Bamboo Brilliance Harnessing Earthquake Resilience for Sustainable Building Solutions

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Abstract

Global climate change is caused by deforestation and global warming. The global community is shifting its focus to renewable energy and sustainability. The construction industry alone is a major contributor to global warming due to its massive pollutant output. We are seeing changes in the weather, such as temperature variations, rising sea levels, earthquakes, and more, as a result of global warming. As of yet, no instruments exist to forecast earthquakes. The whole globe suffers significant losses in terms of money and human lives as a result of earthquake vibration.

There are five earthquake zones in India. And if the data requires it, a number of megacities in India are vulnerable to earthquakes. We cannot comprehend the psychological devastation experienced by earthquake survivors who have lost everything, including family and home. To regain their morale and face the crisis head-on, they need a place to live and assistance. The bamboo house can provide those in need of shelter right away since it is affordable and can be completed quickly. Bamboo is an energy-efficient and renewable material that uses very little energy to produce. It is a cost-effective material since it doesn't need specific equipment for building construction and is available for a much lower price than conventional masonry structures. Numerous studies have been conducted to determine bamboo's mechanical strength. This demonstrates bamboo's safety for use in building. By utilizing the right treatment, the durability risks have also been eliminated. The ideal kind of bamboo house is an Assamese-style home. These homes serve as an example of how to design affordable, earthquake-resistant structures using basic geometry, low rise, grass infill, and flat terrain.

Keywords: Bamboo, low-rise structure, earthquake, economical, sustainable material

I. INTRODUCTION

Throughout human evolution, bamboo has been a vital part of human life, both as a food source and a weapon. Numerous joints, or firm nods on the culms, are seen in grass bamboo (Figure 1). Additionally, bamboo may be used to make a number of commonplace items. Bamboo grows naturally quite quickly; it may reach a height of 40 cm in a single day. Bamboo is employed in many different applications nowadays, such as the creation of multi-story buildings and homes. Bamboo is a strong and readily available material that may be used instead of other construction materials. Its many other qualities, such its low weight and affordability, make it more suitable for building construction.

Bamboo has become more and more popular for use in constructing since it just needs basic equipment to deal with. Because bamboo is readily available in the area, using it is seen as a sustainable approach.

Global warming is a major issue facing humanity, and the only way to combat it is via sustainable practices. More issues will arise the more we tamper with nature. The increasing mean sea level, high temperatures, melting glaciers, tsunamis, and earthquakes are all results of improper exploitation of natural resources.

India and its neighboring countries, including Nepal, Pakistan, and China, have experienced several devastating earthquakes in the past. The most recent one occurred in 2001 and was dubbed the Bhuj earthquake. In all, 20,000 people perished and 1,50,000 were wounded.

The majority of constructed structures do not adhere to Indian byelaws for earthquake resistance. The non-concrete dwellings were constructed from field stone and mud. The building materials for the Concrete homes were cut stone, bricks, and cement mortar. Few people lived in pucca homes while the majority of Kach people lived in kaccha dwellings.

This research paper's goal is to investigate bamboo's potential as a durable construction material for Bamboo is employed in many different applications nowadays, such as the creation of multi-story buildings and homes. Bamboo is a strong and readily available material that may be used instead of other construction materials. Its many other qualities, such its low weight and affordability, make it more suitable for building construction.

From low-rise to high-rise buildings, several experts are debating earthquake-resistant construction using contemporary technologies like dampers and footing isolation. However, each procedure is costly and requires technical expertise. Here is where we should provide humanity an affordable option that they can all use. It must be basic, affordable, made of locally sourced materials, and easy to work with.

II. The seismic threat and India

In India, there are five distinct earthquake zones. Over the last 100 years, the nation has seen many devastating earthquakes; the earthquakes in 1934 in Bihar and 1950 in Assam stand out owing to their severity and fatality toll.

There are currently no instruments available to forecast earthquakes; instead, they are caused by the friction of tectonic plates. India is situated on a minor plate tectonic system.

The India Plate was once a component of the ancient Gondwana continent. After splitting off 100 million years ago, it traveled to the north. The India Plate broke away from Madagascar and clashed with the Eurasian Plate as a consequence of plate tectonics, creating the Himalayas.

Sediment clumped together like soil before a plow during the collision with the Eurasian Plate along the border between India and Nepal, forming the biological belt that gave rise to the Tibetan Plateau and the Himalaya Mountains.

Figure 2: Indian Plate undergoing a north-eastward movement.

