Contemporary Bamboo Architecture in India and its Acceptability

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Abstract

India is the second largest producer of bamboo in the world and has vast traditional knowledge of bamboo based communities with the best bamboo artisans in the world. Use of Bamboo for buildings is part of age- old tradition in India. Because of the distribution of various climatic zones in India, the species of bamboo found in each state are quite different. Hence, India has various bamboo building typologies across the country depending on the climatic zone and the species found in the particular state.

This paper will chart the various traditional typologies of bamboo buildings in India and their evolution through time to the present, influenced by the new interest, research and development in the material globally.

The paper will also discuss the issues that have been hindering the acceptability of bamboo as a preferred material for modern architecture, as also our strengths that will enable us to emerge as a major contributor to the bamboo building sector in the future. The paper will address the above in the following manner.

Traditional Bamboo Architecture in India - literature survey--- Problems and Issues----Contemporary Bamboo Architecture in India--- Acceptability of contemporary bamboo architecture--Identifying major issues --- Systemic solution as the key—The Road ahead

Key words: Bamboo, Building, Traditional, Sustainable, Architecture, Policy, Issues, Materials

Introduction

With the Global warming issues raging the globe, and the construction sector a major contributor, scientists across the globe are looking towards low energy, resource efficient building materials and technologies for solving the problem of keeping the pace of development without further raising the carbon levels.

A sustainable building should be able to perform in both normal and extreme conditions. Safety in a build environment is a fundamental right. (United Nations 1948; United Nations 1994). Recent natural calamities in the last two decades have resulted in very high casualties. From the statistics, it is found that there were much less causalities in developed countries. The 2010 earthquake of Chile, fifth strongest since 1900, had 550 casualties only, mainly because of better seismic building technologies adopted. Tropical and sub tropical regions have the largest housing and infrastructure deficit and are also the sites of major natural disasters .It is in view of these facts, world has started looking for sustainable materials like bamboo as a viable solution for the building sector. Bamboo is now being hailed as the future sustainable material through research, development and usage across the globe.

Majority of the knowledge of bamboo building technologies is based on cultural traditions. India has a rich and diverse tradition of bamboo buildings with various indigenous technologies. In order to develop

it as a modern sustainable building material, in both technical and cultural sense, we need to evaluate traditional building techniques technologically and develop them with design and performance assessment to resolve the issues.

India is still catching up with the world in adopting the newly developed bamboo building construction technologies for mainstream buildings. Several research institutes are working on bamboo building systems, but the lab to land transfer is very slow. Alternative technologies need to be seriously viewed in the light of global warming and rising inflation. But the question is: how far do these alternative materials and technologies match up with the conventional ones? Why do people still hesitate to build a bamboo house for themselves?

This paper tries to find answers to these questions and connect the dots, to explore the reasons for un acceptability, of a material proven for its worthiness, with all its attributes and unique qualities, certified by experts in its multiple applications in the building sector in India, where it is hardly being acknowledged as a strong alternative.

Traditional Bamboo Architecture in India – A literature survey

Bamboo community lives close to the forests and are traditionally dependent on bamboo for their livelihood. Due to the climatic diversity across the country, the building materials and species of bamboo found in different climatic zone are quite diverse. Hence, the traditional building systems and typologies developed over several centuries in response to the local climate and available building materials are also quite diverse.

North Eastern states—Bamboo is available in abundance in these states. Since accessibility is still a big problem here, people build with local materials to the maximum extent. Riang houses, Mizo houses and Adi Gallong houses use bamboo as the primary material for construction. Sometimes even the thatch is made of bamboo leaves. These are typical hill houses constructed on bamboo stilts and have woven bamboo mats for walls. Flooring is made of splits or flattened bamboo. The houses in Assam and some other states are built sometimes with a plinth base with Wattle and daub walling in combination with wooden poles. Bamboo is extensively used for fencing and large temporary structures for festivals and functions (Figure 1,3,6,7,8).

The river planes, in the states of Bihar, Bengal and Orissa house built with bamboo only are found in rural and tribal areas. Walls are made of mats of splits or flattened bamboo, with mud flooring on a plinth. In these, bamboo was also used as reinforcement in lime *surki* flat slabs. There are several examples of houses over 70-80 years old still in working conditions (Figure 4).

