A

Seminar report

On

BAMBOO AS A BUILDING MATERIAL

Submitted in partial fulfillment of the requirement for the award of degree
Of Civil

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Acknowledgement

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Preface

I have made this report file on the topic **BAMBOO AS A BUILDING MATERIAL;** I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to ……..who assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

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INTRODUCTION

Bamboo has a long and well-established tradition as a building material through out the world's tropical and sub-tropical regions. It is widely used for many forms of construction, in particular for housing in rural areas. Bamboo is a renewable and versatile resource, characterized by high strength and low weight, and is easily worked using simple tools. It is widely recognized as one of the most important non-timber forest resources due to the high socio-economic benefits from bamboo based products. It is estimated that there are 1200 species growing in about 14.5 million hectares area. Most of them grow in Asia, Africa and Latin America.

Bamboo is the world's fastest growing woody plant. It grows approximately 7.5 to 40cm a day, with world record being 1.2m in 24 hours in Japan. Bamboo grows three times faster than most other species. Commercially important species of bamboo usually mature in four or five years time, after which multiple harvests are possible every second year, for upto 120 years in some species and indefinitely in others. Bamboo also excels in biomass production, giving 40 tons or more per hectare annually in managed stands. It accounts for around one-quarter of biomass produced in tropical regions and one-fifth in subtropical regions.

It has been used successfully to rehabilitate soil ravage by brick making in India, and abandoned tin-mine sites in Malaysia. It shelters top soil from the onslaught of tropical downpours, preserves many exposed areas, providing micro-climate for forest regeneration and watershed protection It is often introduced into the banks or streams or in other vulnerable areas, for rapid control of soil erosion; one bamboo plants closely matted roots can bind upto six cubic meters of soil.

GENERAL USES

a) Soil stabilization, wind break, urban waste water treatment and reduction of nitrates contamination

b) Creating a fire line in traditional forests-due to the high content of silica.

c) Removing atmospheric carbon- bamboo can capture 17 metric tons of carbon per hectare per year, i.e., effectively than any other species.

d) The shoots are edible.

e) Building and construction.

f) Small scale and cottage industries, for handicrafts and other products.

g) New generation products as wood substitutes

h) Industrial products

i) Transportation industry- truck bodies, railway carriages etc.

j) Boards and furniture

k) Medicine

l) Paper and pulp industry

m) Long time source of biomass for industry

n) Fuel source- capable of generating 1000-6000 cal/g- for households and small industries is an age-old, continuing practice.

PROPERTIES

TENSILE STRENGTH

Bamboo is able to resist more tension than compression. The fibres of bamboo run axial. In the outer zone are highly elastic vascular bundle, that have a high tensile strenght. The tensile strenght of these fibres is higher than that of steel, but it's not possible to construct connections that can transfer this tensile strength. Slimmer tubes are superior in this aspect too. Inside the silicated outer skin, axial parallel elastical fibers with a tensile strength upto 400 N/mm^2 can be found. As a comparison, extremely strong wood fibers can resist a tension upto 50 N/mm^2.

COMPRESSIVE STRENGTH

Compared to the bigger tubes, slimmer ones have got, in relation to their cross-section, a higher compressive strength value. The slimmer tubes possess better material properties due to the fact that bigger tubes have got a minor part of the outer skin, which is very resistant in tension. The portion of lignin inside the culms affects compressive strength, whereas the high portion of cellulose influences the buckling and the tensile strength as it represents the building substance of the bamboo fibers.

ELASTIC MODULUS

The accumulation of highly strong fibers in the outer parts of the tube wall also work positive in connection with the elastic modulus like it does for the tension, shear and bending strength. The higher the elastic modulus, the higher is the quality of the bamboo. Enormous elasticity makes it a very useful building material in areas with very high risks of earthquakes.

ANISOTROPIC PROPERTIES

Bamboo is an anisotropic material. Properties in the longitudinal direction are completely different from those in the transversal direction. There are cellulose fibers in the longitudinal direction, which is strong and stiff and in the transverse direction there is lignin, which is soft and brittle.

SHRINKAGE

Bamboo shrinks more than wood when it loses water. The canes can tear apart at the nodes. Bamboo shrinks in a cross section of 10-16 % and a wall thickness of 15-17 %. Therefore it is necessary to take necessary measures to prevent water loss when used as a building material.

FIRE RESISTANCE

The fire resistance is very good because of the high content of silicate acid. Filled up with water, it can stand a temperature of 400° C while the water cooks inside.