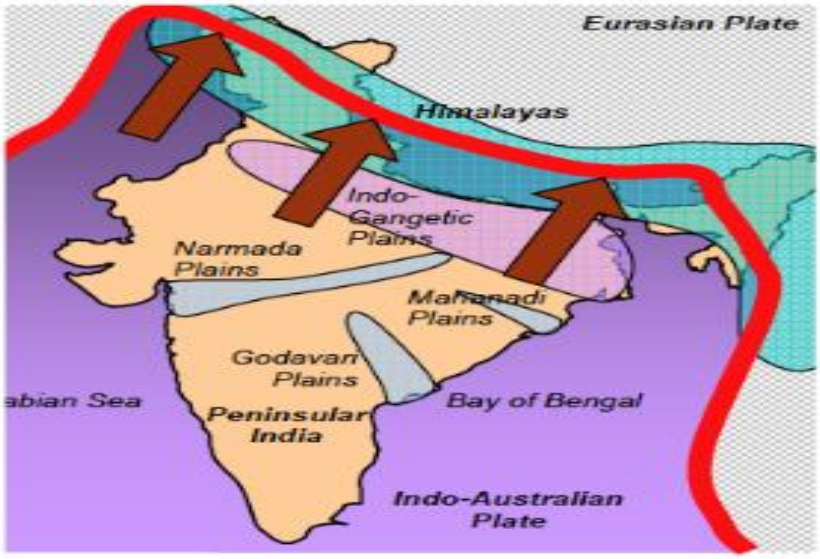


Figure - 3 : Geographical Layout and Tectonic Plate Boundaries at India

III. India and seismic Zone

Table -1: Indian Seismic Zone

Seismic Zone	Intensity	Intensity on Modified Mercalli scale*
Zone V	Very severe intensity zone	IX and above
Zone IV	Severe intensity zone	VIII
Zone III	Moderate intensity zone	VII
Zone II	Low intensity zone	VI
Zone I	Low Damage Risk	V or Less

*measures the impact of earthquakes on the surface of the earth

IV. Post-Earthquake

The impacts of an earthquake extend beyond its immediate aftermath. It affects the earthquake victim more severely. Their morals are destroyed by the psychological pain they experience after losing their home, family members, etc.

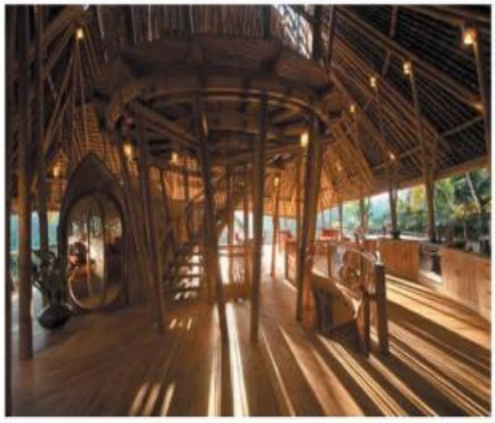
In this circumstance, people seek assistance and backing. A house is a fundamental human necessity, yet building a traditional material house costs more money and takes more time. The speed of labor and the economical construction material can be advantageous for the survivors.

Since bamboo is a robust, sustainable green material that is readily accessible in the area, it may be suggested. It is advised to use bamboo for horizontal members that are no more than three to six meters in length without a center support. According to a research, bamboo has a tensile strength of around 28,000 N/m2 (0.028 MPa), which is comparable to steel.

Because of its cheap cost, affordability, and accessibility locally, bamboo is regarded as a sustainable construction material. The way that bamboo has been utilized over the last 45 years has evolved, and this has also had a significant impact on the final appearance of the home. The evolution of bamboo utilization from traditional to modern styles is seen in Figure 4(a)–(c).

(a)

(b)



(c)

V. Bamboo's characteristics

Excellent strength characteristics are possessed by bamboo, especially in terms of its tensile strength. The kind and species of bamboo determine the strength of the. Bamboo's vascular bundle is very elastic and has a high tensile strength in its outer zone. Additionally, bamboo's fibers run axially, giving it greater resistance to tension than compression. Bamboo strands often have a greater tensile strength than steel, but one drawback is that connections cannot be made that can convey this tensile strength.

When its water content decreases, bamboo has a characteristic that causes it to shrink more than wood. Bamboo may split at the nodes, causing the cross-section to shrink by around 10–16% and the wall thickness to decrease by approximately 15–17%.

The precautionary step to be done to halt the loss of water is to prevent shrinkage.

Bamboo's high silicate acid concentration contributes to its exceptional fire resistance. When loaded with water, bamboo can often endure temperatures as high as 400°C as the water cooks within. It also has a high moisture content, which varies according on the species, age, and harvesting season.

Bamboo, unlike lumber, begins to shrink beyond the fiber saturation threshold; however, this weakness has been addressed by the use of Ecology Diversity Synergy technology, since bamboo treated with EDS is just as durable for use in building construction as solid timber.

