

UTILIZATION OF BAMBOO AS A CONSTRUCTION MATERIAL FOR LOW COST HOTELS AND RESORTS

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Abstract

The main objective of the paper is to develop awareness in the civil society on bamboo as a potential building material for low cost housing and resorts in India. To achieve the goal of the study, a comparative study has been carried out between a two storied conventional reinforced concrete structure and a two storied RC (reinforced concrete) structure having bamboo partitions. From the cost analysis, it is found that the construction cost of a two storied RC building having bamboo partitions is lower than a two storied conventional RC building. Due to lower self-weight of proposed building as compare than conventional building, it is also found that the earthquake load on proposed building is lower than conventional building. Use of bamboo as building materials may reduce the demand of brick production in a country; consequently CO₂ gas emissions will be reduced. Bamboo wall reduce 53 percent of wall construction cost. Furthermore, a bamboo partitions building is not only economically but also aesthetically better than brick partitions buildings.

Keywords: Bamboo, brick partition wall, RC, CO₂, resistant, heat, comfortable

Introduction

From many years ago, bamboo has been used as a sustainable solution of building component of structures in developing countries .It is a rapid growth material has made this grass an interesting structural material due to its long durability. Bamboo can even help the whole world by its remarkable CO2 sequestrating capacity. Bamboo has historically been used as a building material due to its inherent properties, being regenerating with high tensile strength and light weight. Low cost technology reducing the cost of construction through the use of locally available materials, without sacrificing the strength, performance and life of the structure.

The construction cost can be divided into two parts :

Cost of materials : 65 to 70%,

Labour cost : 65 to 70 %,

When bamboo contact with moisture or water its strength increase time to time. Brick absorb heat but bamboos reflect heat so the house gives more comfortable life these are interesting characters. At first, an overview of the project objectives is presented that include mechanical properties of bamboo and current practice in joining methods and connections. Finally, a comparison of structural rebar and estimating of a panel on our work.

Aim: Utilization of Bamboo as a Construction Material for Low Cost

Housing and Resorts

Objective:-

1. To study on mechanical properties of bamboo
2. To study on durability and resistance of bamboo against insect and fire.
3. To study on building of wall panel with bamboo.
4. To find out compression test on bamboo

Limitation

1. Time, Energy were the major constraints.
2. Study was limited to Nagpur city only.
3. Study was limited for civil engineer only.

Review of Literature

2.1 Materials and Methodology

Utilization of bamboo as a building material Bamboo reaches its full growth in just a few months and reaches its maximum mechanical strength in just few years. Some of the positive side such as light weight design, better flexibility and toughness due to its thin walls. There is always need low cost mass housing schemes for people earthquake affected areas, emergency structures in different situations (like low income area). Low cost housing proposal uses bamboo as a cladding material. Bamboo was chosen as it is cheap, lightweight and easy to replace. Bamboo building is suitable in climates .Bamboo is a truly sustainable unrivalled timber, with the compressive strength of concrete and the tensile strength of steel. It's lightweight, hollow, round, curving, and tapering. It's also flexible, making it ideal for earthquakes, as it will bend and flex long before it breaks. Growth of every ton of bamboo consumes nearly a ton of carbon dioxide besides releasing fresh oxygen into the atmosphere. It is adaptable to most climatic conditions and soil types. It can withstand up to 3656 kg/cm² of pressure. It can have reasonable life of 30 to 40 years. Construction techniques using as main material have been found very suitable for earthquake resistant housing. It is an environment-friendly, energy-efficient and cost-effective construction material.

An interesting character occurs on bamboo that is when bamboo comes in contact with moisture or water its strength will increase time to time.



2.2 Mechanical properties of bamboo

The bamboo mechanical properties vary from specimen to specimen and the scientific tests are used in this study as guidance for analysis of the designed structure. It has been found that a large number of studies on bamboo properties and its structural design have been conducted at the Hong Kong Polytechnic University, China. Bamboo fiber has equivalent tensile strength of 650MPa with tensile strength of steel (500-1000MPa) and much higher flexibility determined by lower Young = 50GPa compared to steel .