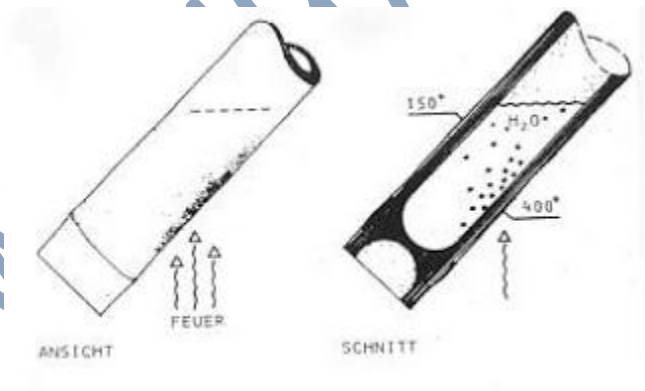

Fig 1 Fire resistance of bamboo cane when filled with water.

THE WORKING OF BAMBOO

METHODS

Splitting

The cane is split in halves and quarters and then driven apart by a wedge. It can also be split with a knife frame into four or eight segments as shown in (Fig 2(a) and 2(b)). By means of splitting you get halved canes, strips and battens. To get planks, all the nodes are smashed and the wall of the pole is split over its entire length and forced open until the wall of the pole lies flat. Up to the age of 18 months, the canes can be peeled. The strips can be used as ties or be woven to make strings and ropes.

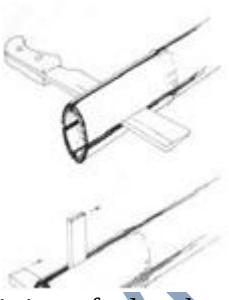

Fig 2(a) Splitting of a bamboo cane.

Fig 2(b) Splitting bamboo with a knife frame

Shaping

Bamboo available in nature is usually circular in cross section. But if bamboo is made to grow in a box of square shape it attains the shape of that box, so that it can be better used for making connections.

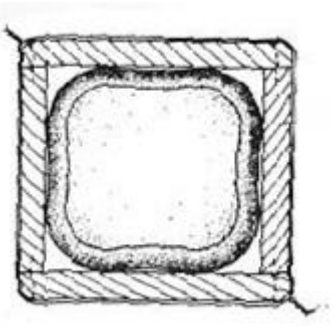

Fig 3 Bamboo being forced to grow in a box

3) Bending

Freshly cut, bamboo can be bent by heating and will keep this shape after drying. When heated above 150° C, bamboo starts changing its shape and remains as such after it goes cold.

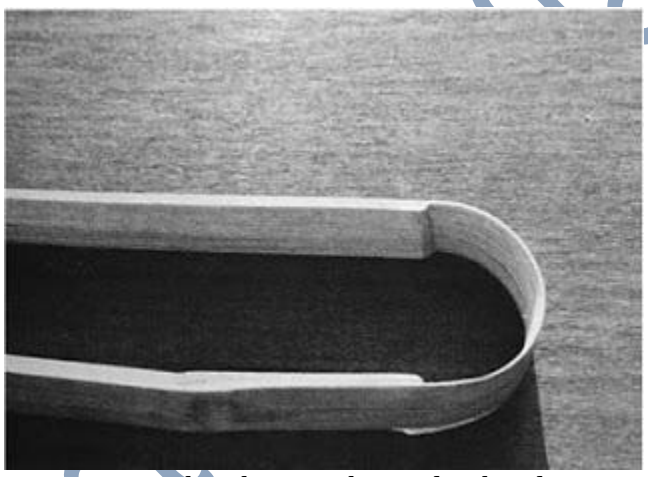

Fig 4 Bamboo being subjected to bending.

PRESERVATION OF BAMBOO

Bamboo is subject to attack by microorganisms and insects in almost any construction applications. The decay and biodegradation of bamboo culms during outdoor storage can be checked to a great extend by adopting a good storage yard practices. Culms should be stacked horizontally over raised wall to facilitate water drainage and air circulation. For reed bamboos, vertical stacking results in a small gain in pulp yield over horizontal stacking because the former suffers less fungal damage. The service life of bamboo is therefore, mainly determined by the rate of attack. A variety of methods to improve the durability of bamboo have however, been developed. Basically, there are two methods for increasing the durability of bamboo.