In Central India, a traditional dwelling of bamboo worker has a walls are made of thick bamboo matt covered with mud plaster, thick bamboos are used for vertical support. The attic floor is made of bamboo mating, covered with mud plaster. The roof consists of wooden trusses, rafters and purlins of bamboo and covering of country tile or thatch. The mud is used for plastering; flooring is done by rammed earth, covered with cow dung. The timber doors and window frames with bamboo shutters, bamboo jail are used for lighting and ventilation (Figure 5)

In the desert regions, bamboo is used as reinforcement in walls, boundary walls and also in main roof structures.

In south India, bamboo was used for walls in a wattle and daub system with composite mud plastering and roof structure in sloped roofs in rural areas. In urban areas, bamboo was used majorly in roofing structure for both sloped and flat lime *surki* roofs.

In the coastal belt, bamboo is used for walling and roofing structure, as also for fencing mostly by the fishermen. The walls are made of woven mats from Bamboo. Famous Kerala house boats use bamboo for their complete superstructure in bamboo (Figure 2).

Major Traditional Construction Systems of Bamboo Buildings of India		
Sr. No	Building Components	Description

Figure 1:Rural House,Assam

Figure 3:House at Tamalpur,Assam

Figure 2: House Boat ,Kerala

Figure 6:House of Adi Tribes, Arunachal Pradesh

Figure 5: Bamboo House in MadhyaPradesh

Figure 4:House at Brahmaputhra river bank

Figure 8:Building at Guwahati,Assam

Figure 7:Naga Heritage Village

Table 1: Major Traditional Construction Systems of Bamboo Buildings of India

1.	Foundation and Structure	Building on Stilts: Beam and Post system with bamboo in combination with local wood. In this case the flooring is made from bamboo in various ways.
		Local stone foundation with mud base with column and beam system with bamboo in combination with local wood. These houses have mud flooring.
2.	Wall	*Ekra* system- Walls made from woven bamboo mats with either strips or flattened Bamboo. They are either left exposed or plastered with mud or lime depending on the climate conditions. If thermal mass is required, plastering is done. But if ventilation and lighting is required, the wall is left exposed.
		The Assam system. Walls with wattle and daub method with widely spaced frame made of bamboo splits covered with mat, jute or mesh plastered with mud or lime mortar.
3.	Roof	Sloped roof- Almost the whole structure is made from bamboo in combination with local wood. Roofing material generally used is thatch, terracotta tiles and more recently tin or sheets.
		Flat roofs- Two methods were used. Some places bamboo was used for the under structure in combination with wood with lime *surki* slab on top. In the second system, bamboo was used as reinforcement in the lime *surki* slab.
4.	Doors and Windows	a. They are generally made of bamboo in combination with wood, or some places with only bamboo depending on economical and climatic considerations.

Problems and Solutions for Traditional Bamboo Houses

1. Only socially and economically weaker sections of the society build bamboo houses. They opt for low cost bamboo houses of poor quality due to their poor economic condition .To construct quality bamboo houses economic condition of the people has to be improved.

2. Supply of bamboo for the construction sector is much less than the demand. The price of bamboo has gone up further due to demand of bamboo from the paper industry. This forces people to go for cheaper and substandard materials. Both forests and homesteads divert their resources to sectors offering higher prices. Quality bamboos, at low cost must be made available to people who wish to construct bamboo houses.

3. Most of the bamboo community knows the construction technology and preservation techniques. If financial help is provided they can build reasonably safe buildings for themselves with little training on latest technology interventions.

4. Growing Bamboo should be encouraged in wastelands, mid and lowland areas and homesteads. These plantations should be included in the Forest department programs in rural and tribal areas.

5. Rationing of bamboos can be implemented in areas of short supply and high prices. Bamboo depots should be established by the government in convenient locations so that people can buy bamboos easily can get bamboo easily.

6. Bamboo should be included in the housing schemes by the state governments as a major construction material, thereby upgrading the status of bamboo houses to 'pucca' house. Economical treatment of bamboo for construction should be popularized. Some prototype bamboo houses suitable for local conditions and climate can be constructed to popularize it among the people.

Contemporary Bamboo Architecture in India

Seeing the global trends, some organizations have engaged in research and development in the field of material science, treatment methods, building components, construction systems and products with bamboo for over few decades. The major organizations and institutes in India working in bamboo sector are:

IPIRTI, Indian Plywood Industrial Research and Training Institute, Bangalore- In collaboration with TRADA and BMTPC, they have developed a modified walling system with Bamboocrete - an up gradation of Wattle and daub system; and also a construction system for two-story bamboo structure. IPIRTI has also developed some treatment methods for bamboo to be used in construction. It has also developed various types of bamboo ply, boards, flooring and corrugated roofing sheets from woven bamboo. Some of these technologies have been transferred to industries and are under manufacture (Figure 19).

