building" has become a national catchphrase. In architects' offices and on construction sites around the country there is increasing emphasis on reducing the environmental impacts of renovation and new construction. Ranking systems like the U.S. Green Building Council's Leadership in Energy & Environmental Design (LEED) and Green Guidelines for Healthcare gain momentum from month to month. [16]

Demolition waste is waste debris from destruction of a construction. Construction industry generates about min 10-12 million Tons of waste annually country wise. While Retrievable items like bricks, wood, metal, tiles etc. can be recycle. [15]

- *Why recycle C & D?*

1. Construction and demolition wastes are one of the largest waste streams in the country.
2. Almost all job site wastes are recyclable.
3. It costs less – usually much less – to recycle job site wastes than to throw them away. [16]

➢ *Embodied Energy:* **-**

The embodied energy of a material refers to the total energy required to produce that material, including the collection of raw materials. This also includes the energy of the fuel used to power the harvesting or mining equipment, the processing equipment, and the transportation devices that move raw material to a processing facility. This energy typically comes from the burning of fossil fuels, which are a limited, non-renewable resource. The combustion of fossil fuels also has severe environmental consequences, from localized smog to acid rain. The greater a material's embodied energy, the greater the amount of energy required to produce it, implying more severe ecological consequences. For example, the processing of wood (harvested in a sustainable fashion) involves far less energy and releases less pollution than the processing of iron, which must be extracted from mined ores.

A revision of a manufacturing process that saves energy will reduce the embodied energy of the material. Conventional materials with a high embodied energy can often be replaced by a material with low embodied energy, while using conventional design and construction techniques. Following table compares the embodied energies (MJ/kg) of virgin and recycled materials [19].

Material	***Virgin***	***Recycled***
Aluminium	196	27
Polyethylene	98	56
PVC	65	29
Steel	40	18

All figures are for MJ/kg

F) ***Compressed Earth Blocks***: Soil being readily available, represents the earliest construction material to be used by mankind. Earthen construction technologies have evolved from manufacturing (low strength and less durable) plain mud-straw utilized sundried brick. But the modern construction materials are quite energy-intensive as they involve burning of fossil fuels which are rapidly depleting.[17]

Compressed soil block, is a building material made mainly from damp soil compressed at high pressure to form blocks. Compressed earth blocks use a mechanical press to form blocks out of an appropriate mix of fairly dry inorganic subsoil, non-expansive clay and aggregate. If the blocks are stabilized with a chemical binder such as Portland cement, they are called compressed stabilized earth block (CSEB) or stabilized earth block (SEB). [18]

The advantages of the CEB: On-site materials can be used, which cuts cost, reduces transport costs for materials, and rises efficiency and sustainability. [17]

VII. CONCLUSIONS:

- The materials discussed above are available or can be arranged easily around Ethiopia.
- These materials can be a good alternative for low cost construction in Ethiopia.
- If practically implemented, it would transform the construction industry by addressing all the environmental concerns of sustainability.
- Study concludes sustainable building materials are locally formed and sourced which drops transportation costs and CO_2 emissions.
- Materials like bamboo, manufactured sand, earth blocks, c & d waste are abundantly available around country that could be a replacement of conventional material.
- The use of these materials not only reduces transport costs, carbon emissions, materials costs, it also offers employment and skills development opportunities around Ethiopia.

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