The bamboo and construction with bamboo biology essay

The world is at the jaws of crisis in many sectors in the near future. One of the most important of them is the availability of timber. World is becoming more and more urbanized. There must be some sort of solution which can give some relief to the hunger towards the need of timber. We need to look for a solution which must have few characteristics such as

A product which can substitute wood in the widest range of purposes of uses..

A product which doesn't have negative environmental impact or is eco-friendly..

A product which can be made in a rural environment to assist in reducing the pressure of urbanization in the current world.

A product whose production scale must be such that it shouldn't displace the rural people from its reach.

A product which is very much meaningful in the activity.

Bamboo is definitely one such solution we got for the near future. Bamboo products can substitute wood-based products in a very wide range. The cultivation and maintenance of bamboo is very easy in comparison with wood. Bamboo can be grown as clumps in most soils and is very cheaper which makes it a feasible material for poor people and in rural regions. More and more people can be involved in this process to make them aware of the possibilities with bamboo. Bamboo based industries must be encouraged by maximum villager involvement as it even requires very low capital. Bamboo based industries can therefore provide the time and space for evolutionary development of the rural economy.

1. 2 THE PROBLEMS

(1) The world produces 3. 5 billion tons of wood from roughly 3. 5 billion hectares of forest. Approximately half of that is used as firewood. In the developed world, less than one billion people consume an average of approximately 1 ton per capita per year, hardly any of it as firewood. The richer the country, the higher this amount (in the USA it is 2. 3 tonnes). Thus, in the poorer parts of the world, people consume far more firewood than industrial wood (by a factor of at least three to one). The overall objective of world development is that standards of living should rise. At the present, China’s annual per capita wood consumption is only 0. 16 m3 – much lower than the global average of 0. 65 cubic meters (China Daily, 13 April 2000). Will the developing world start to consume wood in a manner similar to the developed world as it becomes richer. The evidence is not clear but South Korea has seen a quadrupling of its per capita consumption between 1950 and 1990. Although China’s per capita lumber consumption remains much lower than the global average, its demand for lumber has increased drastically over the last few years, while its supply has remained steady or decreased slightly (China Daily, 13 April 2000). Will new technology (email and Internet) reduce the amount of paper used? Again the evidence is not clear but there seems to be no strong trend as yet. The consequences for world wood consumption are therefore very serious if rising standards of living lead to an accelerated usage of wood products [10]. If the world population (six billion now trending towards eight billion in 25 years’ time)

moved to consume wood in a pattern similar to the more developed countries (e. g. 1 m3 / capita in Germany [11]) the consumption of industrial wood (excluding firewood) would need to at least quadruple (as it did in South Korea). It is unlikely that the wood currently consumed as firewood could assist much, for well-known technical reasons (it is often dead wood, small sized and sparsely distributed).

(2) The area of forest is being reduced by continuing deforestation. This is compounded by a growing consciousness that forests have values over and above their timber value (for carbon retention – mature forests may not actually sequester extra carbon-for biodiversity shelter and for soil, water and air quality values). Thus the supply of timber-producing forest is decreasing, through preservation, in such diverse economies as the USA, Australia, New Zealand, India and China.

(3) In the last two centuries, improving standards of living have been preceded by large increases in population and increasing urbanization. It is paradoxical that the population appears to increase rapidly before gains in living standards appear and that steeply rising population can threaten to cancel out those gains. Developing countries are following along the pattern first established in Britain 250 years ago but with some differences. The English population rose from 6 million in 1750 to 40 million in 1900 but would have increased to over 60 million were it not for the huge outward migration to the US, Australia, New Zealand and South Africa. Even with that safety valve, small villages like Birmingham increased from populations of only 4000 in 1680 to 400 000

in 1881, as people left the countryside for the towns. They had little choice. There was not enough free land in the countryside for farming. Living conditions for most of the population in these cities were very poor and their working conditions dehumanized. Today's developing countries do not have the possibilities of overseas migration; they face the same pressures towards urbanization but do not wish to reinvent the ' dark satanic mills of the 18th and 19th century. It would be good if sufficient employment could be found in a rural environment to reduce the pressure towards urbanization.

(4) Studies in both the developed economies and the developing economies have come to the conclusion that people work best in small to medium size firms/enterprises where they can see the impact of their own efforts and where they feel that they can have an effect on decision-making. These conclusions find their expression in the general concept of ' participation'.

-IAN R. HUNTER, 2002, " Bamboo and Rattan", Vol. 1, No. 2, pp. 101-103, Available at: www. vsppub. com

It's not like bamboo can be the only solution for all these issues outlined above but experiences in few places indicate that bamboo can make some meaningful contribution.