IWST, Indian Wood Science Institute, Bangalore- IWST has developed treatment method for bamboo and developed a bamboo-wood –plastic composite which can be used in several building applications.

CGBMT with Manasaram Architects, have worked on pre-fabricated bamboocrete wall panels, prefab houses, bamboo construction systems with BRC- bamboo reinforced concrete roof, BFRC- bamboo fiber reinforced concrete, freeform bamboo roofs, tensegrity and synergetic structures with bamboo, compressed blocks with bamboo and paper waste with mud etc. They have also taken most of the technologies developed by other organizations from lab to land in an innovative and aesthetical manner in

their live projects, thereby creating a string of examples and database for other architects and engineers to follow (Figure 21-30).

CIBART with KONBAC has been working in the furniture sector and has set up some units. They are also developing a construction system with small diameter bamboos (Figure 9).

IIT, Indian Institute of Technology, Delhi is engaged in some works on bamboo buildings.

Inspirations, an architecture firm has been trying to use bamboo in some of their projects, including their own office building. (Figure 18)

Sangaru objects pvt ltd has been developing high-end furniture and products from bamboo thereby trying to elevate the status of bamboo as a material in the field of product design (Figure 15).

NID, National Institute of Design has been working with bamboo for product design for living spaces etc (Figure 16)

Wondergrass initiatives, Nagpur is involved in developing standardized prefab bamboo panels for walling and has also done some construction projects (Figure 14).

Figure 12: Bamboo Dormitory by Architecture BRIO

Figure 11: Modular Office by Design Purple

Figure 10: Bamboo House, New Delhi

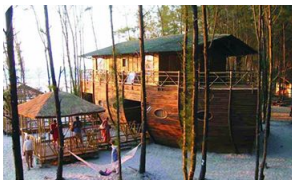

Figure 9:Tourism Building by KONBAC

Figure 16: Bamboo Bridge by Wondergrass

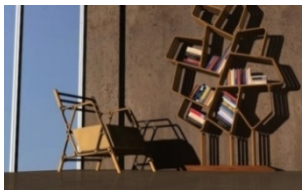

Figure 15: Sangaru Objects Pvt. Ltd.

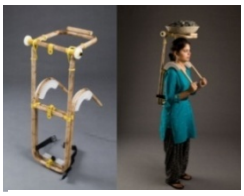

Figure 14: Product Design by NID

Figure 13:Bamboo Canopy by Rebecca Reubens

Several young architects are trying to work with the material, but most of these projects do not see the light of the day and remain on paper due to various factors. (we will discuss them in the next section). Due to its sustainable properties, it is a favorite material used in design competitions to get an edge. It is also being used for eco-tourism projects, but most of them are built as temporary structures, by Architecture BRIO (Figure 12), Cherai Beach Resort- Kochi (Figure 17, 20).

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Figure 17:Inspiration, Cochin

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Figure 18: Two Story House in IPIRTI

Figure 20: Cherai Beach Resort, Cochin

Figure 19:Cherai Beach Resort, Cochin

We are trying to popularize bamboo for the last 15 years by trying to work with various organizations and institutes as a mainstream building material for large scale building and infrastructure projects. These projects will instill confidence and create a strong database for evaluation and use. Some of the projects are:

