IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

# Bamboo as a Sustainable Material for Building Construction in tribal and rural area

**[1]Ruchi Rameshchandra Gandhi,[2]Nirnaykumar Rameshchandra Gandhi**
[1]Assist. Prof. ,[2]PG Student
[1]School of Architecture & Planning ,
[1]P.P.SAVANI UNIVERSITY, KOSMBA,SURAT,GUJARAT,INDIA

***Abstract :*** Materials like cement and steel, which provide structures a long lifespan but also drive up construction costs, are having a significant impact on the construction scene in India's tribal and rural areas. Energy is used extensively during the production process for materials like steel and cement as well as for maintenance in a variety of ways thereafter.
As wood supplies decrease and limits are placed on cutting down natural forests, this replacement construction material is renewable, environmentally beneficial, and generally accessible. Bamboo appears to be a highly ideal substitute owing to its qualities, quick growth, and capacity to adapt to most climatic situations. The demand for conventional resources is growing if attention is not paid to the availability of renewable building materials in close proximity to tribal and rural communities and if locally produced materials are not used. This situation requires that tribal and rural areas focus on locally produced naturally renewable resources and affordable materials that will produce the same results as cement and steel but are more financially viable. Bamboo is one such resource that tribal and rural communities may employ in their construction. When accompanied with the necessary care and skilled laborers, bamboo has significant promise in the building industry. This essay's major goal is to promote bamboo as a useful and affordable material. The current study recommends using bamboo as a building material in tribal and rural construction, together with cutting-edge material technology.

***Key words:*** **Bamboo, Renewable, Environment, Affordable, Construction Material.**

## 1.0 INTRODUCTION:

Ecologically friendly building supplies. Fast-growing and renewable, bamboo offers the advantage of increasing carbon credits. The use of bamboo in construction may help the emergence of alternative and sustainable development, addressing the difficulties faced by the rural construction industry and the expanding housing sector. Promoting inexpensive and environmentally friendly buildings has a big impact and helps society in both socioeconomic and welfare terms.
There are several ways that bamboo may be utilized in construction. Today, bamboo reinforcement is becoming far more popular than steel reinforcement, mostly due to improvements in both the economic and ecological aspects of the material. Engineered bamboo may replace steel for creating tensile stresses for RCC members, and it uses less cement during construction.
Tribal and Rural regions have higher concentrations of deprivation than urban ones do. Many people find it challenging to buy a property since their salaries are often lower than those in metropolitan regions and because seasonal unemployment is a problem. As younger people move to metropolitan regions in pursuit of employment, leaving behind their parents and children, this has repercussions for the social sustainability of rural communities and is producing growing polarization. This has a detrimental effect on rural business and economic viability.Tribal peoples make up around 68 million people in India, or about 8% of the whole population.
In Gujarat, the Kathodi, Kotwalia, Padhars, Siddis, and Kolghas tribes have all been identified as being primitive tribes. Surat, Valsad, Dangs, Dharuch, Sabarkantha, Ahmedabad, and Surendranagar are the districts with the largest populations of primitive communities. Junagadh. Bhavnagar and Rajkot Jainnagar as well as Amreli. Primitive tribes are extremely backward tribes that get more governmental development aid than other tribes.
In Gujarat State, bamboo may be found as a supporting character in Moist Teak Forests, Southern Moist Teak Forests, Moist Mixed Deciduous Forests, Southern Secondary Moist Mixed Deciduous Forests, and Southern Dry Mixed Deciduous Forests.Bamboo may be found in 15 districts throughout the state, including sections of South Gujarat, Central Gujarat, North Gujarat, and Western Gujarat. Only two of the several species of bamboo that have been identified in the State—DendrocalamusStrictus (Manvel) and Bambusaarundinacea (katas)—are the most crucial species for industrial use and may be found in forests naturally. There are 5850 square kilometres of total bamboo-covered land in the state. It makes up around 3% of the state's overall territory. In the past several years, the Narmada, Dangs, and portions of the Tapi, Surat, and Valsad districts of South Gujarat have all recorded gregariously blossoming bamboos.The primary source of energy demand in the modern world is the massive use of energy for construction-related activities. It has been estimated that the building industry alone uses 40% of all available energy, either directly or indirectly. The traditional riches of Mother Earth have been abused by building operations in

urban growth, and now the practice is spreading to rural areas as well. It has long been known that many of the ideas used to describe housing and living situations in urban settings are not necessarily applicable or fitting in rural settings.