2. 1Bamboo as a wood substitute

The bamboo culm, reduced to its finest parts, is an excellent industrial fiber. As such it has been shown, both in the laboratory and in practice, to be an excellent substitute for wood fiber in such things as paper, medium density fiber board and veneer. There are very few technical difficulties in utilizing normal wood-working machinery to work with bamboo. One difference that does need to be accommodated is the higher silica content of bamboo which can dull cutting edges. With good physical and mechanical properties, low shrinkage and average density of 0. 7 g/cm3, bamboo is well suited to replace wood in several applications, especially in panel form. Bamboo mat board and bamboo strip board have been exploited on an industrial scale, and products marketed for various end uses such as flooring, roofing, and other housing components, furniture, packing cases, etc.

At present, in China, over 1, 000, 000 m3 of panels of various types are produced annually in some 200 mills, whereas in India, industrial-scale production of panels is confined to bamboo mat board with about 2000 m3 board by seven mills. The global use of paper is reported to be increased by 5% annually. Today, Asia, and mainly India and China, make the most use of bamboo for pulp and paper. India uses about 3 million tons of bamboo per year in pulp manufacture and China about 1 million tons, and both are set to increase their use of bamboo for paper pulp manufacture (China targets 5 million tons per year). Bamboo pulp is also processed into incense paper in the Philippines for export. Brazil is presently the only American country that uses bamboo for making cellulose and paper. However, bamboo has certain characteristics that are superior. It has a high surface hardness such that laminated bamboo flooring is equal in wear to the hardest American hardwoods.

Many of the products made from bamboo can be and are made in small factories with very limited capital requirements; hence these factories can be distributed around the country-side close to their raw material.

Bamboo also has a unique role to play in constructing strong light-weight houses. It has been known for a long time that light weight timber frame construction houses offer the greatest safety against earthquakes and also greater safety on earth slips. Lightweight timber framing housing is the norm in New Zealand. In 1987, the small town of Edgecombe in the northern part of the North Island of New Zealand was shattered by force 7 earthquakes. The force of the earthquake was sufficient to tip a railway engine on its side. Yet no-one was killed and all of the houses remained standing. There are two technologies utilizing bamboo that can be adapted to provide similar kinds of houses. In one, bamboo poles can be used in a similar way to timber studs to provide a similar space-frame construction. Work needs to be done improving the joins before the result is as strong as a timber frame house. In the other, a bamboo frame or hurdle can be woven out of split bamboo and plastered on either side. The bamboo hurdle effectively reinforces the concrete plastering. This second style of building produces a result which is more culturally familiar in many countries and possibly therefore more acceptable.

2. 2 Properties of Bamboo:

2. 2. 1 Tensile strength:

The bamboo fibers run axially. outer zone constitute of highly elastic vascular bundles, which have a high tensile strength. The tensile strength of these fibers is higher than that of steel, but to construct connects which can transfer load axially is merely impossible.

2. 2. 2 Shrinking:

Bamboos shrinks a lot more tan wood when it loses whole of its water. Nodes are very vulnerable during this shrinking. Bamboo shrinks in the cross section 10 to 15%

2. 2. 3 Fire resistance:

Due to the presence of the high content of silicate acid it offers a very good resistance towards fire.. Filled up with water, it can stand a temperature of 400° C while the water cooks inside.

2. 2. 4 Elasticity:

Bamboo’s enormous elasticity makes it a very good building material in earthquake prone zones. Its is very light in weight and can be easily worked on.

-Bamboo as a building material, 2002, available @ www. bambusnewengreportsbuildingmaterialbuildingmaterial. html

2. 3 Bamboo for construction:

There is a substantial role of bamboo in the construction field as it grows naturally, it has strength, flexibility and versatility and is very suitable material in every part of a house when treated and is used properly. Not only there are technical advantages with bamboo but it is very economical as it is a local product in many places of the country and is amongst the cheapest materials available. Recently there are hikes in the prices of bamboo but with proper cultivation and increased production these inflations in the fields of bamboo can be handled. Cultivating of bamboo properly gives high yields.

Moreover bamboo can replace usage of timber in many areas. It can contribute towards the solution for the deforestation which is a very major concern in the world.

2. 3. 1 Roofing:

Bamboo shingles whose lengths are almost as long as rafters. The bamboo canes are first halved along their diaphragms and are bisected. Then they are threaded as alternative facing units and are tied. They are held in the supports by their own weight.

2. 3. 2 Trusses

Fabrication of roof trusses is about the most promising use of bamboos. Literally, any span of truss is possible, and as indicated in Section 5, a Fink truss of about 8. 5m span can be carried by three workmen and installed by about 5 workmen. The property of lightweight with strength and stiffness is manifested here. Also, substantial savings in the non-use of heavy lifting equipment.