Figure 28:Bamboo Symphony, Bangalore

Figure 29: Interior of House of Five Elements, Bangalore

Figure 27: House of Five Elements, Bangalore

Figure 25:Bamboo Museum, Palanapur

Figure 26: Lunardi's House, Spain

Figure 24:Workshop at Trichy

Figure 22: House of Hungarian Music, Budapest

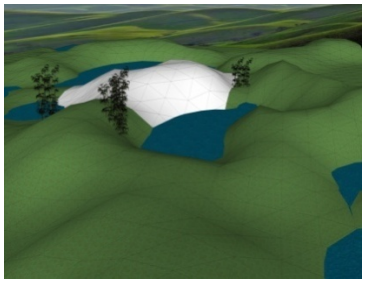

Figure 23: Canteen, Gandhinagar

Figure 21: interior Metro station Bangalore

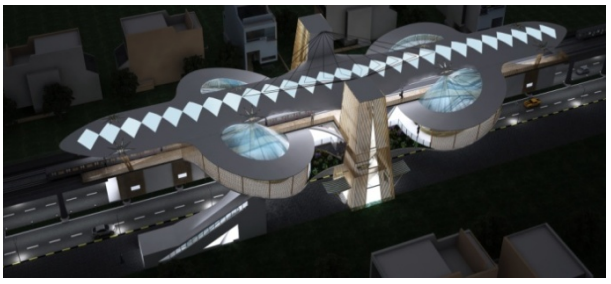

Figure 30:Metro Station, Bangalore

Theme: Architecture, Engineering and Social Housing

Acceptability of bamboo architecture-- Identifying major issues

Could the hesitation be because of lack of awareness or is it due to a simple resistance to adopting an alternative technology? Or does it have a deeper explanation? Why has it become so easy for conventional housing techniques and materials, to completely wipe out the richness of the deep-rooted traditional architecture using mud and bamboo construction, the construction skills which has been perfected over centuries? Why are the conventional houses selling, despite being unaffordable and inhabitable? Are the traditional construction skills vanishing? At this rate a wonder material like bamboo is likely to end up in laboratories and never be able to get transferred on to the land. There is hence a clear need to explore in depth the reasons for non-acceptability of bamboo dwellings.

A. Material Limitations:

Bamboo is a natural material and hence has certain limitations. Research energies, the world-over have been focusing on countering these limitations.

a. Steps need to elevate bamboo technically to a level for it to qualify as a sufficiently durable and structurally safe material for construction for the building sector and for bamboo buildings to become bankable assets.

b. Fire Rating: Susceptibility to fire is another limiting factor in the use of whole bamboo culms in buildings. Engineered bamboo is a solution to this problem, but it is unaffordable to the majority of clients. Hence fire rating of round bamboo and fire retarding treatment material and methodologies need to be developed for bamboo to be used in large-scale projects.

c. Jointing Systems: Owing to the round shape, jointing is very difficult and cumbersome in bamboo. The reduction of diameter along the length is another limiting factor. Various types of engineered and tested jointing systems with appropriate materials need to be developed for effective structural load distribution and transfer. Not many studies have been done relating suitability of joints and their mechanical behavior. Researchers need to include connection types with complete structural systems.

d. Conical form of bamboo: Bamboo reduces in diameter and weight along its length. With an approximately hollow circular transverse section with varying density in both directions, bamboo is a unique and difficult material to design with. Digital Image Analysis (DIA) is a reliable tool to derive appropriate equations to map fiber distribution in sections of bamboo. This can help an architect or engineer to calculate the modulus of elasticity of bamboo with fair degree of accuracy. Use of engineered bamboo, bamboo composites and prefabrication- Though whole bamboo has been and can be used in construction for many types of buildings, for bamboo to be established in the building sector as a mainstream material, we need to use it as composite construction with other materials and an large scale usage of engineered and prefabricated bamboo based components. Many of the traditional construction techniques will have to be either improved or substituted for mass usage of engineered bamboo especially for multi-storied buildings. Extensive study is therefore required in the field of processed bamboo construction materials and methods.

e. Splitting Behavior of bamboo: Most common failure is splitting in longitudinal direction. These failures are usually due to tension, compression and flexure loads in bolted connections and also from drying. It is a technical and practical necessity and needs to be fully addressed. We need to formulate simple mathematical equations involving fundamental properties of bamboo which can be used for designing complex structures with bamboo with the same confidence as for other materials.

f. Hygroscopic nature of bamboo: The main deterrent for bamboo to be used as reinforcement in place of steel is its water absorbing capacity. The swelling and then shrinking of bamboo in concrete results in micro and macro cracks. To avoid this, effective water-repellent treatments for bamboo splits with suitable modification of concrete is necessary.

g. Small spans of bamboo buildings: For a medium size building, a span of 3-4 meters is generally considered suitable and economical even for steel reinforcement. Bamboo can be conveniently used as reinforcement in modest size buildings economically. Large spans difficult with bamboo as it is difficult to get splits of uniform cross-section for reinforcement for very long lengths owing to its tapering structure.

h. Building industry in India is still an unorganized sector and hence even conventional buildings are very poorly implemented. Bamboo buildings are even more poorly implemented for lack of severe human resource deficit.

