

BAMBOO AS SUSTAINABLE MATERIAL FOR BUILDING CONSTRUCTION

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Abstract

The purpose of this article is to review the basic information about the bamboo plant as a building material and its use in the construction industry. Bamboo is considered from different aspects: ecological, social and economic. The paper studies the advantages and disadvantages of bamboo, concludes that bamboo can be used in construction both as a structural material and for decoration; is environmentally friendly and has great prospects for use in the construction industry.

The Keywords

Bamboo; material; sustainability; environmental aspect, economic aspect, social aspect

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Introduction

Bamboo culm has been widely known as a relatively environmentally friendly and sustainable building material to replace the use of conventional materials such as wood, brick, concrete, and steel [9]. This material has been widely used as the primary building material in many countries, especially in Asia, Africa, and South America. Consequently, it is used for flooring, ceiling, walls, windows, doors, roofs, trusses, and rafters in buildings. Moreover, it is also used as structural material for bridges, water transportation, and skyscraper scaffolding. Bamboo is being addressed as a building material contributing to sustainable development because it shows distinctively qualified environmental, social, and economic benefits [10].

Bamboo has a very fast growth rate, so it has been regarded as suitable for afforestation [3, 4]. Bamboo has longitudinal fibers and no cross fibers in its structure. This means that this material is not very suitable for load carrying in cross directions. Moreover, it is said that working fibers in a bamboo beam are those on the top (working for compression) and the bottom (working for tension). The rest of the mass is so called "dead weight" — fibers that don't take part in load bearing processes. All in all, bamboo hollow structure makes it working worse as a beam than a column or bracing. Bamboo is well known plant for having almost 2 times compressive strength of concrete and almost the same strength to weight ratio like steel in tension forces. This is why buildings made of bamboo are resistance to wind and earthquakes [20].

Untreated bamboos have life expectancy no more than five years and can be attacked by fungi and insects. Moreover, it can cause high risk of fire spread when internodes in the clum can burst and collapse the building. That makes bamboo not very impressive building material, but as every product it has to come across well prepared treatment, before being used in construction. This plant consists of carbohydrates (soluble sugars) that attracts fungi and insects. The solution for this issue is to inject water soluble salts into bamboo cells. When water evaporates it removes starch and leave salt inside the fibers. This process is not toxic and makes bamboo beams fire retardant and allows application in structures [20].

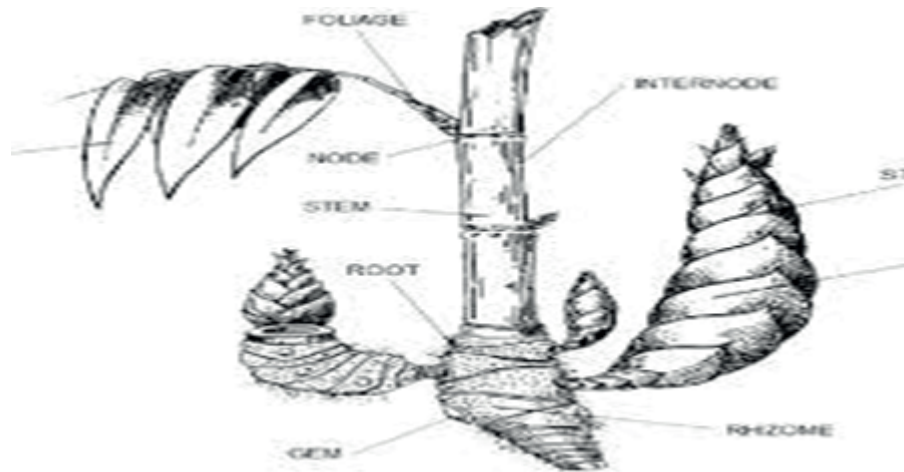


Figure 1. Diagram of bamboo plant

Table 1

Positive and negative sides of bamboo as building material

Advantages of bamboo as building material	Disadvantages of bamboo as building material
The fastest growing grass	Round hollow shape
Strong load-bearing capacity	Tapered
Good comprehensive strength	Irregular shape
Better strength on tension than steel	No cross fibers
Wide range of species	Longitudinal fiber bad for cross direction loads
Flexibility	Easily attack by insects and fungi
Low weight	Natural durability up to 2 years

Bamboo as sustainable material

Sustainability is created when 3 main demands are related: environment, society and economy.