(ii) Scaffolding

(iii) Disaster Mitigation

The lightness of bamboo, wide availability and possibility of building shelter from modular units lends it for use for post-disaster shelter. A project is in the offing by the UNHCR where temporary shelters are fabricated from A-shaped bamboo support frames with horizontal members at the apex and at mid-heights of the A-frame. A water-proof sheet is draped over this frame for cover.

2. 3. 3 Bridges

Bridges attempted consist of:

(a) Footbridges: Simple cross-braced frames with the walkway formed at the crutch.

Culms of 50-75mm diameter are bound by bamboo lashings. They are suited to rivers with muddy or sandy bottoms where the height above bed does not exceed 5m. A typical crossing might be 20m long.

(b) Handcart Bridge: The construction is more elaborate with abutments and pilings. The abutments are formed from pairs of culms staked to the ground. A pair of horizontal culms forms the pile cap and diagonal braces stabilize the assembly. To form the roadway, three longitudinal bamboo beams of 100mm Ø are lashed to the caps and tied together at the center of each bay with a cross-member.

22. 3. 4 Scaffoldings

Bamboo can be used for the construction of safe scaffoldings for very tall buildings because of the favorable relationship between the load-bearing capacity and weight. Bamboo has been used for centuries as scaffolding in Asian countries and, despite competition with many metal scaffolding systems, remains one of the most preferred system in both China and Hong Kong (Fu, 1993). Owing to its high adaptability and low construction cost, it can be constructed to any layout to follow various irregular architectural features of a building within a relatively short period of time (Chung, et al., 2003). They are used in construction sites to provide temporary access, working platforms for construction workers and supervisory staff, and to prevent construction debris from falling on passers-by. In Hong Kong, they are used as Single Layered Bamboo Scaffolds (SLBS) for light work and Double Layered Bamboo Scaffords (DLBS) for heavy work (Chung and Sin, 2002).

Bamboo scaffolding, like any other, must possess integrity and must be laterally stable. The foregoing is ensured by the provision of bracing. The bracing is by two pieces of bamboo fixed in an ‘ X’ shape and at an angle of 60o-70o over the section of bamboo to be braced. For multi-storey structures it is required to tie the scaffolding to the building often through 6mm dia mild steel bars (putlogs) pre-fixed to concrete at every floor. A prop is also required between the building and the scaffolding to prevent the leaning of the scaffolding towards the building.

The canes are not treated even at their connections and only lashed joints are used. The cane extension is carried out by lashing the cane ends together by using several ties. The ties are arranged in such that force acting vertically downwards wedges the nodes in the lashing. By tightening the ropes between the canes the friction can be increased to the maximum. The vertical and horizontal canes used for scaffolding are joined using soft lashing. This technique has a great advantage that the joints can be tensioned to the right degree without difficulty and even released quickly.

-Dunkelberg, Klaus: Bamboo as a building material, in: IL31 Bambus, Karl Krämer Verlag Stuttgart 1992.

3. 1 Mechanical and Structural Properties

Bamboo, being a circular, hollow structure has certain mechanical and structural advantages and disadvantages as compared to a rectangular solid timber of the same cross-section. These advantages/disadvantages are, in other instances, complemented or accentuated by the cellulose fiber make-up of the bamboo. These comparative analyses are tabulated in Table 1. 0. Some rules of thumb for the relationship between the mass per volume of bamboo and some mechanical properties have been derived by INBAR and Janseen (1991). These are given in Table 2. 0. Also, various tests for strength and mechanical properties and design rules have been put forward by INBAR (ISO-22156, 22157, ISO/DTR-23157. 2).

Comparative Mechanical Properties of Bamboo and Rectangular Lumber (Janssen, 2001)

Table 1. 0: Comparative Mechanical Properties of Bamboo and Rectangular Lumber (Janssen, 2001)

Property

Bamboo

Rectangular Lumber

Assumptions

1.

Moment

of Inertia, I

I = 0. 40A2

I = 0. 16A2

- For most bamboos,

d = internal diameter

= 0. 82D

- For timber, mostly

h = 2 x b

2.

Optimum

Material

Use, EI

4900A2

2240A2

- Cellulose =

70, 000N/mm2

- E fiber =

35, 000N/mm2

- 50% of cross-

section of fiber is cellulose.

- Eâ‰ˆ350x% of fibers.

- In bamboos, fiber is

60% on outside and

10% on inside, hence

E outside = 350×60 =

21, 000N/mm2 and

E inside = 350×10 =

3500N/mm2

- Edahoma =

14, 000N/mm2

Bending

- Compression stress during

bending may result in

transverse strain in fibers of top face of culm. Lignin in fibres is weak in strain. Coherence in cross-section is lost and EI drops dramatically.

- If load removed culm

returns to original straight

form.

- Timber will not regain

original length when

load is removed.

- Poisson coefficient for bamboo = 0. 3.

4.