Once these problems are countered, bamboo will become a highly appropriate building material for India. For seismic regions it is reputed to cause the least damage to life and property. Due to its light-weight, foundation costs also can be saved. BRC, Bamboo Reinforced Concrete can also be designed in a manner similar to that of steel reinforced concrete with a few extra precautions. All these technological advancements will help bamboo to get its rightful place in the building sector and result in tremendous economic and environmental advantage.

B. Academics, Research and Development issues:

a. Integration in Academic curriculum: Bamboo is not included as a mainstream material for building construction in the curriculum of architecture, civil and interior design disciplines. Hence most of the designers remain unaware of this wonderful sustainable material. Awareness needs to be built through workshops, seminars and lectures etc by experts in the universities and institutes. The students need to be exposed to innovation and global best practices in the field. All the previous research and findings must seep into the classrooms immediately, through dissemination by academicians by incorporating bamboo in their syllabus.

b. Architectural Solutions: Most of the bamboo buildings in India today have been done by govt agencies as part of some testing and research with minimum attention to aesthetics and finish. These in reality never have been able to attract the public for their own usage. Construction of aesthetically designed prototypes in prominent locations, for active promotions and display, to attract those willing to experiment with construction of bamboo buildings, has to be taken up on to make bamboo a desirable material. Major building components, partially replaced with bamboo can be used to arrive at different permutations and combinations, to create a variety of architectural design options to suit different tastes and budgets. Skill development and training programs must be taken up before the actual construction boom for bamboo buildings in order to provide skilled manpower for high quality construction practices.

c. Non-availability of data and Research results in usable format: Research and innovations in alternative materials and building technologies hardly see the light of day. There could be many reasons for these experiments, though successfully conducted in laboratories, to never reach the field of applications. One major reason is the cumbersome and elaborate precautions that have to be taken for design and also during construction of the structural elements. This makes them non user-friendly. Most of the time they are not

practically possible, are time consuming and very expensive. There has to be an equally robust implementation strategy through timely precipitation and dissemination of the research data in usable format along with awareness building for a widespread market penetration. We need to simplify the treatment methods and eliminate operational problems in making bamboo a mainstream building material.

d. Need for Standards and testing methods: In the world of building construction, today's conventional materials like steel and concrete were once unconventional and unproven and took decades to achieve acceptance through research and development, testing and redevelopment and experiences to evolve into standardized practices. Even today they are being refined through further research and development. Due to global warming, increasing focus is now being placed on the standardization of green and sustainable building materials like bamboo. Standardization of bamboo as a construction material will serve both technical and social purposes. This will give a more reliable understanding of the material's properties which can lead to refinement and confidence in design values, leading to acceptance of the material in the design community. Such acceptance, coupled with advocacy, can lead to broader social acceptance of previously marginalized vernacular construction material and technologies like bamboo.

e. Field Testing: An important consideration in development of standard test methods should be the ease to conduct them reliably in a field setting with minimum equipment and specialized machinery. This would allow material properties to be assessed by non-technical personnel. Also, the field test must produce a useful data that can (1) directly determine design values; 2)get correlated to values obtained in a laboratory test; or (3) be accurately used to compare different batches of materials. Standardization of bamboo test methods is critical if material is to gain greater engineering acceptance. Methods that capture fundamental material properties permit comparison of the behavior and performance of different bamboo species, their geometry, weathering patterns and the treatment methods required. Standardized test methods used in well defined experimental studies also permit the isolation of factors that affect material performance and behavior. This process represents the path to rational and universal design methods for bamboo. Also testing of bamboo is quite difficult due to a) many varieties of bamboo b) Within the same variety itself again there are many variations. So for general usage economical testing methods could be developed even if they are not as accurate. (Accuracy vs. Afford- ability)

C. Legal, financial and policy issues:

Need for Policy frameworks: Government Departments of Town Planning for a re-look at the housing strategies, the necessity for evolving policy frameworks, in order to incorporate alternative materials for building construction. A large potential segment of buildings are considered as being valueless due to usage of materials like bamboo. This is majorly due to the definition of a "pucca house" as per the census. The other factors are the criteria listed for housing finance by funding agencies, the National policies, the building byelaws, the development control regulations and finally the psyche of the inhabitants for whom a house can only mean a pucca house only if it is made of steel, cement, bricks, and concrete.