Some of the important properties of bamboo are:- Average weight – 0.625 kg/m, Modulus of rupture – 610 to 1600 kg/cm , Modulus of Elasticity – 1.5 to 2 x10⁵ kg/cm , Ultimate compressive stress –794 to 864 kg/cm, Safe working stress in compression –105 kg/cm

2.3 Durability and resistance of bamboo against insect and fire

Bamboo is vulnerable to attack by insects such as borers and termites, and rot fungus. Several techniques are available for the chemical preservation of bamboo. However, one method which has proved to be very effective is the ASCU method, whereby bamboo could be protected for at least 20 years. This method developed by the Forest Research Institute, Deharadun (India) bamboo is treated with a solution of arsenic pent- oxide, copper sulphate, and sodium dichromate. The bamboo can be treated with a natural Boron salt solution, which will protect bamboo from insects attack. Bamboo cannot be considered a permanent building material. Without treatment a limited number of works has been done on the fire protection of bamboo.

A reasonably cheap fire resistant composition comprises of ammonium phosphate, boric acid, copper sulphate, zinc chloride and sodium dichromate.

2.4 Methodology

1. Preparation of bamboo

It is required to prepare bamboo using the following steps before utilization as a construction material-

- Depending on the species, 3 to 5 year old bamboo is best for construction purposes.
- The bamboo should be harvested in dry season in order to avoid fungus attack.
- Use the appropriate species for the particular application.
- (iv)The bamboo will not be exposed to direct sun, moisture and rain.
- Its need to use only straight portions from the bamboo culms for construction.
- (vi)Bamboo should be treated against insects and fungus.

2.5 Making of wall panel

- Select the bamboo as per the checklist, the length of single rounded bamboo 25 to 30 ft.
- Remove the lower and upper part of bamboo; it is not useful because it is solid in nature.
- Cut the rounded bamboo in required height of wall panel i.e. to 7 ft.
- By using wooden batten prepare a frame of required size of wall panel
- Fix the rounded bamboo vertically by using nails.



2.6. Connection and Joining Systems

- Avoid openings in culms (e.g. drilling & cutting).
- Construct joints near nodes, they are stronger and protects against insects.
- Securely fit joints by edge preparation and a correct level of tightening.
- Make durable connections (i.e. materials and quality, design solution, etc.).

2.7. Compression test on bamboo

Bamboo may be the strongest stuff on the planet. It has greater tensile strength (or resistance to being pulled apart) than steel, and it withstands compression better than concrete. Both qualities are essential to keeping the plant, which grows to nearly 60 meters but is only as wide at the base as the very top, from falling over. It needs the compression strength to hold up its own weight and tensile strength to bend in the wind without breaking. "Our concept of strength is, it doesn't move, it doesn't break," says Dan Smith, who owns Smith & Fong, the largest manufacturer of bamboo plywood in the United States. "The Chinese concept is, you've got to bend with things. If you don't bend, you break. Bamboo's strength is in its ability to bend, and that's the miracle."

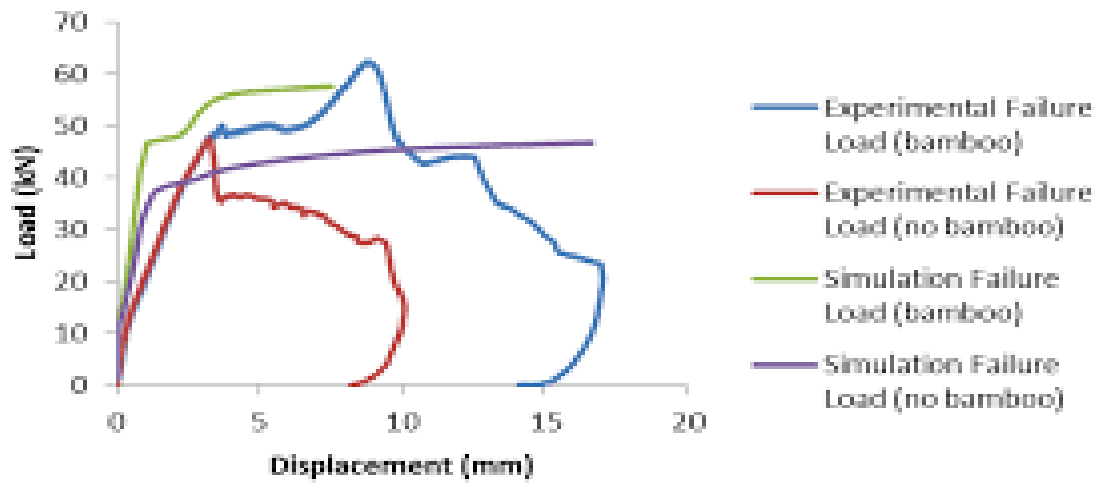
Bamboo is 6 times stronger than steel reinforcement or threaded rebar. This is because Bamboo is quite high tensile strength as comparison to steel. Bamboo is the best choice for reinforcement in concrete because of its higher strength as compared to steel by weight.

