

Sustainability and Applications of a Timber as Structural Material: A Review

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Abstract – Sustainability of building structure must be environmentally stable, easy in usage, and handling or durable. This study considers that wood is an important building material. The main advantage of wood in construction is its strength, environmentally friendly, simple handling, and ease of use in construction. Trees, and their derivative products, have been used by people around the world for thousands of years. Wood was perceived as an appropriate building material. Timber or woodwork requires a well-skilled or professional worker. Wood, the only truly sustainable construction material should play a vital role in a future application. Timber is a high performance or speedy construction material. The advantage of wood as a sustainable building material is the increased use of wood in a built-up environment. Timber is a renewable material and requires less energy and it has been mostly used for building all over the world for many years. Timber should be considered as one of the best building materials, as it could be used in all climatic zones. Timber should be sustainable in many ways: like a tree, it contributes to mitigating the level of carbon dioxide in the atmosphere. Timber building has the main advantage of storing carbon and efficient use of wood is important to ensure sustainable construction with wood.

Key Words: Timber, Structural Material, Sustainability of Timber, Building Material, Qualities of Timber.

1. INTRODUCTION

Timber is considered as one of the most sustainable materials requires less energy than most material to process into finished products. Timber logging, manufacture, transport, and disposal of timber products have substantial environmental impacts. Sustainable timber refers to timber that has been harvested responsibly from well-managed forests that are continuously replenished, and ensure that there is no damage to the surrounding environment. Timber can be used for construction have good compressive strength, however, it is strongest in tension. Moreover, there are many varieties of timber that can be used for construction, such as plywood, particleboard, fireboard, and engineered product. Timber is also recommended due to its quality of environment sustainability, physical and aesthetic

qualities, workability and flexibility of space arrangement, dry construction, industrial production, and comparative cost-effectiveness. Sustainable wood comes from sustainably managed forests. As a raw building material, wood merits are extensive and wood creates far less carbon dioxide emissions than competing building products, and the sustainability movement and green building initiatives. Treated wood preserves wood against termite attack and fungi decay.

1.1 Qualities of Timber as a Building Material

The qualities of timber as a building material include availability, physical and aesthetic qualities, workability, environmental sustainability, the flexibility of space arrangement, dry construction.

- a. Availability-** Timber is locally available in India and also it can be purchased from local suppliers and transported to the construction site using small vehicle trucks, tractors. Timber is accepted as an attractive and elegant building material in most cultures in most of India timber houses can be constructed in many areas the best advantages of timber houses is warm in winter.
- b. Physical and Aesthetic Qualities-** Timber has a high strength to weight ratio making it an attractive framing material. Some species are highly resistant to rot. Timber withstands humidity with less structural change than other building materials. It is very durable and enhances the natural beauty of the materials.
- c. Workability-** Timber can be easily shaped and cut by simple hand tools and chiseled. There are many design options possible with wood i.e. wood can be framed or shaped in many ways. Wood can be of flexible material and can be easily shaped in many directions. Bamboo can be used in construction as scaffolding. Bamboo is a fast-growing plant and easily available in all parts of India. In some cases, bamboo can be used as a roofing material.
- d. Environmental sustainability-** The most significant environmental benefit of timber is its renewability and biodegradability. Timber is an excellent insulator against

hot or cold weather. Timber should be environmentally sustainable in many ways as if timber can be properly preserved to decay and rot the life of timber structure should be more.

- e. The flexibility of space arrangement-** Partition made from timber can easily remove around to change the layout in response to new functional requirements. Timber can be flexible material easy to work and handling.
- f. Dry construction-** Timber construction should be faster finishing is also faster, since the timber wall can be painted immediately. Timber floors do not require a curing period for achieving maximum

1.2 Classification of Trees

The word timber is derived from an old English word "timbrian" which means to build. Timber or wood as a building material possesses several valuable properties, such as low heat conductivity, amenability to mechanical working, low bulk density, and relatively high strength. Trees can be classified into two types-

- a. Endogenous-** Plant grows by the addition of new cells only at the tip or ends i.e., the trees grow inwards and fibrous mass is seen in their longitudinal section. Such trees show very little branches. The timber from these trees has very limited engineering applications. Examples of endogenous trees are bamboo, cane, palm, etc.
- b. Exogenous-** These trees increase in bulk by growing outwards and distinct consecutive rings are formed in the horizontal section of such trees. These rings are known as annual rings because one such ring is added every year. Such trees grow bigger in diameter as well. The timber, which is mostly used for engineering purposes.

1.3 The exogenous trees classified as-

- a) Conifers-** The conifers are known as evergreen trees. These trees bear cone-shaped fruits. These trees yield softwoods, which are generally light in color, resinous, light in weight, and weak.
- b) Deciduous-** They are also known as broadleaf trees. The leaves of these trees fall in autumn and new ones appear in spring. Timber for engineering work is mostly derived from deciduous trees.