NON CHEMICAL METHODS OR TRADITIONAL METHOD

Non-chemical methods are otherwise known as traditional methods of preservation are widely used by villagers and is usually done on bamboos used for structural purposes. However, the treatment cost is almost nothing and thus can be carried out at village level without special equipment. This method includes curing, smoking, whitewashing and soaking.

a) Smoking

Traditionally, bamboo culms are placed above fireplaces inside the house so that the smoke and heat rises up and both dries and blackens the culms. It is possible that the process produces some toxic agents that provide a degree o protection. Alternatively, the heat generated by the fire could possibly destroy or reduce the starch content of the parenchyma cells by pyrolysis. This is considered an effective treatment against insects and fungi.

b) White washing

Bamboo culms and bamboo mats for housing construction are often painted with slaked lime. This is carried out mainly to enhance the appearance, but there is also an expectation that the process will prolong the life of the bamboo structure by preventing moisture entering the culms. It is possible that the water or moisture absorption is delayed or in some cases prevented which will provide a higher resistance to fungal attack.In Indonesia, bamboo mats are tarred and later

sprinkled with a layer of sand. When this is dry, upto 4 coats of whitewash are applied. Plastering is also a common practice using cow dung mixed with either lime or mortar.

c) Curing

Bamboo culms are treated during or immediately after extraction and before stacking in the storage yard. Curing involves harvested culms, with branches and leaves intact, in open air. The leaves continue to transpire causing the starch content of the culms to fail.

d) Soaking

The culms are submerged in either stagnant or running water, or mud for several weeks. This is one of the best methods to preserve bamboo against the attack of microorganisms and insects.

CHEMICAL METHODS

Methods that use preservative chemicals are generally more effective than non-chemical methods in the protection of bamboo under storage, but they are not always economical or feasible. The penetration of liquids into the culms takes place through the vessels in the actual direction from end to end. The vessels account for only 5-10% the bamboo cross-section. Thus even when the vessels are filled to saturated point, the bamboo can still be vulnerable to fungal insect attack if the preservative does not diffuse sufficiently into the main tissue of the culms. The chemical treatment techniques are as follows:

a) Butt treatment

The butt ends of the freshly cut culms with the branches and leaves intact are placed in a drum containing the preservative. The continued transpiration of the leaves draws the chemical solution into the vessels of the culms. This process is very slow and often the vessels do not take up enough of the liquid to preserve by diffusion, the surrounding fibers and parenchyma cells. The preservative in the barrel must be replenished regularly in order to maintain the desired level. When the treatment has been completed, care should be taken in the disposal of the contaminated foliage. Butt treatment is usually adopted to bamboo posts.

b) Open tank method for cold soaking

This method is economical simple and provides good effective protection for bamboo. Culms, which have been prepared to size, are submerged in a solution of water-soluble preservative for a

period of several days. The solution enters the culms through the ends and sides by means of diffusion.

c) Boucherie method

This method requires the culms to be in green condition. Best results are obtained when the bamboo is used during or shortly after the rainy season. The water transporting part of the culm can be penetrated completely and the treatment itself is applied by an inexpensive installation. Preservative is fed by gravity from a container placed at a higher level than the culms through pipes into the base ends. The treatment is terminated when the solution at the dripping end shows a sufficiently high concentration of chemicals. Allowing the bamboo to dry slowly in the shade for a period of at least two weeks after treatment ensures that the solution diffuses into all of the tissues surrounding the vessels.

d) Pressure treatment

Pressure treatment, using either creosote or water borne preservatives offers the best method of preservation for bamboo culms. The applied pressure ranges from around 0.5-1.5N/mm^2 and as such requires special plants and equipment. Costs are high, but a service life upto 15 years can be expected from adequately treated bamboo when used in the open and in contact with the ground.

e) Hot and cold bath process

The bamboo is submerged in a tank of preservative, which is then heated, either directly over a fire or indirectly by means of steel coils in the tank. The bath temperature is raised to 90^o C and maintained as such for 30 minutes and then allowed to cool. The bamboo should be allowed to dry slowly to provide further diffusion of the preservative to take place.

f) Glue line treatment

This is specific to bamboo mat board and involves adding preservatives to the glue during manufacture. Additives that have been shown to provide effective preservation treatment without impairing the bond strength of the mat include 1% chlordane or 1% sodium octaborate tetra hydrate with a 1:2 diluted pH solution containing 17% solid content.

BAMBOO HOUSING

The majority of bamboo construction relates to the rural community needs in developing countries. As such domestic housing predominates and in accordance with their rural origins, these buildings are often simple in design and construction relying on a living tradition of local skills and methods. Other common types of construction include farm and school building s and bridges. Further applications of bamboo relevant to construction include its use as scaffolding, water piping and as shuttering and reinforcement for concrete. In addition, the potential number of construction applications has been increased by the recent development of a variety of bamboo-based panels.