1. Environmental aspect

Life Cycle Analysis (LCA) is the leading tool for assessment of impact that products and services have on the environment. Since there have been only eight LCA-based studies for bamboo construction materials [1], including the reference article, instead of the LCA impact categories, this review looks at the following environmental aspects of bamboo-based construction material.

1.1. Renewability

Bamboo as a sustainable construction material arises from the fact that bamboo, when harvested in a sustainable manner, can have a more positive impact on the environment than other building materials. Sustainable harvesting can be achieved by maintaining a regular population of current live stems by cutting selectively the 20 % of mature stems since they will be replaced annually by an equivalent emergence of young shoots [2]. Unlike other timber, bamboo can be harvested after 3 – 4 years after planting and yearly after that. In fact, harvesting of bamboo yearly keeps the clump or the bamboo forest healthy. When bamboo is harvested, the root system is unharmed and is ready to produce more shoots, which allows for a sustainable harvest of bamboo [16]. Bamboo has a very fast growth rate, so it has been regarded as suitable for afforestation [3, 4].

1.2. Carbon sequestration

By growing, bamboo takes in carbon dioxide and it in turn gets stored when used in the building. When bamboo is used in a building, carbon is stored and not released into the atmosphere until the end of the life of the building. The carbon storage and sequestration rates for bamboo is 30 – 121 Mg per ha and 6 – 13 Mg per ha per year, respectively [8].

1.3. Embodied energy

Bamboo can be used as solid wood substitute materials, especially in manufacture, design and construction usage [11], decreasing the pressure on forest resources. It can also reduce the current trend of construction industry's use of high energy consuming building materials. Whereas the fabrication of bricks and cement consumes large quantities of energy and emits accordingly large amounts of carbon dioxide, the act of bamboo cultivation (which is sometimes called the act of growing architecture) is one of the best ways to reduce the green-house effect [13]. A study of a bamboo-structure residential building prototype showed that compared to typical brick-concrete building, the bamboo-structure building requires less energy and emits less carbon [14].

1.4. Environmental pollution

Bamboo is considered to be environmentally friendly because it comes from a rapidly renewable resource [15]. The increase in bamboo use can help to reduce deforestation, encourage new and existing cultivators to grow more bamboo, utilize wasteland, unused land and river banks, which will result in better soil conservation and mitigation of flood disasters [16, 17]. This will not only improve the environment as bamboo has a negative impact on greenhouse effect, as it lowers the atmospheric and soil carbon content but this could also generate significant employment opportunities and thus promote the socio-economic status of the local people [18, 19, 27]

2. Social aspect

Bamboo by being used as a construction material can have good impact on society. By developing a bamboo based construction industry, it can not only preserve traditional skills but also create new income opportunity and ensure a much stronger social cohesion.

2.1. Traditional skills of construction and income generation opportunities

The socio-economic aspects of bamboo are significant because of the commodity's role as a major non-wood forest product [22]; many people depend on this commodity as a source of income. The promotion

of bamboo reduces deforestation, a key cause of poverty and urban migration [5]. By developing housing based on locally available building material, the skills of local people can be increased, which in turn will support them in income generation and prevent them migrating elsewhere, thus improving the social fabric [18, 19]

2.2. Resilience to disaster

Bamboo as a building material has a positive social impact on the people affected by disasters as it can be used to speedily build houses that are disaster resistant and support livelihoods to recover from those disasters. Bamboo can help not only to reduce greenhouse effect by reducing carbon dioxide in the environment but it has roots that spread underground in all directions, turning land solid and preventing landslides that can be caused by heavy rain and earthquakes [6]. Bamboo has been regarded as a building material with which to construct earthquake-resistant buildings. An ideal structure for effective seismic resistance needs to be strong yet not very heavy, because the earthquake force imparted to a structure is a product of its mass and the imparted acceleration; therefore bamboo, which has a higher density but is lighter than timber because of its hollow nature is an ideal material as it will impart smaller earthquake force due to its smaller mass [23, 24].

2.3. Social cohesion opportunities

Natural disasters affect people with low-economical resources bringing about a psychosocial depression that leads to abandoning of agricultural activities, which forces them to move to urban centers [7]. This is one of the biggest causes of increase of urban poor population.

3. Economical aspects

The economical aspect of bamboo-based materials studied so far consist of the cost of the material and the income opportunities it creates. They are elaborated below.