Trees can also be classified based on hardness in the following categories.

- a) Hardwood b) Softwood**

The softwood forms a group of evergreen trees while the hardwood forms a group of broadleaf trees. Examples of softwoods are deodar, pine, and other conifers. Hardwood includes sal, mahogany, teak, oak, etc.

1.4 Application of Timber as A Sustainable Building Material

Sustainable building material is the one that does not have much negative impact on the environment. The use of sustainable materials for constructing buildings is not a new concept. The demand for environmentally friendly materials is rapidly increasing. The smart cities are attempting to focus on using materials that reduce the energy we use in operating buildings while heating, cooling, and light. People make us feel that wood is good for future generation and development. Wood grows from the earth is 100% renewable and extremely durable and equally strong. Sustainable building material should have the following characteristics-

- To determine the qualities of timber as a building material.
- To analyze the sustainability of timber as a building material.
- Easily available and affordable to the users.
- It should be environmentally stable and should not create any health hazards.
- Timber should be versatile in usage, that is, it could be used for different purposes.
- A well-seasoned timber should be durable and easy to work..

2. OBJECTIVES

This paper aims at assessing the potentials of timber as a building material and to determine its comparative sustainability against other commonly used building materials.

- Investigate the qualities of timber as a building material
- Examine the challenges of timber as a building material

- c) Investigate the sustainability of timber as a building material
- d) To advance the recommendation that will enhance the sustainability of timber as a building material in India.

3. LITERATURE REVIEW

Rosemary J. Kennedy et. al (2005) [1] described the use of timber in residential construction and developed the system for integrating timber products and aimed at a contemporary, environmentally sustainable housing approach for qualities of timber housing.

Ronald W. Anthony et. al (2005) [2] analyzed that wood construction should have economic competitiveness and must provide reliable service in the existing building and prepared to know the next generation of engineers comfortable with wood construction.

M. Frese et. Al (2006) [3] studied that failure occurred in a timber structure due to the weight of snow and they concluded that to build a database that contains relevant data concerning the failure of timber structure and create the basics for integral reflection.

Roos, A. et.al (2010) [4] influenced the properties of wood and create the beliefs for the control and ease of building in a wood and no longer regulations are seen in timber construction. They found material Preference among architects and structural engineers are influenced by attitudes regarding the properties of wood, normative beliefs, and beliefs about the control and ease of building in Wood.

Tom Kuhlman et.al (2010) [5] aimed more at exploring the theoretical basis for defining sustainability than providing a practical manual for measuring it. They suggested better to use sociological insights to assign values to the different aspects of well-being, and economics to combine those values into an overall assessment.

Barbara L. Zimmerman et. al (2012) [6] concluded substantial and all points in one direction for the sustainability of the timber. Their research is pointed to the key components that how to increase the potential for sustainable yields of high-value tropical timber.

Robert Gerard et.al (2013) [7] evaluated the current knowledge of tall timber construction, identify gaps in knowledge, and reflect on the gaps that, if fulfilled, and also have provided a better understanding of the potential fire safety performance of tall wood buildings. They collected and summarizes resources in the literature to identify fire safety challenges in tall timber structures.

D. Thomas et. al (2014) [8] studied the various innovations in wood treatments, wood protection, and insulation have provided solutions to these issues so that timber is once again a viable option with added benefits such as environmental sustainability and erection speed. They also investigated the comparative performance of a timber veneer/structural timber home to a concrete floor/brick veneer home to evaluate whether the perception of timber performance matches reality.

Hafner, Annette et.al (2014) [9] discussed various factors on climate change used to focus on energy efficiency. They focused on the sustainability of materials in better and efficient ways. They found buildings have the specific property of storing carbon temporarily in its material.

Abimaje J. et .al (2014) [10] assessed various building materials for its sustainability using data from various secondary sources. They established a new idea that a sustainable building material must be environmentally friendly, affordable, flexible in usage, and durable. They also discussed various problems associated with the usage of wood, such as attack by insects, fungi, fire, depletion of natural resources, etc. and preventive measures.

Duncan Brack et.al (2014) [11] studied various policies aimed at excluding illegal and unsustainable timber products that have proved a valuable weapon in the armory of consumer states committed to using their buying power to affect the international timber market. They highlighted how governments are displaying increasing interest in the development of sustainable procurement policies.

Ioannis N. Athanasiadis et.al (2015) [12] investigated how smart Information and Communication Technologies (ICT) solutions can be used for combating illegal logging and timber trade. They put together techniques from agile requirements engineering to propose a methodology for identifying user stories and associated risks and priorities and via a collaborative, participatory, single-day workshop, named inception workshop.

Ed Pepke et.al (2015) [13] studied the illegal timber trade stemming from illegal logging that has tremendous social, economic, and environmental consequences. They Found how illegal logging results in huge losses in assets on, and revenues from, public lands, as well as losses in taxes and royalties within developing countries.