DOMESTIC HOUSING AND SMALL BUILDINGS

There is a long-standing tradition of bamboo construction, dating back to many hundreds of years. Different cultures have found in this material an economical system of building, offering sound yet light and easily replaceable forms of shelter. The methods, activities and tools are often simple, straightforward, accessible even to the young and unskilled. Despite human exploitation and unfavorable treatment, trees maintain its contributively role towards the dwelling of mankind. Man has for centuries enjoyed the benefits of the free gift of nature.

Housing is one of the priority items and sensing the current shortage of the dwelling units, the present administrative leaders around the world find tough to hit upon a solution for. The search for an efficient economical and replicable housing solution based on the contextual needs is the need of the hour. Apart from the other substances already in practice, bamboo appears to be the most promising material. Bamboo building construction is characterized by a structural frame approach similar to that applied in traditional timber frame design and construction. In this case, the floor, the wall, the roof elements are all interconnected and often one dependent on the other for overall stability.

Bamboo culms are used in building. The thicker culms or strands made up of several culms are employed for load bearing materials such as girder, purlin, post or rafter. Bamboo based materials are widely used too. In its natural condition as solid culms, halved culms or as

longitudinally split strips, bamboo has been used in almost all parts of house construction except for the fireplace and the chimneys. These are described in detail below:

Foundation

The use of bamboo for foundation is rather restricted. This is mainly due to the fact that like timber when in contact with damp ground, they deteriorate and decay very quickly unless treated with some very effective preservatives. However, in spite of their short life considerable use of bamboos is made as foundation or supporting posts in case of houses built on raised platforms. The types of bamboo foundations identified are:

(a) Bamboo in direct ground contact: Bamboo is placed either on the surface or buried. For strength and stability, large diameter and thick walled sections of bamboo with closely spaced nodes should be used. Where these are not available, smaller sections can be tied together. It can decay within six months to two years, and hence preservative treatment is recommended.

(b) Bamboo on rock or preformed concrete footings**:** where bamboo is being used for bearings, it should be placed out of ground contact on footings of either rock or preformed concrete. The largest and stiffest sections of bamboo should be used.

(c) Bamboo incorporated in to concrete footings**:** the poles are directly fit into concrete footing. It can take the forms of single posts or strip footings.

(d) Composite bamboo/concrete columns**:** a concrete extension is given to a bamboo post using a plastic tube of the same diameter. The result is a bamboo post with an integral durable foundation.

(e) Bamboo piles**:** it is used to stabilize soft soils and reduce building settlement. The treated split bamboo piles were filled with coconut coir strands wrapped with jute. The sections were then tied with wire. After installation of the piles the area was covered with a sandy material.

Flooring

The floors may be at ground level, and therefore consists only of compacted earth, with or without a covering of bamboo matting. The preferred solution is to raise the floor above the ground creating a stilt type of construction. This improves comfort and hygiene and can provide

a covered storage area below the floor. The surface of earth floor is sometimes made more stable by paving it with crude bamboo boards made by opening and flattening whole culms. The various types used are:

(a) Small bamboo culms: they are directly tied and nailed together.

(b) Split bamboo: culms are split along their length into strips, several centimeters wide.

(c) Flattened bamboo: formed by splitting green bamboo culms removing the diaphragms, then rolling and flattening them. The resulting board is laid across the joists and fixed by nailing or tying. They are screeded with cement mortar for reasons of hygiene and comfort as they are uneven and difficult to clean.

(d) Bamboo mats: thin strips varying in size from 5-6mm or 10-15mm and thickness of 0.6-1.2mm. These slivers are then woven into mats of different sizes according to the available hot-press plates and user's demands. After drying the mats to 6-10% moisture content, sufficient glue is applied to ensure enough bonding between the overlapped areas. In construction using bamboo mats, phenolic resins are employed.

(e) Bamboo plastic composites: it is an innovative technology in which bamboo fiber is the raw material and compounded with plastic as the core material of the flooring. This has higher water resistance and dimensional stability properties than those of normal floorings.

The ratio of plastic should be over 30% for higher water resistance and dimensional stability. Polypropylene is recommended, and if recycled plastic is used it is ideal to reduce the cost of production. The density of substrate should be higher than 1gm/cm^3 to ensure best mechanical properties. It prevents the floor from swelling and cracking, which is the disadvantage of other timber based flooring materials.

Walls

The most extensive use of bamboo in construction is for the walls and partitions. The major elements, the posts and beams, generally constitute part or structural framework. They are to carry the self-weight of building and loads imposed by the occupants and the weather. An infill between framing members is required to complete the wall. The purpose of the infill is to protect

against rain, wind and animals, to offer privacy and to provide in plane bracing to ensure the overall stability of the overall structure when subjected to horizontal forces.

