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Construction Materials: Modern Techniques for Green Home

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ABSTRACT: In most of the building projects, the selection of construction materials takes place at the stage of design development. Nowadays, many new emerging innovative materials are being invented, and lots of new materials are being in research. New innovative thinking and new invention are necessary to save lots of our valuable time and energy. The application of innovation to the construction industry is not straightforward. Every construction project is different, which means construction companies must adapt their processes and resources to suit each project. The anticipated revolution in construction is gaining momentum. Researchers of various institutes are taking technology to the next level with development in concrete and different other construction materials. Indeed, selecting the appropriate sustainable materials for a building is an integral part of good design and the key to good design lies in realizing the importance of occupant health and comfort, and harmonizing it with the inherent properties of materials. Consequently, evaluating the properties of sustainable building materials and their impacts on the environment becomes central to the design and construction of green buildings. This article highlights some of the suitable sustainable construction materials for the green home.

KEYWORDS: Aluminium Metal Foam, Bio-char, Graphene, Laminated Timber, Metakaolin, Modular Bamboo, Papercrete

I. INTRODUCTION

[1] Green materials are now the preferred material for construction since they are capable of lighter weight and affordable (Shewit Birhane, Mikyas Mesfin, Werku Koshe, 2017). Choosing material in architecture includes numerous design considerations. Physical characteristics, including its performance and visual appearance, are on of the main considerations in choosing building materials. The material chosen must be able to produce the visual appearance in accordance with the concept of the building. For physical appearance, a material has a different performance depending on the raw material, additive material, and the manufacturing process. Along with structural importance & constructional behaviour, visual impact with the historical value of particular materials gives an essence of built environment.

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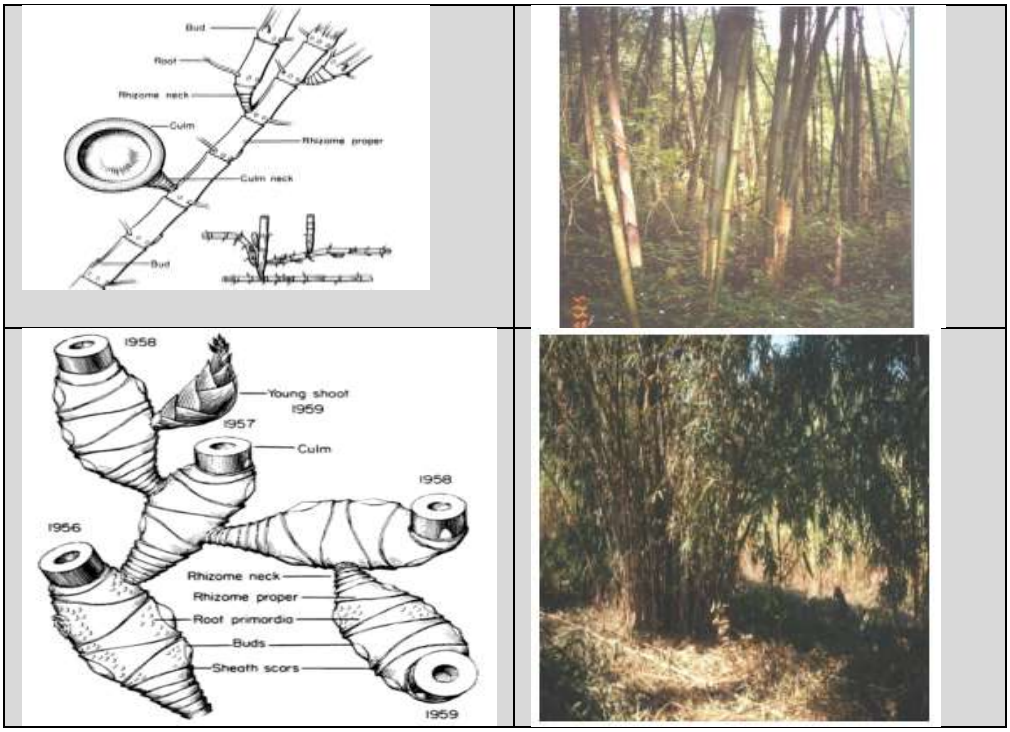

Figure 1. Basic forms of the subterranean parts of Monopodia Bamboo in Ethiopia and their terminology.