Shear

- Shear in neutral layer =

1. 3x shear for timber

- Smaller thickness to resist shear.

- Larger forces on bolt fasteners at joints.

- Advantage of not having a

ray structure is nullified by

hollow nature.

- Larger thickness to

resist shear.

- Has rays. Rays are mechanically weak.

Hence, timber material is weaker in shear

than bamboo material.

5.

Torsion

- Better torsional resistance

due to circular shape.

- Poorer torsional

resistance because of

sharp corners.

Table 1. 0 (Cont’d)

Property

Bamboo

Rectangular Lumber

Assumptions

6.

Wind

Resistance

- Bending stress due to wind

is constant over height of

culm.

- At top (near skin) vessels

decrease and cellulose

replaces vessels, leading to increase resistance to bending stress.

7.

8.

Compression

Density

- Because of hollow nature

and thus greater distance of

solid mass from center, longitudinal shortening is greater and thus greater the likelihood of lateral strain in lignin.

- Friction due to clamping at

top and bottom of culm

reduces lateral strain.

- Amount of lignin deter-

mines compressive

strength not cellulose.

700 – 800kg/m3

- Solid nature makes for better compression resistance and reduced lateral strain.

850kg/m3

Table 2. 0: Rules of Thumb Factors for Mechanical Properties of Bamboo

Air-dry bamboo

Bending

Compression

Shear

E

0. 14

0. 094

0. 021

24

Green bamboo

0. 11

0. 075

Ultimate stress (N/mm2) = Factor x mass/volume (in kg/m3)

1

Allowable stress â‰ˆ 7 x Ultimate stress

JANSSEN, J. J. A., 2000. Designing and Building with Bamboo. INBAR Technical Report No. 20, page no. 18-23

3. 2 Earthquake Resistance

Bamboo, being lightweight and hollow, makes it naturally highly resistant to earthquake (because it has high stiffness in relation to its weight). That, it does not shatter at failure means that when the earthquake is over the building can be left standing with relatively minor damage; providing shelter whiles the damage is being repaired. In a 7. 5 magnitude earthquake in April, 1961, in Costa Rica, 20 bamboo houses were left standing near the epicenter (Janssen, 2000).

4. 1 Problems related to Bamboo.

4. 1. 1 Structure

The available bamboo tends not to be very straight, have variable diameters, culm thickness and show marked tapering. These attributes have a costly effect on preliminary attempts at construction in bamboo, as will be indicated later.

4. 1. 2 Insect and Fungi Attack

More than anything else, the problem with bamboo is pest and fungi attack. Insect attack is through the relatively softer tissues in the inside wall of the cavity wall and at the budding points in the nodes. Fungi attack is severe when the bamboo is exposed to damp conditions. Various methods exist for prevention of these attacks (Jayanetti and Follet, 1998). They range from the sophisticated modified Boucherie process, through immersion in a boric acid/borax mixture in water, injection and painting with creosote, to hanging in a flowing stream immediately after harvesting for at least a week for the sugary ingredients to be washed out.

Traditional preservation methods also exist such as curing, smoking and lime-washing. The real effects of such traditional methods are not known since they have not been documented and quantified.

4. 1. 3 Fire risk

4. 1. 4 No standardisation possible: no 2 culms are alike

4. 1. 5Maintenance

4. 1. 6Difficulty of making the junctions of the culms

4. 1. 7 No construction skills with bamboo culms in non-bamboo available countries

4. 2 Measures to be taken

4. 2. 1Treatment of the surface

For small parts this information about bleaching and dyeing are determined for kite-constructions. though it can´t support enough weight. Bleaching and dyeing possibly can change the structure of the bamboo that far, nevertheless these methods should be introduced.

4. 2. 2 Bleaching:

For removing traces of resin or wax bleaching in hydrogen peroxide can be done. The bamboo will get perished if it stays long.

4. 2. 3 Dyeing:

There are different traditional styles of bleaching in different countries.

In principle:

1. The color can´t penetrate into the bamboo if at all the wax is removed.

2. The color will become more regular if it is bleached before dying.

3. Fix the color in a solution of vinegar after dying.

4. 2. 4 Other methods:

In Japan, the surface will be peeled off, hydrochloride acid is put on the bamboo and the canes are put in an oven. The canes get a brown color. treating the canes with copper sulfate will give a green color to the bamboo and protects it from mold. These methods only dye the surface of the bamboo. To get a through and through dyeing, the bamboo can be carbonized. The bamboo is put into a boiler and is incubated with a pressure of 5 kg/cm^3 and a temperature of 150° C for 20-30 min. After that, the bamboo will be brown through and through.

-K. A. Solomon-Ayeh,” USE OF BAMBOO FOR BUILDINGS”, Building and Road Research Institute (BRRI), page no 5-7