## 2.0 TRIBAL AND RURAL CONSTRUCTION SECTOR:

Traditional tribal and rural structures are based on environmental adaptations, and they are frequently erected by the people themselves without the use of outside mechanized inputs. In tribal and rural communities, affordability, attractiveness, maintaining traditions, and residing in climatically appropriate homes are all admirable goals, but structures' long-term viability is also crucial to take into account.

A structure made of traditional materials like cement and steel is far more durable and has a longer lifespan than one made of mud with a thatched roof. The price of building as a whole goes up because of these traditional materials.

The building structure types are gradually changing from temporary ("Kutcha" - in which both the walls and roof are made of materials that need to be replaced frequently) to permanent ("Pucca" - in which the walls and roof of which are made of permanent material) and semi-permanent ("Semi Pucca " - in which either the walls or the roof is made of permanent material) types in India, according to census reports and other reports by different Government Departments.

The conversion of temporary constructions to permanent or semi-permanent ones is a trend that is anticipated to continue given the general population's economic prosperity. In the near future, it is anticipated that a significant number of structures will be built using reliable and widely accessible traditional materials like brick, sand, cement, steel reinforcement, etc., and that the demand for these construction materials will soar. Due to the ongoing increase in construction costs across the board, low-income groups in tribal and rural areas are most affected by inadequate housing and other buildings.

This calls for the employment of efficient technology in the construction of buildings utilizing readily available and renewable local resources. Although this knowledge has been created, there is still a significant applicability gap. Therefore, in tribal and rural communities, access to building materials, technology, and construction delivery networks is crucial for cost-effective construction activity.

Due to the rise in the price of labour and basic building supplies, the cost of construction is rising by 50% over the rate of normal inflation. As a result, even basic housing in tribal and rural regions is now out of the price range of the average citizen. Utilizing technological choices that produce cost-effective outcomes that people in rural regions can afford is essential. Even though several scientific and government organizations have attempted to develop cost-effective technologies at the laboratory level, these efforts have not proven successful in the field. Furthermore, both consumers and experts have had little 'knowledge' of these alternate and sustainable solutions.

The traditional methods now used in building in rural and tribal communities result in the waste of expensive and precious resources. With regard to the depletion of traditional resources, such practices have a more negative influence on the environment. Another obstacle preventing the employment of cost-effective choices in the construction industry in rural regions is the lack of assistance provided by the building regulatory system. As a result, the construction structures made available to rural residents are either pricey or beyond their means of affordability. In rural regions, there is a clear dearth of training and skill development for both traditional and cost-effective technology. Since there are never enough financial resources, this has had a negative impact on housing and building programmes for all target groups as well as community buildings.

## 3.0 BAMBOO AS A SUSTAINABLE BUILDING MATERIAL:

Bamboo is regarded as a sustainable and renewable building construction material that is gathered and refilled sustainably with essentially little environmental impact. When compared to other building materials like concrete, steel, and plastic, bamboo has very low embodied energy. As a result of its ability to photosynthesize, bamboo also aids in reducing erosion, flooding, and local climates. Bamboo is often grown as an annual crop, with younger culms being allowed to continue growing while only mature and ripped ones are collected. Similar to how grass may continue to produce new shoots after being harvested, mature bamboo maintains its robust and untouched root system.

Because bamboo may be burned or decomposed in sewage, it is also recognized as a biodegradable material. High levels of flexibility, strength, and adaptability are characteristics of bamboo as a building material. When treated and used properly, bamboos advantageous properties make it a perfect building material for almost every aspect of a building (such as the foundation, flooring, walls, and roofs). Due to its beneficial qualities of easy availability, low cost, and great strength, it also has numerous uses within the building construction business. It can be used to substitute common and somewhat scarce materials like mild steel, galvanized steel mesh, or different fibers like asbestos in reinforcing cementation materials.

