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Alternative Materials for Sustainable Development

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Abstract: Construction materials utilised nowadays include bricks, cement, steel, aluminium, plastics, paints, polished stone, ceramics, and more. Before being used for construction, these materials must be transported over long distances, using a lot of energy. Regarding the utilisation of contemporary building materials, the following issues demand attention: Natural resources and raw materials used in manufacturing processes; energy intensity; issues with long-distance transportation; recycling and safe disposal; impact on environment; and long-term sustainability. Many researchers are looking for new materials as a replacement or alternative for the current scenario because these elements have had a significant impact on the building industry in recent years and in many regions of the world. As a result, these materials are expensive and in short supply. Numerous materials have recently demonstrated promise for usage as a primary construction material in the future. In order to promote sustainable growth, this article will showcase alternate building materials.

***Index Terms* - Building Material, Sustainability, Alternative material, Sustainable development, Ecology.**

I. INTRODUCTION

Materials that were widely used around a century ago are still in high demand in the building construction business. Different alternative building materials are available that offer better, more effective, long-lasting, and cost-effective construction as well as assure the wise use of scarce resources with the least amount of environmental deterioration.

Building procedures, technologies, and materials have changed over time. The state of a community's housing and physical structures reflects its standard of living. The oldest building materials used to make homes were stones, mud, thatch/leaves, and timber. The production and use of these natural building materials consumes almost any energy. It is debatable if materials made mostly from natural resources, such as soil, thatch/leaves, timber, etc., will last. Ever since man began building things, there has been a constant search for strong building materials. One of the first instances of employing energy (other than living energy) to create strong construction materials from the soil or dirt is brick burning. The primary energy source for burning bricks was firewood. The next energy is represented by using metal items.

1.1 Why Alternate Materials?

Regarding economic output, the amount of raw materials and other natural resources consumed, the amount of products produced, the amount of jobs created, the amount of environmental consequences, etc., the construction sector is one of the largest. According to estimates, the building industry in India contributes 22% of the country's greenhouse gas (GHG) emissions.

Building materials are in ever-increasing demand. For instance, since 1980, the demand for homes has increased by nearly double. To calculate the predicted demand, compound growth rates of 2.5%, 5%, and 5% have been used for cement, steel, and bricks, respectively. Currently, the topsoil equivalent of 300 mm from 100,000 hectares (1000 sq km) of fertile land, along with 22 106 tonnes of coal and 10 106 tonnes of biomass, are used in the brick-making process. Our 1.62 x 106 sq. km of arable land is made up of alluvial soils, black soil, red soil, laterite soil, and desert soil. Red, laterite, and alluvial soils are all good for building bricks. Not more than 50% of the property must be under soils appropriate for building bricks. The 300 mm depth of fertile topsoil on arable land may be consumed by brick-making activities to satisfy current and future demand in around 90 years (2.5% compounded growth rate). Similar pressures on raw materials and energy needed to create these materials, be addressed.
From highly decentralized, labor-intensive methods and procedures to a centralized, machine-dependent industry mode, the production of construction materials has gradually and consistently changed. A centralized production model involves long-distance transportation of both raw materials and finished goods. These actions necessitate the use of fossil fuels for transportation once more.

Another important issue that can affect the cost of supplies, increased energy usage, and environmental problems is the transportation of unfinished and finished building components. It is debatable whether the current building material production, consumption, and distribution models and construction methods now in use are sustainable.

1.2 Need for Alternate Building Materials

Energy-intensive building materials include steel, cement, glass, aluminum, plastics, bricks, and others that are frequently used in construction. These commodities are typically transported over long distances. The ecology could suffer and the energy supplies could be depleted if these materials were used extensively. On the other hand, using just conventional building materials and techniques that are energy efficient (such as mud, thatch, lumber, etc.) will make it difficult to meet the ever-increasing demand for buildings. To meet the growing demand for structures, it is necessary to make the best use possible of the energy resources and raw materials now accessible to create straightforward, energy-efficient, environmentally friendly, and sustainable building options and techniques. Following is a summary of some of the guiding ideas used to design sustainable alternative construction technologies: Reduce the use of high-energy materials; conserve energy; environmental awareness; application of environmentally friendly technologies; reduction of transportation; and increased utilisation of materials and resources available locally; a decentralized production process that makes the most of local talent; utilizing mining and industrial waste to create building materials; Utilizing renewable energy sources and recycling construction waste. Building technologies created in accordance with these principles may be more environmentally friendly, sustainable, and enable more effective resource sharing, particularly with regard to energy.