a. Redefining a 'Pucca house -It is immediately required to change the census definition of a pucca house with inclusion of alternative buildings, to make these building also a financial asset for the house owners throughout its life span. This will also change the statistics of housing stock and make it more realistic.

b. Inclusion in SSR and National Building Code – Bamboo needs to be included in the Standard Schedule of Rates and National Building Code published by the government for all

civil and infrastructure works in the country. Formulation of a set of standards for using bamboo, with treatment and testing methods etc included into the National building Code will make it convenient for architects and civil engineers to include bamboo in material specifications of their projects easier without risking the clients financing options. This will also facilitate software based designing of complex bamboo structures. Inclusion in the Schedule of Rates will spur its free unhindered usage in large government and institutional projects

c. Definition of Bamboo as Tree: This has created numerous hurdles for material availability of bamboo and its exorbitant costs. In the last 10 years there seems to be some efforts being made, but they have not borne fruit so far. Bamboo needs to be liberated from this problem at the earliest throughout India to ensure consistent supply of bamboo for all industries.

d. Special Policies for bamboo buildings: A national level program can be proposed to streamline the financial / administrative/local level machinery, so that special bylaws can be framed for bamboo buildings. These could extend specially for seismic zones which generally have bamboo readily available. Special relaxations in criteria for housing finance for bamboo houses meant for the rural and urban poor, cross subsidy and house insurance etc could be a great booster. Special provision can be made for smooth and fast clearance of applications for buildings with alternate materials like bamboo with an incentive package.

e. Finance for bamboo buildings: Techno- financial environment has to be created to encourage the use of bamboo for construction purposes, and attempts have to be made to elevate a bamboo building to the status of a capital asset having an appreciating property value. A parallel research on financial management is required to evolve soft criteria for offering cheap loans, subsidies and formulating social security measures to extend over the right to modest housing and humane living environment for the poor under the provisions of Article 43 which currently focuses only on just and humane environment for work. Insurance facility against fire, theft, death along with the medical insurance to promise financial security will have to be dovetailed to the package of benefits and privileges legitimately acquired by a citizen. Funding is now being available for bamboo buildings from the Ministry of Rural Development and National Wasteland Development Board.

f. Housing standards: 25 sq m is the recommended minimum size of a dwelling as per standards in India. Often the size of the house, number of rooms, provision of basic amenities and facilities are compromised, creating a favorable situation for catalysts to thrive for creation of slums rather than their eradication. Cost Cutting should not mean size, safety and quality compromises and this can be achieved with bamboo buildings. The contribution of alternative materials in cost reduction may not be large, but it cannot be ignored. However small the saving may be, it is sufficient reason to prevent dilution of standards of a “Pucca” house or building, which is a major hurdle in achieving the national target of having slum free cities or total eradication of homeless population. Bamboo structural elements and inner walls in the superstructure alone can bring down the costs up to 13.8% which saves enough to prevent dilution of standards in a conventional house. The National Policies considers what is “Possible to the built in a small budget while keeping the technology constant and certainly not what is “desirable” or “acceptable “in terms of size and number of rooms. A unilateral compromising the standards is being made uniformly across the country, thereby reducing the area, size, and number of rooms making the houses inhabitable without exploring other possibilities.

g. Disconnect among various agencies –While the policies may have an ambitious and well-intended package in place for alternative building materials it require fine coordination among multiple agencies. Historically, multiplicity of functions and overlapping of jurisdictions have been the cause for the failure of most of the policies, schemes and programs.

Theme: Architecture, Engineering and Social Housing

h. Alternative Materials should be used only on merit –It has to be noted that all alternative and unconventional materials do not result in a 'pucca' (permanent) house. In fact if the damage and destruction due to failure of structural design, were to be included in the cost benefit analysis, most unconventional materials would qualify as being pucca in the sense of being safer if not durable. Habitability is not related to durability. A pucca house despite being durable, safe and secure can still be inhabitable by virtue of its size, climate non responsiveness, persons to room ratio. In both the cases, several hidden cost like transportation, betterment, processing and user charges, taxes etc make the houses unaffordable.

i. Affordability varies with time: Affordability should not dictate the size of the house and number of rooms etc. and consider the limit when it starts to become inhabitable or inadequate. Affordability can vary with time and can be linked to incremental housing solutions. Habitat not housing is what needs to be planned for. Each being valueless, without the other