Ernest Boampong et.al (2015) [14] experienced major challenges that have subjected the sector to severe pressure regarding raw material unavailability and a struggle for efficient use of the limited available timber. This studied the availability of timber species and their sizes in two local timber markets and the factors that influence their selection for furniture and joinery production.

Isao Sakamoto et. al (2016) [15] studied the feasibility of buildings with more than four stories using timber effectively as a component of structural members under the current Building Standard they provided the structural and fireproof design for timber-based hybrid structures, as the final results of this project.

Michael H. Ramage et.al (2017) [16] discussed that Trees, and their derivative products, have been used by societies around the world for thousands of years. They suggested a growing interest in the potential for building with wood at a scale not previously attainable. As wood is the only significant building material that is grown, we have a natural inclination that building in wood is good for the environment or there are other aspects of civil and structural engineering, or large-scale infrastructure, that would be a better use of wood.

Steve Jennings et.al (2018) [17] resulted in deforestation and a loss of biodiversity often violates the rights of local communities and indigenous peoples and contributes to climate change. A significant proportion of this deforestation is embedded within the global trade in commodities, including timber, pulp, and paper, and the huge international trade in illegal timber contributes appreciably to these negative environmental and social outcomes.

Mick Stephens et.al (2018) [18] analyzed that the sustainability factor that supports the use of timber products is the low carbon emission impact compared to substitute products such as steel and concrete. This has contributed to increasing interest and adoption by many public authorities of Wood Encouragement Policies in the built environment. Processing and manufacturing innovations are increasing the availability of new engineered wood products that enable a timber substitute or alternative to many traditional timber products including bridge components. These products can be made in a wide range of dimensions and offer many key benefits including being lightweight, stable, and minimal variation in mechanical performances.

Jim Hart et. al (2020) [19] studied that the built environment is one of the greatest contributors to carbon emissions, climate change, and unsustainable pressure on the natural environment and its ecosystems. which identifies a "substantial increase in the use of wood in the construction of buildings" as a top priority.

Dinwoodie J. M. Timber et. al (2020) [20] analyzed that Wood is a natural resource capable of being grown in most parts of the world. It is possible to grow an endless supply of timber. The environmental benefits of wood are immense. Trees absorb CO₂ from the atmosphere, store the carbon and release O₂ to the atmosphere, and so wood forms a carbon sink – which is unique for an engineering material. Timber

harvested from trees and used in construction continues to store carbon. The carbon is only released back into the atmosphere when the wood decays or is burned.

Chadwick Dearing Oliver et.al Studied that both enough extra wood can be harvested sustainably and enough infrastructure of buildings and bridges needs to be built to reduce annual CO₂ emissions by 14 to 31% and FF consumption by 12 to 19% if part of this infrastructure were made of wood. The range is based on the efficiency of wood use [21].

4. RESEARCH GAPS

It is important to mention that our analysis of the sustainability of timber structure is playing a vital role. Some expert stated that the future challenges for the further development of sustainability are not about developing more criteria and indicators, but instead the already available criteria and the indicator should be used better and more frequently, another expert mentioned that there are still some gaps regarding the specific principle. Although our analysis and comparison of the sustainability issues showed a wide range of criteria and indicators implemented.

5. CHALLENGES OF TIMBER AS A BUILDING MATERIAL

No building material exists without its challenges. With the advancement in technology, materials must be studied and scientifically explored. Following challenges must be taken in timber work are as follows-

- a. **Fire**-The greatest challenge of wood as a structural material has been a fire. The greatest disadvantage of timber building is fire. When timber burns, it gets momentarily protected by its charring, which creates an insulating layer that reduces the speed of the spread of fire.
- b. **Weathering and decay**- Another factor that affects the timber is weathering and decay. Timber decay arises from the fungal attack in combination with excessive moisture. The effect of weathering can be prevented through the coatings on the surface of the timber. If proper coatings should be done on the surface of the timber the timber should be safe on weathering agencies and decay.
- c. **Termite infestation**- Termite control is of very high importance, however, the termite encroaching into a dwelling is not dependent upon the type of frame used

in construction. Some of the processes involved in controlling termite infestation are suppression, site management, soil barriers, and choice of foundation

6. DISCUSSION

This paper analyzed that good technical knowledge of timber is necessary for its application. For the choice of timber specific construction work include detailed knowledge of the function of the structural unit and the specific property of timber is given. Adequate information on the magnitude of load, rate of loading, and duration of the load should be well known. Proper seasoning of timber should be done to reduce dimensional instability and distortion of the timber structure.

7. SUMMARY

Sustainable building material is those that are environmentally friendly, readily available, durable, maintainable, and versatile in usage. The strength and durability of wood are evident. Timber as a building material possesses all these qualities and performs better when compared with most other common building material. Timber is also a renewable building material and flexible and easy to work thus it is a sustainable building material.

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