II. SELECTED MATERIALS FOR CONSTRUCTION

2.1 Bamboo as Construction Material

[11] Bamboo as a building material can be used in various forms. Bamboo reinforcement as replacement reinforcement is gaining immense importance today, mainly on account of the improvement in the economical aspect combined with ecological benefits. An engineered Bamboo of steel can substitute steel in making tensile stresses of RCC members and also reduces the consumption of cement in building. Bamboo's growth is more rapid than any other tree species on the planet, even faster than Eucalyptus species (locally we call it Baher Zaf) that can be annually self-renewable, wide spread, low cost , enhancung resource with grate potential to improve alleviiation and environmental conservation and harvestable if managed properly. Bamboo is a high yield renewable natural resource for agro forestry and engineering based products.

In Ethiopia, it is found in differnet parts of the country.These are:

- In Southern Nations, Nationalities and Peoples Regional State (SNNPRS):-(Agere-Selam, Chencha, Indibir-Jembero, Jima-Ameya, MizanTeferi-Kulish, Wushwush-Bonga, Bonga-Ameya, Masha, Shashemene)
- Oromiya National Regional state:- (Agaro, Gera, Bale Mountains, Shenen-Jibat Mountains, Gera, Gera-Lola),
- Amhara National Regional State: -(Injibara, Choke Mountains)
- Also in most parts of Benishangul Gumuz Regional state and others.

[11, 12] Bamboos are perennial woody grasses belonging to the Poaceae (Gramineae) family and Bambuseae subfamily. Since most bamboos have a tree morphology and attain tree size at maturity they are named tree-grasses. The main stem of the aboveground part of the plant is the culm, while the underground part constitutes the rhizome and root system. The mature the culm of the Ethiopian highland bamboo is hollow, while that of the lowland bamboo is solid.

[12] Bamboo, being a circular, hollow structure has certain mechanical and structural advantages and disadvantages as compared to a rectangular solid timber of the same cross section. These advantages and disadvantages are, in other instances, complemented or accentuated by the cellulose fibre make up of the bamboo. Advantages of Modular Bamboo

- It is an ideal construction material as it is durable, sustainable and environmentally friendly.
- It is as strong as steel in terms of tension because of its cylindrical and hollow.
- Related to this it is stronger than compression in terms of compression, thereby giving it a

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high strength – to – weight ratio.

- Less in weight when we compare with other construction material such as concrete, wood and also steel.
- It's a flexible material, so it may be curved or flattened by the application of heat or pressure.
- Naturally water resistant unlike that of wood, steel and others.
- In addition to this Bamboo may be easily treated with borax and boric acid as a fire retardant, fungicide and insecticide.
- It has low cost (cheaper) when we compare with other types of construction materials.
- The building is light and has a very comfortable internal ambiance.
- The construction time or period is faster than construction time being taken up by cement, sand , mortar plastering and floor screeding.
- Its highly resistant to earthquake because of it has high stiffness in relation to its weight

Generally, the above listedare some of the advantages of Modular Bamboo.

3.2 Disadvantages of Modular Bamboo

- If the Bamboo is not treated with borax or boric acid, it will be attracts fungi and insects due to high level of starch.
- Has poor fire resistance and limited durability when exposed to UV rays and humidity.
- In some area or country of the world is not readily available.
- When we see the technical aspects, its difficulties of building with bamboo is joining them together
- The cost of labour as a percentage of cost of materials is relatively higher.
- Lack of straightness and uniform culm thicknesh problems

More over less these are some of the disadvantages of Modular Bamboo.

2.1.1.. Application of Modular Bamboo in different sectors

As we know Bamboo is very useful for the production of different kinds of furniture, accessories, scaffolding, paper, medicines and also Roads and bridges. Some of the following applications are shown below in figures (1- 4).

Figure-1 Bamboo House

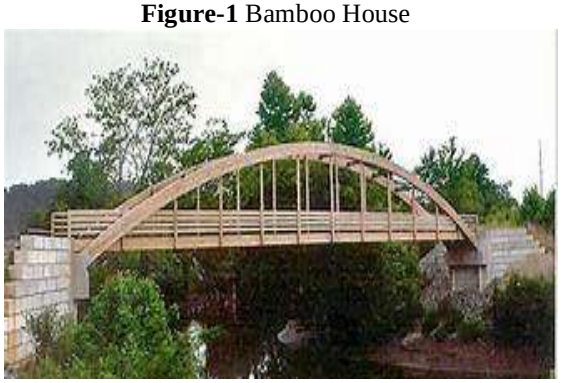

Figure-2 Bamboo Bridge

Figure-3 Bamboo Roof

Figure-4 Bamboo Scaffolding

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2.1.2. Environmental health, social and economic benefit of Modular Bamboo

Bamboo is a highly sustainable plant. It can grow to full size in just 3 to 4 months in the right condition; it can grow 3 feet tall in 24 hours which means you can literally watch it grow with your own eyes. This makes it a super sustainable alternative due to its naturally renewing properties. There are many reasons why Bamboo is important for sustainability and healthy environment. These are:

- ❖ Bamboo is the fastest growing plant on earth
- ❖ It's strong and durable. Bamboo named as green steel for its versatility and strength.
- ❖ Also it's safe and hygienic. Naturally bamboo fibres are anti bacterial without needing any toxic chemical treatments.
- ❖ Bamboo is good for the Community. In our country, Ethiopia as far as in the world the bamboo production and manufacturing sustains the traditional industry and creates new well playing stables jobs for locals in areas that need social and economic stability.
- ❖ Bamboo is great for the environment. The bamboo forests have enormous positive benefits for the environment as this incredibly productive plant efficiently stores carbon. It absorbs large amount of carbon dioxide from the atmosphere and release large amount of Oxygen to the surrounding environment or atmosphere.

Generally, Bamboo has great role in protecting the biodiversity and endangered species by creating homes for a variety of different animals. Even though we had use the Bamboo forest in construction industry and manufacturing of different materials it's expect from us to conserve the bamboo plant by planting again after cutting (reforestation).

2.2 Aluminum Foam as construction material

In collaboration with steel, aluminum foam is perfectly suited for light-weight design, in particular as sandwich structure with cover sheets. Those sandwiches are highly versatile and convince due to their excellent properties. That is why they are ideal for an employment in the building industry:

- high bending stiffness with low weight,
- effective shielding against electromagnetic waves,
- burning resistance,
- acoustic insulation,
- Energy absorption and vibration reduction.

A possible field of application for sandwich panels is the industrial construction and hall building. At this point, semi-finished products can take up both supporting and stabilizing functions instead of wall bracing and bay rail. Due to a relatively high melting range of the aluminum foam and its cellular structures it has high potential for application in fire protection, especially in production halls and offices. The sandwich panels can work as wall and ceiling elements in order to reduce footfall sound. Another application could be fire prevention bulkheads between the single production- / and office sections.

For the assembly of aluminum foam semi-finished products among themselves or with other materials, practicable joining processes and joining elements were needed. Welding can be considered as an established procedure in order to join prefabricated raw materials to larger elements or assemblies. Afterwards these elements can be installed at the building site by means of screwing.

General Advantages and Disadvantages of Aluminum Foam

Advantages

- ✓ Foam blocks can floats in water.
- ✓ Foam blocks can saw drilled, cut and bend.
- ✓ By screwing and riveting foam blocks can join to dense material.
- ✓ Welding of foam block is possible, mainly laser welding.
- ✓ Foam blocks can point with organic or inorganic point.

Disadvantages

- ✓ They are difficult to manufacture as precision manufacturing is required.
- ✓ High cost.
- ✓ Difficultly in manufacturing high temperature metal.
- ✓ Once damages it cannot be repaired, the whole metal foam has to replace by new one.

2.3 Laminated Timber as construction material

[1] According to Schickhofer G and Guggenberger W, (1994), Laminated timber is an engineered wood that was developed in Austria in the 1970s and 1980s. [2] After 30 years of intensive research and development, laminated timber is gaining popularity as construction materials in residential and non-residential applications. [3] A typical laminated timber is a rectangular-shaped product made from at least three orthogonally bonded lamellae of lumbers which are bonded on top of one another in perpendicular direction using a structural adhesive. [4, 5] The resulting alternating grain directions give laminated timber strength and stiffness in two

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directions, making it suitable for primary structural material in multi-story construction such as two-way spanning slabs, walls, and diaphragm.

2.4 Marble as construction material

[13] Marble is environmentally friendly because it is a natural stone and this benefits the environment in many ways. Because it is in its natural state, marble does not require any energy production and therefore does not cause pollution and conserves energy. In addition, marble has a hot weight that helps protect your home naturally, saving energy because you will not need to heat or cool your home. [13] Marble as naturally existing methamophic calcite or dolomite mineral has a tremendous application in construction Industry. It is dimensional material needs series of production processes from quarry extraction up to manufacturing plants. [13] Marble products are used for interior and exterior of building in different applications such as floor tiles, steps, skirting, window sills and the sold as well as slurry waste generated during its processing can also be used in the cement manufacturing, as base material and coating material in road construction. The manufacturing of marble products has negative and positive impacts on ecosystem which should need mitigation. The manufacturing of marble products need huge initial investment capital and the transportation cost which can be compensated with the free of charge utilization of raw marble deposits. Even if the use of marble is old as the construction Industry, in Ethiopia it is almost new manufacturing sector and seems to sustain for years supported by technology.