Bamboo is a popular construction material that is being used for many types of structures, including contemporary structures like arenas and pavilions. Low-rise apartments, communal homes, farmhouses, etc. One benefit for areas that are prone to earthquakes is its modest weight. In actuality, lightweight materials are also advised by earthquake-resistant buildings to minimize damage to society after an earthquake. An additional benefit of working with bamboo is that it may be produced in a workshop or on the job site. Because of its reduced weight, transportation is not a major issue. By giving the bamboo the right care, it is possible to both prevent shrinking and improve its lifetime while protecting it from insect damage. Another way to boost the age and strength is to use infill.

VI. Bamboo: An Everlasting Resource

When gathered methodically, bamboo may be collected with less harm to the environment than other building materials. This allows for improved output. If it is allowed to continue growing in a sustainable way, it may provide large amounts of this sustainable material for building construction. Bamboo grows at a very rapid pace and may aid in reforestation with other plant and tree species.

VII. Impact on the environment

Bamboo's strong growth qualities make it an eco-friendly material. Increased bamboo usage may lessen the danger to many trees, which can aid in halting the deforestation process. The widespread gathering and use of bamboo may boost the socioeconomic standing of farmers and provide jobs for a large number of people.

As bamboo grows, it absorbs carbon dioxide, which is then stored for usage in the structure. Bamboo only lasts two to three years in its natural state, but it may last up to thirty to forty years with chemical treatments to keep out pests and appropriate design components that shield it from the impacts of the weather.

As a result, carbon is held when bamboo is used in construction and is not released into the atmosphere until the structure eventually collapses. Bamboo has a 30–121 mg/hand and a 6–13 mg/ha annual carbon storage and sequestration rate, respectively.

VIII. Resistance to seismic activity

The building's resilience to seismic impact is increased by the great strength and low weight of bamboo. Even in the case of a powerful earthquake, the structure will not fall with effective anti-corrosion treatment. For instance, an earthquake of a magnitude of 7.7 struck Costa Rica in 1991. The bamboo structures only sustained little damage, but the typical concrete and brick buildings at the core were entirely demolished.

IX. A resilient material: bamboo

Bamboo's strength-to-weight ratio makes it an excellent material for withstanding stresses from earthquakes and strong winds. With the compressive strength of concrete, it is just as strong as mild steel. Amazingly, seven and a half tons of weight can be supported by one inch of bamboo.

Bamboo is an ideal material for earthquakes because of its light weight and high rigidity due to its hollow structure. Because of its inherent tensile strength, fibrous shape, and light weight, bamboo is a very desirable material.

X. Case study: House in Assam style

Generally, northeastern states are home to Assamese-style homes. is also present in Bangladesh, Cambodia, Myanmar, and other places. The buildings are usually one storey high, however sometimes two stories are observed as well. The wall may be plastered from our side and is composed of bamboo loaded with Ikra grass, which is found in the Ganges plane. Ikra grass is often used in roofing. Some of the dwellings, according on their financial situation, have metal roofs.

Any kind of terrain may be used to build these homes. These dwellings are typically kept at least 10 to 15 meters apart and do not share any shared walls. Assamese homes are typically rectangular in design and intended for a single household. For big families, L- and C-shaped furniture is also available.Small windows and doors are often positioned in the middle of the space. The dimensions of the door and windows are respectively 900 x 1200 mm and 900 x 2100 mm. The fundamentals of earthquake-resistant architecture are shown by the simple geometry of Assam-style homes.

When masonry buildings are not properly connected to one another or experience seismic activity, the masonry joints break and the structure collapses. When there is a seismic tremor, a non-engineered home, like an Assam Type house, operates as a single unit because to its straightforward design and solid foundation.

It is not possible to build a home that is 100% earthquake resistant. However, bamboo has the benefit of being a relatively light material that is readily accessible locally. It may also be reused for new building, depending on the age and degree of partial or whole unit damage.

XI. Conclusion

Although humans have created a wide range of instruments for various purposes, no mechanism has yet been created to forecast the location and strength of an earthquake. Therefore, we must design our structure to withstand shaking. While it is impossible to design a structure that is 100% earthquake resistant, we can build one that significantly reduces damage by adhering to some

fundamental earthquake resistance construction guidelines. A different kind of construction material, bamboo has several benefits, including being strong, lightweight, environmentally friendly, locally accessible, and renewable. It may also be used to create structures that are less harmful to people and more resilient to earthquakes. Bamboo is a material that is really green and can help any architecture work as intended. It also contributes to lessening deforestation and raising the socioeconomic standing of farmers. According to the Assam-style home case study, basic geometry on level, plain terrain is the most ideal to withstand seismic vibrations. It also demonstrates that lighter materials are more suited for seismically active regions.

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