The load vs. displacement

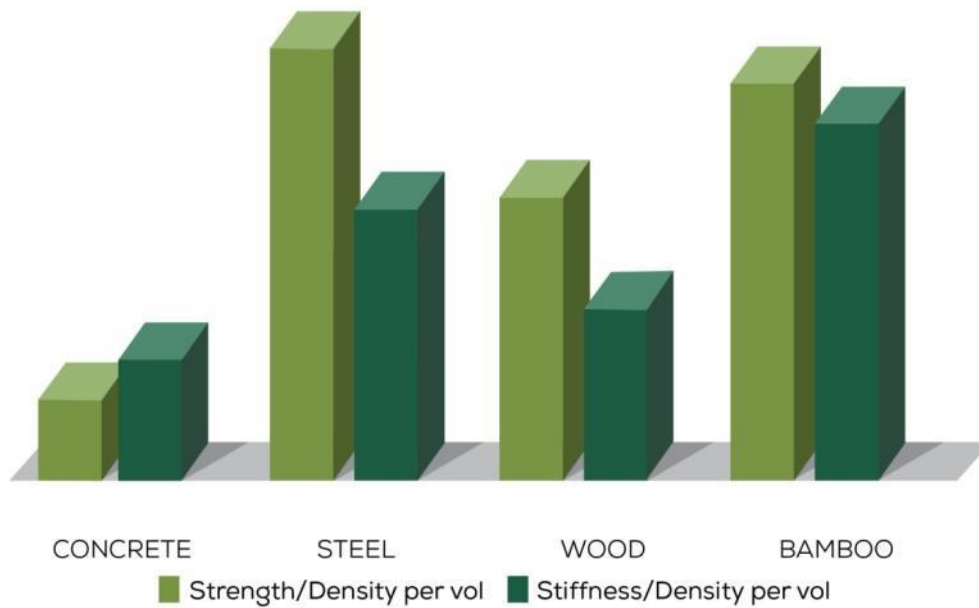
Compression test on bamboo was carried out using universal testing machine.

Test Parameters: Width - 300 mm, Thickness - 65 mm, C/S Area – 19500 mm

Load vs. Displacement



Strength & Stiffness Comparison



Source: Data Charted From Jansen, 2000

2.8. Model of bamboo wall houses

Two low cost model houses are presented in Fig. 6. These models describe how bamboo can be used as wall purpose in housing. In the first image, which present tiles sloped roofing resort and another image presents inclined roofing bamboo housing.



2.9 Advantages of Bamboo

The various advantages of bamboo are mentioned below: .

- Light, strong and versatile
- Environment friendly
- Accessible to the poor
- Self-renewing resource
- Fast growing
- Highly productive

2.10 Disadvantages of Bamboo

The major disadvantages of bamboo are as follows:

Requires preservation

- Requires preservation
- Shaped by nature
- Durability–bamboo is subjected to attack by fungi, insects; for this reason, untreated bamboo structures are viewed as temporary with an expected life of not more than 5 years.
- Jointing–although many jointing techniques exist, their structural efficiency is low.
- Lack of design guidance and codes.

- Prone to catch fire very fast by the friction among the culms during wind, and is seen to cause forest fires.

3. Research Methodology

The methodology sections describes the rationale for the application of specific procedures or techniques used to identify, selection and analyze information applied to understanding the researcher problem, thereby, allowing the reader to critically evaluate a study's overall validity and reliability (Kallet, 2004).

The detailed methodology adopted for the study has been discussed below.

3.1 Research design: It is the backbone of study which has to be carried out in a proper and systematic way. The experimental method of research design was adopted due to the nature of the study.

3.2 Selection of area: The researcher carried out the comparative study on the civil contractor and builders of local area.