2.5 Papercrete as construction material

[6] Papercrete was first patented in 1928, is a newly fashioned experimental material and recently rediscovered by individuals that are curious to test the possibilities and potentials of such material that started re-experimenting with it again. Papercrete presents high environmental potential due to the fact that it replaces an amount of cement by the use of paper and the total weight, cost and CO_2 emissions during production are reduced. It has potentials to become a future building material for lightweight applications thanks to its low cost and high recycle paper content. [7, 8] Papercrete is mainly made from recycled paper that is combined usually with sand and Portland cement creating a composite material that is malleable and can be casted and molded in various forms and shapes. Papercrete can be casted and pressed into bricks, blocks and panels and can be used in the building industry for a variety of applications. Papercrete can be used also as a casting material in-situ that can be applied directly to walls as "gunned/shotcrete" to construct monolithic structures. Waste paper can be derived from newspaper, junk mail, magazines, and books. [6] It is noticed that some types of paper work better than others; newspaper is most commonly used because it produces consistent results.

2.6 Metakaolin as construction material

[13, 14] Metakaolin is a cementitious material used as an additive to produce high strength and maintain the consistency of concrete. The cement can be partially replaced by metakaolin (0% to 10% at the interval of 2.5%) to improve strength and durability characteristics of the concrete. The color of the mineral is white, but sometimes red, blue or brown tints due to impurities. [14] Kaolinite is a naturally available rock mineral in abundance. Rocks that primarily constitute Kaolinite ($Al_2Si_2O_5(OH)_4$) mineral are named Kaolin. Kaolinite contains alternate layers of silicate sheets weakly bonded with aluminium oxide. [14] The weak bonding causes cleavage and softness to the mineral. Figure 5 shows the chemical composition of Metakaolin. Figure-6 shows the experimental study result with variations on the chemical compositions using Cement versus Metakaolin

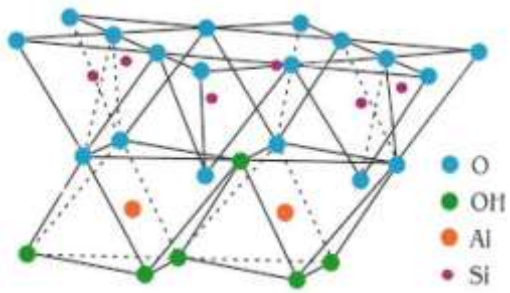

Figure-5 Chemical Composition of Kaolinite

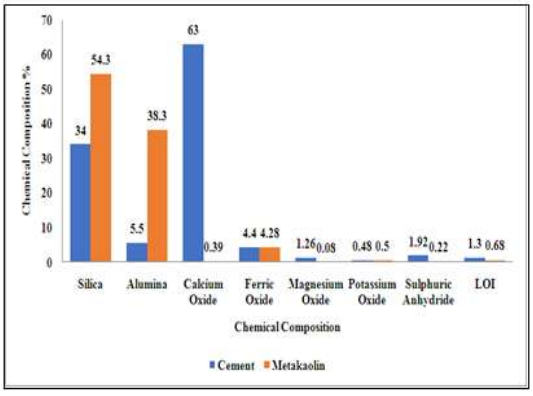

Figure-6 Variations on chemical compositions for

Cement vs Metakaolin

2.7 Fly ash as construction material

[9] Fly ash can be a cost-effective substitute for Portland cement in many markets. Fly ash is also recognized as an environmentally friendly material because it is a byproduct and has low embodied energy, the measure of how much energy is consumed in producing and shipping a building material. By contrast, Portland cement has a very high embodied energy because its production requires a great deal of heat. Fly ash requires less water than Portland cement and is easier to use in cold weather.

2.8 Graphene as construction material

[10] Graphene is a single layer of carbon atoms organized in a hexagonal lattice. When graphene sheets are neatly stacked on top of each other and formed into a three-dimensional shape, it becomes graphite. It is a waterproof layer for constructions. This feature can be also used against freezing and melting problems in building works in very cold places. Graphene is 200 times stronger than steel, lighter than paper, and with extraordinary mechanical and electrical properties.

III. CONCLUSION

- The future of construction materials or Innovative material opens up insights and choices for designers to produce more varied and creative work. Laminated timbers have high surface quality, laminated timber retains its shape & dimensions, structural stability, and it does not deform.
- Laminated timber has outstanding thermal insulation and can help save on related expenses in colder climates.
- Employment necessities are also reduced as specialists aren't required, and building can be completed earlier, meaning the building can open and start making returns faster.
- From materials that generate their own energy to those that provide greater structural protection, the future of building is evolving. While many of these innovations not yet realized on full-scale buildings, they may be making their way into our projects within the next one or two decades. Until then, staying on trend will help you improve your bottom line and play your role in keeping our environment.

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