3.1. Cost of material

Bamboo is often adopted as a cheaper construction material alternative. Although this might be true in cases where bamboo is available locally, the transportation costs could significantly increase construction cost and its sustainability in places where bamboo is not grown. This is true in the case of European markets. However, in China, the bamboo industry has become a backbone industry in economic development and poverty alleviation of rural areas, and a new growth point of economy in remote mountainous areas of southern China [16]. Also, due to bamboo's new uses (bamboo flooring, bamboo bicycles, etc.) in industrialized countries in Europe and America, the cost of bamboo is increasing because the demand for bamboo is growing due to the increasing cost of other wood and actual tendency towards sustainability that bamboo can bring to the housing industry [25, 28]. The major issue is that the commercialization of most highly valued bamboo products has been identified to cause major impacts on sustainability of raw material production [26]. When demand for bamboo increases, rapid and uncontrolled harvesting can lead to serious depletion of bamboo and deforestation. A study conducted in the northeastern Yunnan province of China showed that one of the major reasons for decline of bamboo forest (*Qiongzhusua tumidinoda*) was extensive logging of mature bamboo and ravaging of shoots [27]. Also, the addition of transportation from the country of manufacture to the country of use adds hugely to the embodied energy and cost, undermining the sustainable benefit of bamboo [15].

3.2. Financial gain opportunities

The economic benefits of bamboo housing arises, not only from the low cost of bamboo as a material but also from the fact that it is a means of income for people who work in the bamboo industry, be it construction of houses or making engineered bamboo construction materials. These jobs include conventional agricultural jobs common in developing regions as well as higher-skilled jobs required to process the bamboo raw material into value-added products, such as furniture, housing, composites, etc. [28].

Summary

Table 2

Positive and negative sides of bamboo as building material

Advantages of bamboo as sustainable building material	Disadvantages of bamboo as sustainable building material
The fastest growing grass	More complex production process for industrial products (like floor panels)
Absorbs CO ₂	
Recyclable	
Decreases poverty in country of production	
Fast spreading plant	
Creates animal habitats	
Prevents from soil erosion	
Requires less energy in production of bamboo plywood than normal softwood	Eco- costs of production are high in countries where the plant doesn't grow
Short production process of clums	
Easy to harvest	
Biodegradable	

Conclusion

From the advantages and disadvantages of bamboo, we can see that there is majority of positive impact of bamboo in our life. Starting again from bamboo possibility of the fast grows and growing extension is vital nowadays when we are facing with the fact of deforestation. Enlarging forest area, we are provided with bigger CO₂ absorption. Bamboo forests can sequester 17 times more carbon dioxide than a normal tree forest and provide natural surroundings for animals. Within an extensive underground network it prevents from soil erosion and can grow even in uncomfortable grounds. Easy to harvest, uses less energy in bamboo clum or plywood production. This plant is biodegradable and recyclable. This means that any bamboo wastes are generated into other textiles or convert into biomass. To sum up positive impact, by bamboo cultivation, this plant provides more jobs for poor and decreases poverty in country of production. Being totally natural product, it is difficult to point out negative impact on environment. This plant is simple and easy to process, so the only disadvantage in sustainable production can be caused by more complex products that require usage of more pesticides and energy. Overall, eco-costs in country of production are very low and they can have bad impact while transported to the country where the plant doesn't naturally grow.

In addition to this I could read that, a lot of constructions can be made of bamboo. Simply harvested bamboo clum can make a lumber such as beam, column, and rafter. With this building material it is possible to build houses, shelters, churches, pavilions, scaffoldings and bridges. Basically everything that this material can support. Its properties allow bamboo to be the main structure as well as finishing material.

According to the literature review conducted it is conclude that bamboo is a sustainable material for future building industry and can help to solve the problems of shortage of materials for building construction.

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БАМБУК КАК УСТОЙЧИВЫЙ МАТЕРИАЛ ДЛЯ СТРОИТЕЛЬСТВА ЗДАНИЙ

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Аннотация

Целью этой статьи является обзор основной информации о бамбуковом растении в качестве строительного материала, его использовании в строительной промышленности. Бамбук рассмотрен с разных аспектов: экологического, социального и экономического. В работе изучены преимущества и недостатки бамбука, сделаны выводы о том, бамбук может быть использован в строительстве как в качестве конструкционного материала, так и для отделки; является экологически чистым и имеет большие перспективы для использования в строительной индустрии.

Ключевые слова

бамбук, материал; устойчивость, экологический аспект, экономический аспект, социальный аспект

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