II. Various Alternative Building Material Types

Over the course of 2.5 decades, a substantial number of practical alternative building technologies have been created, which include:

2.1 Earth Construction

Building with unfired, untreated, raw soil is known as "earth construction." Since it has been used successfully for more than 11,000 years, earthen structures are thought to be used by around half of the world's population today to live and work. One of the most prevalent and fundamental building elements is earth. It is low tech, simply manipulated with basic tools, and yet anyone can use it to build walls, floors, and roofs with complex architectural designs. Buildings made of earth are extremely fireproof, non-toxic, and offer excellent humidity control and sound insulation. When constructed with thick walls and utilized in conjunction with passive solar architecture, they offer excellent thermal mass and insulation. Particularly when the materials are sourced locally, earth constructions have relatively little embodied energy and little influence on the environment. Earth is the most sustainable option in terms of both building materials and construction techniques.

A. Adobe Brick:

Native soil is used to make adobe bricks, occasionally with the addition of an organic ingredient. Knowing which types of soil to utilise is necessary to produce sturdy bricks. (Hohn, 2011). Adobe is a composite building material comprised of water and dirt that has been combined with organic resources like straw and manure. Unbaked earth is a common building material in hot, arid climates, with estimates claiming that one-third of all homes there are built with it. According to estimates, one-third of the world's population and 50% of people living in developing nations live in homes made of unfired earth-based materials. There is no denying the strength of Adobe Brick's potential as a substitute material for sustainable development. However, some disadvantages, such as best mechanical strength, physical and chemical stability, etc., turn the construction industry away from using such materials. Additionally, there are instances like "The grand mosque of Djenne" and "San Estevan del Rey Mission Church in New Mexico" that highlight the longevity of the Adobe and point it out as a reliable material with a little detrimental ecological impact. Even though the steps for manufacturing Adobe Bricks are quite straightforward, they still need to be handled carefully.

Case Study: Veena Lal's House



Fig.1: The exterior of the building is being constructed using sun-baked bricks that are then plastered with mud. Fig 2 (left): The house is made of mud, stone and wood and requires no A/C. Fig. 3(right): the flooring is from stones found around the house.

B. CSEB:

Building materials that are inexpensive, environmentally benign, and have high energy efficiency are compressed stabilized earth bricks (CSEB). The primary building material in CSEB is soil, which is also quite economical. More than 30 nations utilise it, including Mexico, the United States, South Africa, India, and Thailand. It is simple to create, serves as a concrete substitute, has undergone testing to determine its strength, and is employed in the building sector as a load-bearing material.(Mbuh Moses Kuma, 2020)

The energy and carbon emissions used in the production of CSEB and regular bricks are in stark contrast. In comparison to concrete blocks (143 kg CO2/tonne), typical burned clay bricks (200 kg CO2/tonne), and aerated concrete blocks (280–375 kg CO2/tonne), CSEB brick generates 22 kilogramme CO2/tonne during production. (Fetra Venny Riza, 2010).

Case Study: Ochre house, Banglore


Fig. 4 The three storied house located in west Bangalore is made out of load bearing CSEB Structures. Fig. 5 Most of the materials used are clay and lime and are sourced at around the site, with different types of finishes are used in the interiors and exterior.

C. Superadobe:

When combined with barbed wire reinforcement, superadobe can be coiled into vaults and domes, much like a potter coils a pot, to create structures that meet international earthquake requirements. The traditional earthen structures are stabilised, waterproofed, and finished as permanent homes using structural engineering techniques like base-isolation and post-tensioning. The barbed wire adds the tensile element to the traditional earthen structures, creating earthquake resistance despite the earth's low shear strength. Hurricane resistance comes from aerodynamic shapes, whereas flood resistance comes from easy-to-build sandbags and insulation comes from the earth itself.

Based on Timeless Materials (earth, water, air, and fire) and Timeless Principles, a Sustainable Solution to Human Shelter (arches, vaults and domes). To achieve the utmost in strength and beauty, the engineering of single and double curvature compression shell structures are used to construct the timeless shapes of arches, domes, and vaults out of earth, sandbags, and barbed wire. The self-supporting arched ceiling structure allows for the creation of either a single area or several spaces by joining different arch systems. (Kamal, 2018).