3.3 Selection of Samples: After the completion of study the researcher select the group of civil engineering students, civil contractor and builders of local area.

3.4 Sample size: Sample size was limited only.

3.4 Data Collection: In order to get the information about the study the researcher collected the data from two main sources which were:

A Primary data: Primary data was collected through the survey method.

B. Secondary data: Secondary data was collected by referring various books, websites, journals, electronic media and encyclopaedias and all the references have been duly acknowledged in the references.

4. Result and Discussion

Based on the material properties and economic considerations, bamboo is a very suitable component for cheap architectural implementations in India. Because of, from the cost analysis it is seen that, to make a 10' wall of bamboo 4415/- INR is required. Whereas, to make 10' brick wall 10935/- INR is required. Therefore one can conclude that cost of brick wall more than twice of bamboo wall.

4.1. Comparative analysis

An ETABS (Extended 3D Analysis of Building System) analysis has been performed for comparative analysis. A two storied building is analyzed using bamboo partition wall load and also considering brick partition wall load and then the performance and results are compared with each other. In a specific beam section for a brick wall building need 0.83 percent rebar where as a bamboo wall building need 0.48 percent rebar. Along with a column section for a brick wall building need 1.61 percent rebar where as a beam section need below than 1 percent rebar. It says it is a low cost housing.

4.2. Where this types of building uses

- Rural & Low income area.
- Resort area likes (Hill area, Forest area)
- Where bamboo price is lower.

4.3. Cost analysis

From the analytical investigation carried out in this study on a 10'-0" wall made of brick and that made of bamboos, a cost analysis result is presented here. A 10 ft wall made of bamboo cost is 4415/- INR and a 10' wall made of brick wall, cost is 10935/- INR respectively.

A comparison between 10 ft. brick wall and 10 ft bamboo partition is given table -1 & 2.

Table 1: A 10 ft. bamboo wall detailed construction costs are as below

Sr No	Item	Description	Quantity	Total Quantity	Unit Price	Total
1	Along Width	Ht. below lintel = 6.8'	40 Nos	328 Ft	5	1640/-
2	Along Width	Ht. upper lintel =2.8'	40 Nos	135 Ft	5	675/-
3	For Wall	Nails	8 Nos	1.10 Kg	1	100/-
4	For Wall	Wooden Batten	70 No /0.015 cft	1.1 cft	700	700/-
5	For wall	Hard board	2 Nos/50 sft.	100 sft	4	400/-
6	Chemical	Boric Acid	1 kg. 1 kg. 100	1 kg.	100	100/-
7	Chemical	Borax	1 kg.	1 kg.	300	300/-
8	Labour Cost	-	1 Nos	-	500	500/-
Total Cost						4415/-

Table 2: A 10 ft. brick wall detailed construction cost are as below

Sr No	Item	Description	Quantity	Total Quantity	Unit Price	Total
1	Along Width(brick)	Let, A 5" wall, Height = 9.5'	95 sft.	480 nos	10	4800/-
2	Along width	Cement	95 sft.	2.5 bag	580	1450/-
3	For Wall	Sand	95 sft	11 cft	25	275/-
4	Plaster Work	Cement	190 sft.	2 bag	580	1160/-
5	For wall	Sand	190 sft.	10 cft.	25	250/-
6	Head Mason	-	2 Nos		750	1500/-
7	Helper	-	3 Nos		500	1500/-
Total Cost						10935/-