After being treated to stave off fungal and insect infestations, bamboo is a lightweight yet strong building material that is frequently used for construction. It possesses the light weight and incredibly durable qualities of a hardwood. Buildings made of bamboo are often flexible, lightweight, strong, and earthquake resistant in some way. In addition to the technical benefits of being used as a sustainable building material, bamboo also offers the economic advantage of being among the least expensive building materials. Prefabrication, simple assembly, and simple structural element replacement are additional key benefits of using bamboo as a sustainable building construction material. It is a sustainable building material since its components can be readily taken apart and reused. Additionally, scaffolding, bridges, and fences are constructed from bamboo. They can be used to strengthen soil-cement components as well as flexural and compression members of cement concrete. Similar to other plant fibers, bamboo fiber can be used to reinforce cement, concrete, and mortar in place of steel reinforcing rods. The procedure results in thin, fiber-like cement that is reinforced by meshes formed of bamboo splints.

### 3.1 Main properties of bamboo:

As was previously mentioned, bamboo is an excellent substitute for steel, concrete, and masonry due of its qualities, which are listed in detail below.

#### 3.1.1 Tensile strength:

More tension than compression can be withstood by bamboo. The axially running bamboo fibers are made up of a highly elastic vascular bundle with high tensile strength. These fibers have a tensile strength that is greater than that of steel, but it is not feasible to build connections that can transmit this tensile strength. This is another area where slimmer tubes excel. Axial parallel elastic fibers with tensile strengths of up to 400 N/mm2 are present inside the silicate outer skin. In contrast, very strong wood fibers may withstand a stress of up to 50 N/mm2.

#### 3.1.2 Compressive strength:

In terms of their cross-section, bamboo with lighter tubes has a better compressive strength rating than bamboo with bigger tubes. Because bigger tubes of bamboo typically have the drawback of having a small portion of the outer skin that is very resistant to stress, lighter tubes of bamboo have better material qualities. As a result, the amount of lignin in the culms affects compressive strength, and the amount of cellulose, which serves as the foundation for bamboo fabrics, affects buckling and tensile strength.

#### 3.1.3 Elastic modulus:

Similar to how it affects tension, shear, and bending strength, the buildup of extremely strong fibers in the outer regions of the tube wall has a favorable effect on elastic modulus as well. The quality of the bamboo increases with an increasing elastic modulus. Its enormous elasticity makes it an extremely practical building material in regions with significant seismic hazards.

#### 3.1.4 Anisotropic properties:

Anisotropic bamboo is a material. Bamboo has radically different qualities in the longitudinal direction than in the transverse direction. While lignin, which is found in the transverse direction, is fragile and brittle, cellulose fibers, which are long and rigid, are found in the longitudinal direction.

#### 3.1.5 Shrinkage:

Bamboo has a characteristic that causes it to shrink more than timber when its water content is lost. Bamboo canes have a tendency to split at the nodes, causing them to shrink in cross-section by roughly 10–16% and in wall thickness by roughly 15–17%. Because of this, it is important to take safety precautions to stop water loss while utilizing bamboo as a building material.

#### 3.1.6 Fire resistance:

Bamboo contains a significant amount of silicate acid, which gives it great fire resistance. Bamboo can typically endure temperatures of 400° C while the water cooks inside while it is filled with water. It also has a high moisture content, which depends on the harvesting season, species, and age. Although bamboo begins to shrink above the fiber saturation point, unlike timber, the adoption of Ecology Diversity Synergy technology has overcome this shortcoming, as bamboo is treated with the same durability as solid timber for building construction.

### 3.2 Bamboo used building construction:

Uses however, at the moment, only certain temporary or permanent structures in Tribal and rural urban regions make use of bamboo for building construction. This use falls short of fully utilizing bamboo's potential as a sustainable building material. Therefore, other noteworthy applications of bamboo that might be investigated with diligence in the construction of structures include,

#### 3.2.1 Foundations:

Due to bamboo's rapid degeneration and degradation when in contact with damp earth, its usage for foundation purposes has been restricted. When treated with some efficient preservatives and constructed on raised platforms, bamboo can be used for foundations or supporting pillars in buildings despite this drawback of decay. The following are a few of the several methods used to build bamboo foundations.