D. Social issues

a. Affordability vs. Priorities- Affordability is perhaps the prime reason for people to opt for a more permanent solution. At the same time a substandard house can be very demanding in terms of time, energy and money for its maintenance. Ever increasing expensive lifestyles, new emergent priorities, and erratic non-budgeted expenditure patterns, could lead to a skewed result, making affordability a highly sensitive variable rather than a constant indicator. Bamboo being one of the cheaper materials can play an important role in providing an economic alternative in combination with other materials for a durable and safe house. This is especially true for urban areas close to bamboo growing regions.

b. Substituting Bricks, Cement, Steel and Timber Alone can Account for a Cost Reduction of up to 40%: By substituting bricks, cement, steel and timber with bamboo even partially for constructing walls, floors, roofs etc., buildings can be designed for a longer life, improved quality, and low maintenance. Bamboo in combination with other alternative materials for these components alone can give a cost reduction of up to 40% (Figure 31).

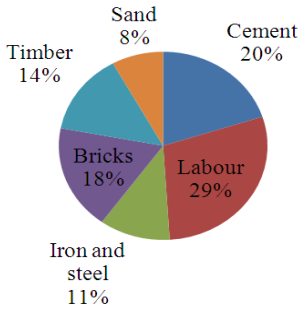

Figure 31

c. Social acceptability: Experts from the industry indicate that whole bamboo has failed to live up to the social urban image. This can be dealt with by modern bamboo construction and aesthetical architectural design using global innovations and best practices. Cost reduction by using prefabricated components, increasing the speed of construction, availability of finance and insurance facilities will go a long way in social acceptance of bamboo buildings.

d. Need to evolve Standards: -Some of the important housing terminologies needs to be redefined, so that the benefits of all the research reaches the general public. Translating them into a series of standard thumb rules will make it easy for bamboo to be used for construction in rural and tribal areas without the involvement of professionals further reducing the cost. This will tap a vast market segment of buildings in the rural and tribal sector thereby generating livelihood options as well and solving the housing and infrastructure problems.

E. Execution Issues

a. Material availability: Availability of good quality and quantity bamboo of suitable species for building sector is a major issue hindering the usage of this material . If treated and standardized

graded bamboo is made available readily, use of bamboo in building sector will increase manifold within no time. Bamboo depots need to be set up by government and private agencies in across the country to make the material available to clients, architects, designers and engineers.

b. Skill development: Capacity building measures at every level of design, supervision and execution, and on war footing basis on large scale must precede the actual construction boom in order to cater to the demands of bamboo building sector. The training institutes can provide vocational education and training programs with emphasis on hands-on experience. NGOs, grass-root level workers, elected representatives, along with self help etc all have to work in coordination to create a skilled workforce for the bamboo building sector. The skill development program could be implemented through smaller action plans, either location specific or activity specific through it is, Polytechnics etc. Training schedules and content could be designed accordingly.
c. Pre fabrication- Building components, partially replaced with bamboo and bamboo composites etc if made available to create permutations and combinations, for creating a variety of architectural designs, will provide choices for selection for design and budget, and also enhance the speed of construction on site thereby making it economical. Engineered bamboo can provide more options for increasing speed of construction.
d. Treatment of bamboo- Elaborate procedures of treatment also is a major issue in usage for bamboo by contactors. Quality treated bamboo is a mandatory requirement for structurally safe, economical and long lasting bamboo buildings. Governments need to set up treatment plants near forests and other areas for value addition to bamboo from the forest areas and ensure continued and sufficient supply of bamboo in bamboo depots. SHGs and JFMs could be financed by the govt to set up these units creating large livelihood opportunities to otherwise economically poor and marginalized bamboo communities.
e. Raising the standards of implementation: In India, bamboo had been a well-established building material. But this has drastically changed recently because of bamboo buildings being generally very poorly implemented most of the time. Concrete and steel buildings are typically difficult to construct, requiring skilled workers and quality materials for a successful result. Bamboo offers an easier alternative. However, the implementation of bamboo structures seem to be generally quite poor, with poor planning and design, and specifications being abandoned in favor of other building techniques. We need to form superior guidelines and frameworks for building bamboo structure. A multipurpose kit for constructing bamboo structures that includes pre-fabricated connections, tools and instructions etc can be made available. In this way, we will empower the execution team with basic building skills to become more confident and execute high quality bamboo building.
f. Elaborate, expensive and inaccurate testing methods- The testing procedures for bamboo building components are complex, expensive and inaccurate and unavailable most of the time. This makes it very uneconomical and difficult for the contractor to adhere to standards and timelines. Standard field tests for non-conventional materials will also provide rural communities greater equity in terms of safe, adequate, and reliable housing and sustainable development using local resources resulting in an improved standard of living and will serve both technical and social purposes.
g. Backward linkages unavailable – In order to be able to substitute the energy intensive materials on a large scale ,parallel activities involving plantation, drying, seasoning and chemical treatment have to be promoted and up scaled as parallel industries , as backward linkages within an extension of a “focused agro-based employment scheme” for small and marginal farmers. The product would thus be “especially and exclusively treated and graded bamboo for the purpose of building and mass housing for the urban and rural areas, following the customized design specifications and construction details.