4. Conclusion

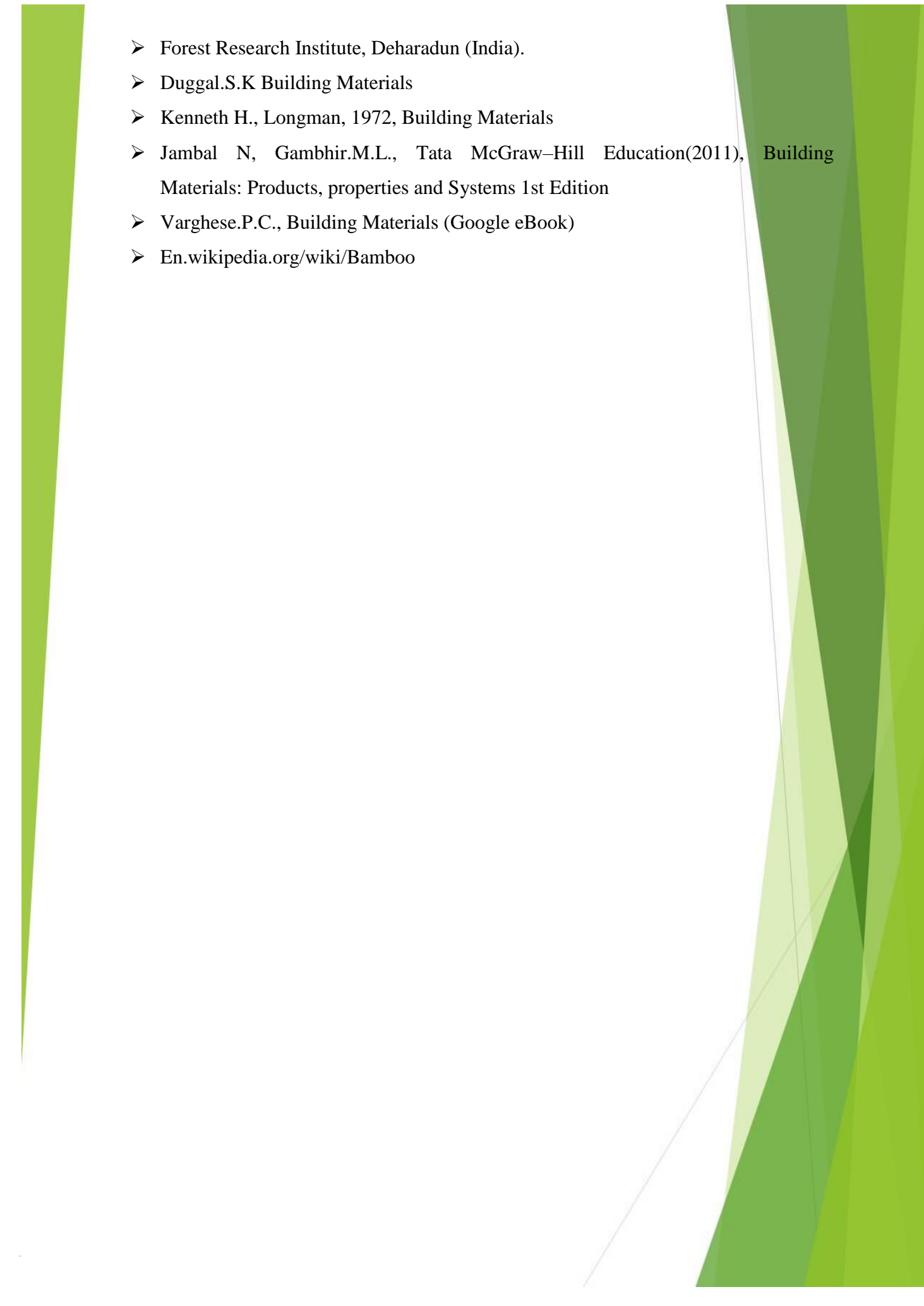
At conclude we can say bamboo is a well-established building material. It is not easy to create beautiful spaces by using bamboo, because it is uneven material. We try to control the accuracy of the construction by applying unit-frame pre-fabrication. It is essential for us to educate workers and build the construction together. Good plantation control and management, straightening the culms through heat treatment, as well as good quality control can diminish irregularities of the material. However, bamboo gives a good thermal insulation by reflecting heat while brick absorbs heat, so the inside of house kept more comfortable.

5. Suggestion and Recommendation

- Bamboo has played an important role in the development of mankind.
- Used for a wide range of day-to-day purposes, both as a woody material and as food.
- Backbone of much of the world's rural life and will remain so as the population increases.
- Properties as top grade building material and increased availability of bamboo in our country make it possible to use.
- Bamboo in the field of construction extensively.
- High valued utilization not only promotes the economic development, but also saves forest resources to protect our ecological environment as a wood substitute.
- An economic building material, bamboo's rate of productivity and cycle of annual harvest outstrips any other naturally growing resource.
- if today you plant three or four structural bamboo plants, then in four or five years later you will have mature clumps, and in eight years you will have enough mature material to build a comfortable, low cost house.

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