Superadobe is a type of construction technique that may be used anywhere in the world to produce either permanent or temporary constructions. Construction using earthbags is another name for it. It is a quick and inexpensive construction method. An untrained worker can readily construct a compression structure out of superadobe. To prevent over turning, it employs the structural concepts of single and double curvature compression structures with buttresses.



Fig. 6 (left) The first layer of Earth Bag, Fig. 7 (centre) Showing barb wire for Horizontal clippings, Fig. 8 (right) Above layer uses one layer of barb wire.

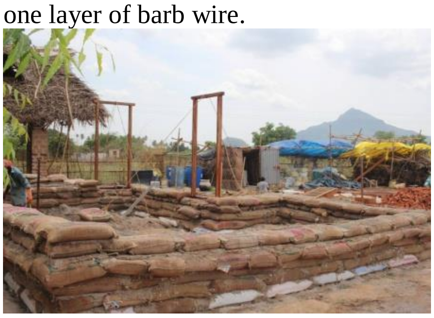

Fig. 9 (left) Showing fixing Doors and windows, Fig 10 Showing Bamboo roof. Fig. 11 (Right) Showing Painting with earth paint.

2.2 Timber Construction

One of the many forest products used globally is timber for building. It is utilized in both large and small buildings; here, we focus on timber for structures of six or more stories, as well as the biochemistry and chemistry of wood alteration that may allow for far greater structures. Although there is a global trend toward deforestation, it is typically caused by clearing land for agriculture rather than by logging for lumber, and there is sufficient global supply for the foreseeable future. However, illegal logging continues to be a problem.

How should wood be used? Timber has a high strength to weight ratio and is employed most effectively in constructions where it is bearing a lot of its own self-weight, despite the fact that there are an infinite number of designs that may be used and that construction is based on both engineering and cultural experience. Building codes sometimes take precedence over engineering in many parts of the world, limiting heights much below what is feasible with timber. We also discuss crucial issues pertaining to the service life of timber structures, which is primarily impacted by their fire performance and moisture sensitivity, and how this can be prolonged by alteration of the natural material and the use of efficient design features. Although these changes may lengthen the time that carbon is sequestered by extending life, there may be negative side effects.

Why would one want to utilise wood? Some of the highest valued products from trees include engineered forest products and construction-grade lumber. This implies that for economies that rely on forests, structural utilisation is crucial. Additionally, there are numerous secondary or tertiary uses for waste timber from construction projects that maintain its value after its first usage as a structure. When ought one to utilize wood? Given that modern lumber is generally manufactured in factories and transported to construction sites for quick assembly, timber can offer cost advantages. Since there are both regional and international markets for timber, both may be significant when determining the benefits of using it extensively. Although the environmental advantages have been proven on some projects, they are not always simple to measure or generalize.

A. Bamboo:

From the cradle to the grave, rural communities throughout Asia and the Pacific use bamboos as the single most significant item of forest produce. The term "poor man's timber" is no longer appropriate. It is one of the most sought-after raw materials in the tropics due to its well-known use as a long fibre raw material in the pulp and paper industry. The classification of bamboos as a "Minor Forest Produce" in some countries and as a "non commercial species" in other countries should be reviewed in light of their use in housing, agriculture, horticulture, fishing, basket making, transportation on land and in the water, and the production of edible shoots. The bamboos grow in abundance in the states of Andhra Pradesh, Arunachal Pradesh, Assam, Manipur, Meghalaya, N. E. Mizoram, Nagaland, Sikkim, Tripura, Orissa, West Bengal, and Madhya Pradesh and are found throughout most of India. A few species are also dispersed over various regions of the nation, in both the plains and the hills. Except for the Kashmir Valley, the bamboos can be found as an understory or in their pure form.