- Bamboo planted in close proximity to the ground: Bamboos are either planted on the ground's surface or buried there. The strongest and most stable bamboo is bamboo with closely spaced nodes, huge diameters, and thick sections. In the absence of this, smaller bamboo sections can be knotted together and treated with preservatives to slow the decay process, which typically takes 6 to 24 months to complete.
- Bamboo on prefabricated concrete or rock footings: The largest, stiffest sections of bamboo are used as bearings and are set on footings of either preformed concrete or rock that are not in direct contact with the ground.
- Bamboo is integrated into concrete footings: Concrete footings, which might be single posts or strips, are directly supported by bamboo poles.
- Composite bamboo/concrete columns: By employing a concrete extension to the bamboo and a plastic tube with the same diameter as the bamboo, it is possible to create a bamboo with an integral and lasting post.
- Bamboo piles: Bamboo piles are used to stabilize soft soils and minimize construction settlement. This is accomplished by using bamboo poles that have been cut into sections and filled with coconut coir strands that have been wrapped in jute and secured with wire. After the piles are installed, the area is covered with sand.

### 3.2.2 Floor:

Because of its durability and resistance to wear and tear, bamboo can be used as a building material for flooring. Bamboo boards, mats, and other flooring materials are used, and the frame is reinforced with wire.
The various techniques used to create bamboo flooring include:

- Small bamboo culms: Bamboo culms are joined by straight tying and nailing.
- Split bamboo: Bamboo culms are split lengthwise into strips that are a few millimeters broad.
- Flattened bamboo: It is made by dividing bamboo culms in half, removing the diaphragms, and then rolling and flattening the culms. The resulting board is then laid down and fastened to the joists with nails or ties. They are then screeded with cement mortar to make cleaning easier.
- Bamboo mats: According to construction demand and specification, thin strips of bamboo that range in size from 5 to 6 millimeters (mm) to 15 millimeters (mm) and thickness from 0.6 to 1.2 millimeters (mm) are woven into mats of various sizes.
- Bamboo plastic composites: This cutting-edge bamboo flooring technology uses plastic and bamboo fiber as the flooring's core constituents. The advantage over other forms of bamboo flooring is that it is more water-resistant and has greater dimensional stability.

### 3.2.3 Partitions and Walls:

The walls and partitions of buildings are where bamboo is most frequently used in construction. Building components like columns and beams, which often make up the structural framework, are made of bamboo. They are used to support both the building's own weight and the loads that its occupants have imposed. To shield the wall from wind and rain and to provide privacy, an infill must be placed in between the framing members. When exposed to horizontal forces, the infill in the wall attempts to offer in-plane bracing and assure the overall stability of the overall structure.

### 3.2.4 Doors and windows:

Building doors and windows can also be made of bamboo. Bamboo door frames typically take the place of the traditional timber door frames that are frequently used. Then, after being hinged to the wall, bamboo mat shutters are attached to the bamboo frame to act as the door. Additionally, a little bamboo frame that is hinged to the top of a wall can be used as a window.

### 3.2.5 Scaffolding:

Scaffolding made of bamboo is known as "bamboo scaffolding" and is widely used all over the world. It is recognized for its durability, adaptability, and creative potential and has successfully replaced steel in many applications.
Bamboo scaffolding is a resource that some nations rely on to be used in construction projects. Bamboo can grow swiftly and robustly in tropical countries, where it is harvested for use as scaffolding material. Hong Kong has backed the innovative "up-cycling" strategy of using bamboo scaffolding, which will reduce the need for landfill space.

### 3.2.6 Trusses:

Making roof trusses out of bamboo is a common application for the material in building construction. Bamboo is a great material for roof structure because of its high strength-to-weight ratio. Bamboo's combination of strength, rigidity, and light weight makes it feasible to construct trusses of any span. Because no heavy lifting equipment is required when using bamboo for trusses, there are also significant financial benefits.

### 3.2.7 Roofing:

Building roofs provide shelter for the usable space beneath the roof canopy as well as protection from many types of weather, such as sun, rain, and wind. The enormous pressures produced by wind and roof coverings should not be able to damage the roof. Due to its resilience and low weight, bamboo is a good choice for roofing. Bamboo trusses, rafters, and purlins can be used to construct the bamboo roof.