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Systemic solution is the key—The Road ahead

The question is not just that of "Why not bamboo?" but that of "how to promote it". If bamboo building technology is made convenient to handle and promoted along with standards, codes and bylaws, tied up with the legal and the financial machinery, then the entire package put together could go a long way in creating a gateway for bamboo and all other alternative materials and technologies.

A. Create a Parallel Construction Industry: A new segment of alternative building sector is needed to be initiated. A fresh look at the age-old materials and technologies, repackaged to blend with the current socio-cultural environment, and the demands of the time, is inevitable. Measures need to be evolved to formulate techno-financial models or system mechanisms which should operationally be able to transform an architecturally designed bamboo house into an easily accessible commodity which can be treated as an asset or an investment, attracting speculations for its value and appreciation. It could be visualized as a material which shall simultaneously create a parallel construction industry, while also being commercially beneficial for the owner. This would encourage investments in bamboo buildings. In this context it would be beneficial to review global best practices for alternative technologies, where the Policies have led to an increase in the efficiency in construction and distribution, for the bamboo-building sector.

B. Selection and Looping- In order to arrive at a standard package, several looped packages linking limitations, potentials and possibilities, measures, policies and the legislative-techno-financial models are expected to be generated, through experiences, developments, innovative break-through and traditional practices. All of these are inter-dependent factors and only by connecting all these factors appropriately, a reasonably workable package with a comprehensive strategy can be evolved.

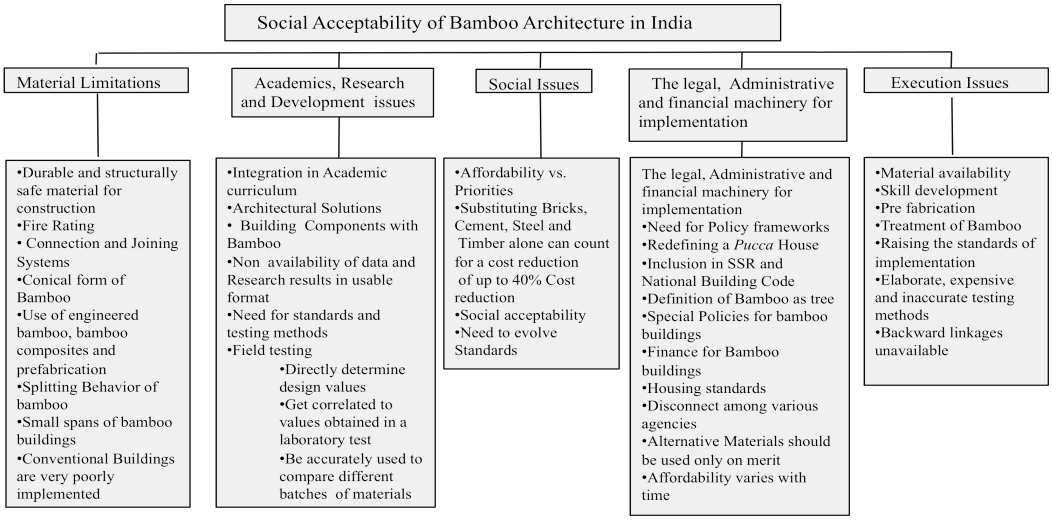

Table 2: Social Acceptability of Bamboo Architecture in India **– an overview**

Unless the policies are converted into programs, programs into projects, projects into small action plans, carried out by heterogeneous group of professionals who can take responsibility of hands-on delivery, Bamboo building technology, would forever remain a part of ambitious policies.

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