Bamboo culms are strong, straight, light, combined with hardness, come in a variety of diameters, are hollow, have long fibres, and are simple to deal with, making them appropriate for a wide range of uses. Without utilising a single iron nail, buildings are constructed entirely of bamboo in the humid tropics. Large suspension bridges are only constructed of bamboo or cane. (The Chinese Academy of Forestry, People's Republic of China, 1985)

Case Study: The Arc at Green School

Fig. 12,13 The Arc at Green School is made up of a series of intersecting 14-meter tall bamboo arches that span 19 meters. These arches are interconnected by anticlastic gridshells, which are strong enough to curve in two opposite directions

B. Mass Timber Construction (MTC)

Engineered wood products are the go-to structural material in the mass timber construction (MTC) method of constructing. Wet poured steel reinforced concrete, solid section "tilt-slab" concrete, and steel framing are frequently replaced by mass timber construction in these situations. Mass wood construction has been successfully applied internationally in public occupancy buildings (like libraries) and detached and multi-family residences. It is best suited for low- to medium-rise constructions.

Compared to many other construction methods, such as the manufacture of steel and concrete, mass timber construction has a lower embodied energy usage. MTC can reuse wood that has already been used and can even be recycled itself because it uses wood pieces. Austria, Germany, Switzerland, Sweden, Norway, and the United Kingdom are among the nations where the markets for MTC are maturing, with use in Australia only recently starting. According to estimates from UK, 0.3 million cubic metre of this "made" timber were built up to 2010, and 1 million cubic meters are anticipated in 2015. However, MTC has yet to establish a significant foothold outside of the European-centric bastion; for instance, there have only been a total of five projects in Australia.(P.D. Kremer, 2015)

Case Study: Wood Innovation Design Centre

Fig. 14,15,16 Showing structural detail and assembly of the MTC in the interior of the building and in the structural framework.

C. Hempcrete

Hempcrete is a bio-composite made of lime binder, water, and hemp fibre. It is a relatively light substance, weighing roughly an eighth as much as concrete. Hempcrete can be moulded (monolithic), sprayed, or precast to build walls, floors, and roofs (e.g. hemp bricks or panels) Hempcrete satisfies the criteria for an eco-friendly material. It is sufficiently made of renewable materials. Production requires less energy. It emits less greenhouse gases than it does. It offers construction that is resilient, long-lasting, and conducive to healthy living. This substance can be recycled. (Hana Bedlivá, 2014)

Hemp shivs and a lime-based binder make up hempcrete. The high-yielding cannabis sativa plant varieties used to make paper, plastic, textiles, and other industrial products are together referred to as hemp. Due to its agricultural origin and the use of lime and other industrial wastes as the mineral binders, hempcrete is successful since it is carbon negative. According to research, each kilogramme of hemp shivs sequesters between 1.6 and 1.8 kg of carbon dioxide. (Jami, 2016). Historical research revealed that hemp served the purpose of inhibiting insect activity in the approximately 1500-year-old lime and clay plaster found in the Ellora Caves. (Rizwanullah, 2016). In light of its suitability as a feedstock for a variety of industries and applications, including food, clothing, shelter, and recreation as well as more complex ones like Nanotechnology, as well as its excellent capacity to quickly sequester carbon dioxide, hemp plant cultivation for industrial uses is a viable geoengineering mechanism. (Tarun Jami, 2018)

Fig. 17 the house is mostly defined on the exterior by two perforated stones and a thin wooden sheet**.** Fig 18. the hempcrete and the other materials used not only provide good sustainability and unique feature but also great insulation

2.3 Circular Economy

In the current system, we take resources from the Earth, turn them into products, and then eventually discard them as waste. Contrarily, in a circular economy, waste generation is avoided altogether.

The circular economy is founded on three design-driven principles:

- Cut back on waste and pollution
- Distribute goods and supplies (at their highest value)
- Restore nature

It is supported by a shift to renewable energy and resources. A circular economy dissociates the use of limited resources from economic activity. It is a robust structure that benefits society, the economy, and the environment.

The circular economy is a framework for systems-level solutions that addresses issues including pollution, waste, biodiversity loss, and climate change.

A. Container Buildings

A shipping container is a steel frame, typically cuboid-shaped, with sufficient strength to withstand the transit and storage of heavy cargo. There are several different kinds of containers, from refillable to globally standardised. For purposes of international trade, the term "container" is synonymous with a shopping bag that can be put onto a variety of modes of transportation without the need to unpack its contents first. Most containers are constructed to last at least one decade, with three decades being the primary lifespan aim, depending on the function for which they are intended. To enable safe cargo transit over a long distance, they are built to be incredibly strong and secure. The average container's lifespan in use now is predicted to be ten years. (Radwan, 2015)