### 3.2.8 Bridges:

Bridges may also be built with materials made of bamboo. Due to its nature of being far more elastic than solid timber, bamboo used for such building applications requires particular construction procedures that prevent vibration, bending, and twisting. When made of bamboo, these bridges are typically covered to lessen their exposure to bad weather. The following materials are used to create various bamboo bridges.

#### 3.2.8.1 Footbridges:

These are straightforward bamboo frames with cross braces; the walkway is built at the crutch. The 50 to 75mm diameter culms are fastened together using bamboo lashings. When the height above the bed does not exceed five metres, these bridges can be used over rivers with a sandy or muddy bottom. A normal bridge crossing might take up to 20m.

#### 3.2.8.2 Handcart Bridge:

This bridge's structure is more complex and includes abutments and pilings. The bamboo culms used to build these abutments are anchored to the ground in pairs, and the bridge is supported by horizontal culms that serve as the pile top and diagonal bracing. The highway is made of three 100mm-diameter longitudinal bamboo beams that are lashed to the caps and connected in the middle of each bay by a cross-member.

### 3.2.9 Reed board:

The reed is flat-pressed at high temperatures to create reed boards. The flooring, ceiling, roofing, and decorative mosaics are all made of these reed boards. Additionally, they can be used as a door, window, or divider.

## 3.3 ADVANTAGES AND DISADVANTAGES OF BAMBOO:

### 3.3.1 ADVANTAGES OF BAMBOO

#### 3.3.1.1 Fast-growing:

In the world of plants, bamboo has the fastest rate of growth. Some varieties of bamboo may grow 35 inches each day! Bamboo is a considerably more sustainable option than any other woody plant since bamboo forests regenerate much more quickly.

#### 3.3.1.2 Durable and strong:

Although technically a grass rather than a wood, bamboo's special tissue makes it an excellent construction material. It differs from other grass plants like maize and sugar cane because it toughens up like wood over time and gets tougher over time. Natural bamboo is tougher than oak and ash, scoring 1380 on the Janka Hardness Scale. Bamboo is a fantastic material for earthquake-prone locations since, unlike wood, it is bendable and light because to its short fibers.

#### 3.3.1.3 Affordable:

You could spend less money if you decide to build using bamboo. If you compare prices at Home Depot, you'll find that many bamboo flooring alternatives only cost between 120 and 300 INR per square foot, compared to between 250 and 350 for wood. Naturally, conducting research is essential when building sustainably to ensure that you truly get bamboo that has been approved for sustainable practises.

#### 3.3.1.4 Easy installation:

Bamboo requires no additional installation methods and performs nearly identically to wood. Bamboo may be installed and harvested in a straightforward manner. It is simple to cut, doesn't require any peeling of the bark during processing, and is lightweight, making it easy to handle, transport, and store. Additionally, there are several styles and variations available, letting you tailor the bamboo to your house. For instance, you can choose bamboo flooring in a variety of stains or styles that mimic a typical hardwood floor.

#### 3.3.1.5 Positive environmental effects:

In addition to its quick growth, bamboo cultivation has environmental advantages. When it rains or floods, a sophisticated root network anchors the soil, preventing erosion. Additionally, it aids in soil water retention, regulating soil moisture throughout both wet and dry seasons. Due to its rapid growth, bamboo also absorbs more CO2 than trees. The rapidly expanding bamboo business could be good for the environment.

### 3.3.2 DISADVANTAGES OF BAMBOO:

#### 3.3.2.1 Susceptible to deterioration:

The high starch content of bamboo makes it particularly susceptible to the effects of the elements when sap or humidity levels are high. Harvested bamboo may be quickly harmed by insects, fungi, rot, and fire if it is not chopped, handled, and stored properly. Although there are natural ways to cure it, such as air drying or heating, some manufacturers still employ dangerous chemicals like formaldehyde and arsenic. Even if chemical emissions are often modest, it is something to take into account.

#### 3.3.2.2 Diversity in quality:

Given the lack of regulations around bamboo as a building material, it might be difficult to predict what results you'll obtain. The quality of bamboo is determined by a number of factors, and it can be challenging to distinguish across businesses. It all depends on the type of bamboo, where it was grown, when it was collected, how it was treated, and how it was finished. Furthermore, there is inadequate information on how effectively bamboo flooring may be refinished, endangering the durability of your floor.