Roofing

The roof offers protection against extremes of weather including rain, sun and wind, and to provide shelter, clear and usable space beneath the canopy. Above all it must be strong enough to resist the considerable forces generated by wind and roof coverings. In this respect, bamboo is ideal as a roofing material- it is strong, resilient and light weighted. The bamboo structure of a roof can comprise of purlins, rafters and trusses.

(a) The simplest form consists of a bamboo purlin and beams, supported on perimeter posts. Halved culms are then laid convex side down, edge-to-edge, spanning from the ridge to the eaves. A second layer, convex side up, is then laid to cover the joints.

(b) Corrugated sheets made out of bamboo are also used commonly as roof covering. The bamboo mats are dipped in resin, dried and heat pressed under pressure in a specially made platen, to give strong, reliable sheets of bamboo, which is lightweight. It has good insulation properties too.

(c) A layer of bitumen is sandwiched between two mats of bamboo forming a semi rigid panel. The mats can be fixed to rafters at 200-250mm center to center. A bituminous or rubberized weatherproof coating is then applied to the finished roof.

(d) Plastered bamboo: A cement plaster, with or without the addition of organic fibres, is traditionally applied to bamboo roofs, to get stronger roof coverings. Various forms of trusses are also adopted using bamboo culms of diameter ranging from 40mm-100mm. The king post trusses are the most common and the simplest.

Fig 5(a) Double layers of bamboo shingles

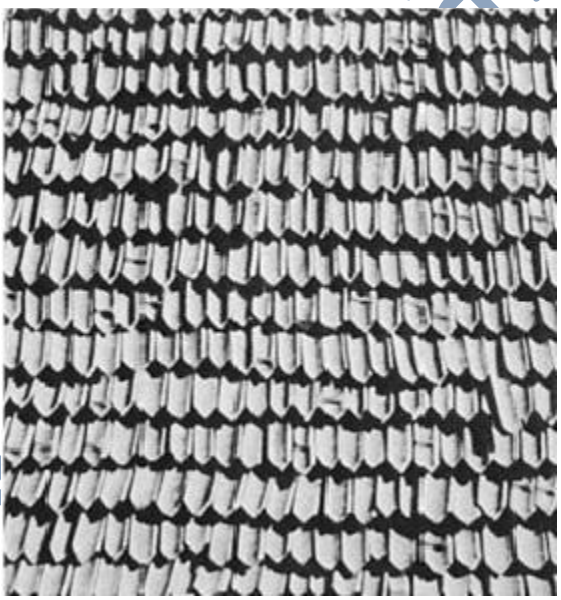

Fig 5(b) Lancet shingles.

Scaffolding

Because of the favourable relationship between load-bearing capacity and weight, bamboo can be used for the construction of save scaffoldings even for very tall buildings. Even at their connections the canes are not treated in any way. Only lashed joints are used. The cane extension is carried out by lashing the cane ends together with several ties. The ties are arranged in such a

way that a force acting vertically downwards wedges the nodes in the lashing. With larger cane diameters the friction can be increased by tightening the rope between the canes. The vertical and horizontal canes used for scaffolding are almost exclusively joined using soft lashing. This technique has the great advantage that the joints can be re-tensioned to the right degree without difficulty and also quickly released again.

Fig 6 Bamboo canes used for scaffoldings

ADVANTAGES OF BAMBOO

The various advantages of bamboo are mentioned below.

1) Light, strong and versatile.

2) Light, strong, versatile.

3) Environment friendly.

4) Accessible to the poor.

5) Self renewing resource

6) Fast growing.

7) Highly productive.

DISADVANTAGES OF BAMBOO

The major disadvantages of bamboo are as follows:

1) Requires preservation

2) Shaped by nature

3) 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.

4) Jointing- although many jointing techniques exist, their structural efficiency is low.

5) Lack of design guidance and codes.

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

CONCLUSION

Since time immemorial, bamboo has played an important role in the development of mankind. It is used for a wide range of day-to-day purposes, both as a woody material and as food. It has been the backbone of much of the world's rural life and will remain so as the population increases. Bamboo will continue to play an important part in the development of enterprises and the transformation of rural environments, in all regions of the developing world where it grows.

On account of the enforcement of our natural forest protection project, wood is becoming increasingly scarce. The realization that bamboo is the most potentially important non-timber resource and fast-growing woody biomass, has evoked keen interest in the processing, preservation, utilization and the promotion of bamboo as an alternative to wood. The properties as top grade building material and increased availability of bamboo in our country makes it possible to use, bamboo in the field of construction extensively. Its high valued utilization not only promotes the economic development, but also saves forest resources to protect our ecological environment as a wood substitute.

As 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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