Case study: H-Container

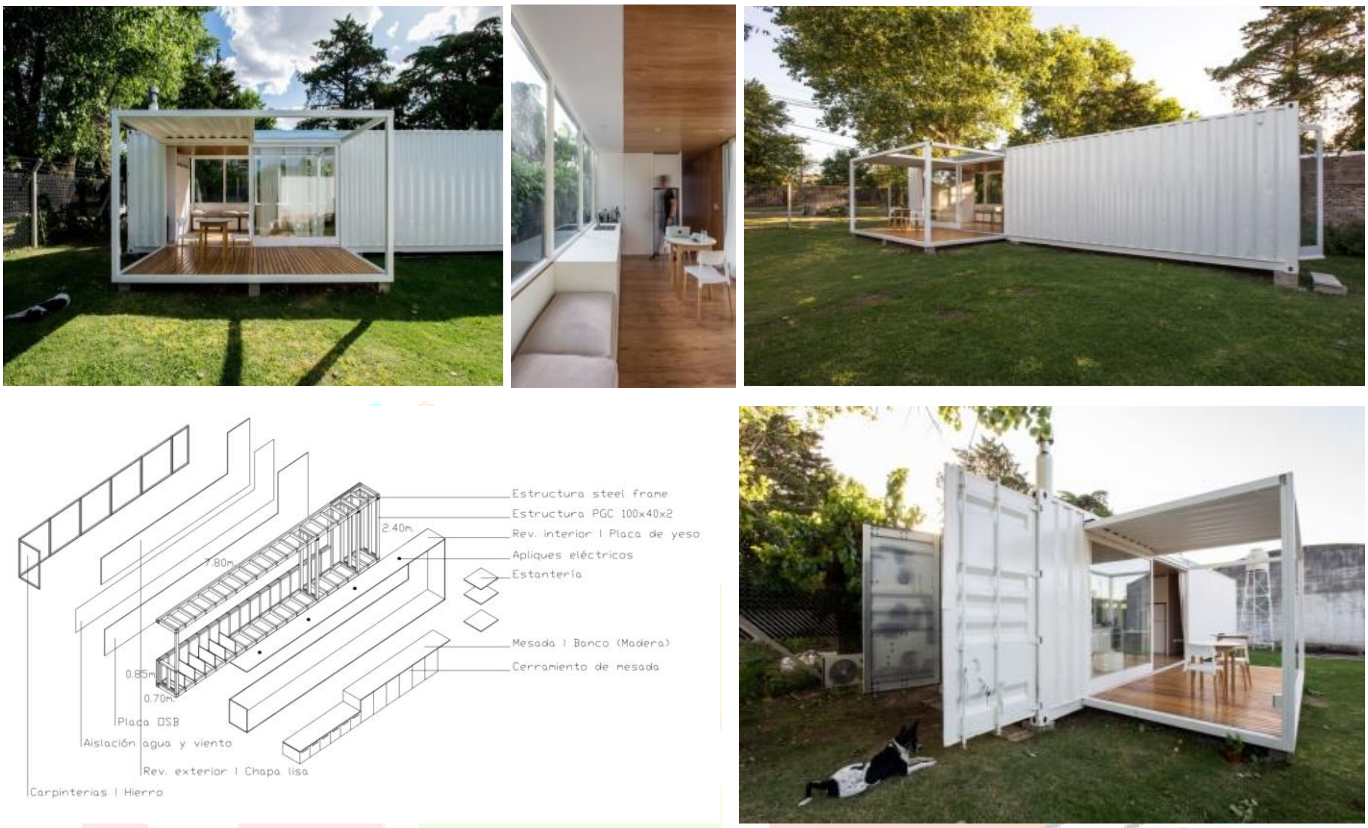

Fig 19. And 20. Showing interior and exterior views of the house and it's structural system.

B. Green Concrete

Due to factors including using waste products as a partial substitute for cement, avoiding waste disposal fees, consuming less energy during manufacture, and having higher durability, green concrete is frequently also produced at a reasonable cost. Green concrete is a type of concrete that mimics ordinary concrete but uses less energy and has fewer negative environmental effects during production or use. Between 0.1 and 0.22 t of CO_2 are released during the manufacturing of one tonne of concrete.