## 3.4 TRADITIONALLY TO TREAT BAMBOO:

Bamboo is a robust, naturally occurring resource, but because it is natural, it may have a few natural predators. Insects, particularly the powder-post beetle, would consume bamboo from the inside out if it was not maintained. As a result, the bamboo culm's structural integrity would be jeopardised and finally fail. The first step to keeping your bamboo building standing for a lifetime is making sure that the bamboo you use for construction, or any other activity, becomes unattractive to these predators.
Since ancient times, bamboo has been used in building. To make bamboo more durable, mankind has mostly employed extremely straightforward natural methods.

### 3.4.1 Water-Leaching:

One of the earliest methods for preserving bamboo was this. The idea is to immerse the bamboo for four to eight months in pure, flowing water. The bamboo's water-soluble constituents, such as its starch and sugars, will slowly wash away. As a result, insects are less likely to find the pole tasty. It's crucial to remember, though, that even after this procedure; the bamboo is not entirely immune to mould growth and insect invasion.

### 3.4.2 Fermentation:

In this method, the bamboo is supposed to decompose for three to four months in mud and tree leaves. The starches and sugars in the compost are converted into acid by the microbes and bacteria, which reduces the risk of insect predation. Although clever, this strategy lacks confidence that it will shield the bamboo from future insect infections. It is also quite unpredictable.

### 3.4.3 Smoking and Heating:

Smoking bamboo poles reduces the humidity content in lately gathered bamboo and extrudes out the sugars that are in the pole. Likewise, the chemical composites set up in bank are absorbed by the bamboo apkins and help to cover them from insects. The main challenge with this system is to maintain thickness of heat and bank quality throughout the bamboo preservation process, so

that each pole is treated slightly. Burning large quantities of material to produce bank also has its own environmental challenges.

### 3.4.4 Saltwater and Seawater:

Sumberging bamboo into swab water is an effective treatment result. The bamboo is submerged in the ocean for 30 days- 3 months to allow the filaments to absorb the swab result and release the sticky tire from the parenchyma within the bamboo. Holes are punched through the core of the pole, to break free the internodes of the bamboo to allow for maximum penetration of mariners into the bamboo. On some occasions, bitty holes are also drilled from the outside skin at each internode for veritably thick- walled bamboo.

The only challenge with this system is that seawater is composed of sodium and chlorine( NaCl) and the chlorine is largely sharp. This presents issues during construction as it rusts sword bolts used for joinery connections and collects moisture out of the air which can lead to issues in the long term. There's the sense behind all the traditional practices to treat bamboo and these practices are generally not environmentally dangerous, but they're frequently impracticable or unreliable in the ultramodern environment of the construction assiduity.

## 4.0 CONCLUSION

The ideas discussed in this study may be practical resources for the overall, economically advantageous development of Tribal and rural urban regions. The bamboo structure may be made appealing rather than merely tolerable by using creative design and other locally accessible materials. According to the present study, bamboo has evolved into an alternative material to traditional materials as a result of the development of new technologies, consequently displacing the resources that are quickly running out. In addition to being a useful building material, bamboo also maintains the regional economy, maintains environmental harmony, and creates jobs in the area. As a cost-effective building material, bamboo will thus continue to play a significant role in the rural construction industry.

## 5.0 REFERENCES

[1] Bamboo as a building material, http://www.bambus.com/new/eng/reports/buildingmaterial/buildingmaterial.html (accessed January 2018).

[2] National Mission on Bamboo Application. Accessed from http://www.bambootech.org/

[3] Salam, K. (2008). Bamboo for Economic Prosperity and Ecological Security with Special Reference to North-east India. Cane and Bamboo Technology Centre, Guwahati.

[4] Prof. Satish Pawar, “6Bamboo in Construction Technology”, Advance in Electronic and Electric Engineering. ISSN 2231- 1297, Volume 4, Number 4 (2014), pp. 347-352 © Research India Publications available at http://www.ripublication.com/aeee.htm

[5] Nick Gromicko, “Bamboo Construction and Inspection”, available at http://www.nachi.org/bamboo-constructioninspection. html.