However, because to the enormous volumes of cement and concrete produced and the sheer volume of concrete created, the absolute estimates for the environmental impact are extremely high. Concrete contributes approximately 5% of the global CO_2 emissions and is the second most utilised material after water. Instead than using other materials in place of concrete to solve the environmental issue, concrete and cement should be used less frequently. The ability to construct with green concrete has enormous potential environmental benefits for civilization. It is reasonable to anticipate that technology can be created to reduce CO_2 emissions associated with concrete production by half. The deposit issues associated with residual products have come to the attention of society in recent decades, and as a result, demands, limits, and taxes have been put in place.

"Green concrete" refers to concrete that is produced from environmentally friendly concrete waste. Green concrete is created by using as many recycled resources as feasible and producing it with the least amount of carbon emissions. Green concrete is also known as constructions that use fewer resources and have less of an impact on the environment, such as on energy use, CO_2 emissions, and waste water. The concept of "green concrete" is novel in the history of the concrete industry. Dr. WG created this for the first time in 1998 in Denmark. Slag, waste from power plants, recycled concrete, trash from mining and quarries, waste glass, ash from incinerators, red mud, burnt clay, sawdust, and foundry sand are examples of concrete wastes.

The term "green concrete" refers to concrete that has undergone additional mix design and placement stages to provide a long lifespan and low maintenance surface, such as reducing energy consumption, CO_2 emissions, and waste water.

The Centre for Green Concrete seeks to lessen concrete's negative effects on the environment. New technology is created to make this possible. The technique takes into account all stages of the life cycle of a concrete construction, including structural design, specification, manufacture, and maintenance, and it incorporates all performance-related factors. (Neeraj Agarwal, 2016)

Fig. 21 Showing the front of the house made with green concrete and top stone cladding, Fig 22 Showing the interior of the house.

III. CONCLUSIONS

Alternative environmentally friendly building materials and technologies will be used at different levels, which will not only lower construction costs but also guarantee that the world's natural resources are not lost. It is now necessary to make concerted efforts in the direction of substituting eco-friendly materials for conventional ones. It is hoped that various government organizations, top engineers and technicians, significant consumers, and businesspeople will play a constructive role in bringing the sustainable development process to the building industry. In addition to being environmentally friendly, these materials have the following benefits when used in construction:

•Improved operational effectiveness.
•Monetary efficiency.
•Improved durability
•Simplicity in construction
•Better completion
•Little waste.
•Less expensive upkeep.
•Minimal flaws
•Less energy-consuming.

Sustainable construction procedures are a key element of eco-housing strategies using "Alternate Building Materials."

REFERENCES

I. Fetra Venny Riza, I. A. (2010). A Brief Review of Compressed Stabilized Earth Brick(CSEB). 2010 International Conference on Science and Social Research (CSSR 2010), December 5 - 7, 2010, Kuala Lumpur, Malaysia, 1012.
II. Hana Bedlivá, N. I. (2014). Hempcrete – an environmentally friendly material? Advanced Materials Research Vol. 1041 (2014), 84.
III. Hohn, C. M. (2011). ABCs of Making Adobe Bricks. Guide G-521, 01.
IV. Kamal, R. (2018). A Study on Feasibility of Super Adobe Technology –An Energy. SEU Journal of Science and Engineering, Vol. 12, No. 1, June 2018, 6,7.
V. Mansoure Dorhohamadi, R. R. (2020). Combined effect of compaction and clay content on the mechanical properties of adobe brick. Case studies in Construction Materials, 1.
VI. Mbuh Moses Kuma, K. D. (2020). Compressed Stabilized Earth Brick (CSEB) As Building Construction Elements . IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN, 42.
VII. Neeraj Agarwal, N. G. (2016). A RESEARCH ON GREEN CONCRETE. IJIRMPS | Volume 4, Issue 4, 2016, 1.
VIII. P.D. Kremer, M. S. (2015). Mass timber construction as an alternative to concrete and steel in the australia building industry: a PESTEL evaluation of the potential. International Wood Products Journal, 138.
IX. Radwan, A. H. (2015). Containers Architecture Reusing Shipping Containers in making creative Architectural Spaces. International Journal of Scientific and Engineering Research, 4.
X. Tarun Jami, S. R. (2018). Hemp Concrete – A Traditional and Novel Green Building Material. Advances in Construction Materials and Structures (ACMS-2018), 2.
XI. The Chinese Academy of Forestry, People's Republic of China. (1985). Proceedings of the International Bamboo Workshop. Recent Research on Bamboos, 4, 26, 31.