Bamboo as Eco friendly Substitute of Wood Timber

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Abstract - **Bamboo belongs to the family Poaceae and subfamily Bambusaideae. It is an evergreen perennial flowering plants and one of the fastest-growing plants in the world. Growing human population increase the consumption per capita and cause scarcity of some natural resources. The demand of natural resources specially wood cause rapid extraction of these resources with the depletion of forests. Again depletion of forest has devastating effect on climate change. So searching of alternative materials that can be used aside from wood becomes a very important point to save our environment. Due to its natural characteristics and good mechanical properties in recent time bamboo is recognised as conventional construction materials. Bamboo can be used as valuable and superior alternate for wood composite manufactured, such as for pulp and paper, stripboards, mat boards, veneer, plywood, particleboard and fibre board. Moreover, several researches have used it as raw material for structural composites such as Oriented Strand Board (OSB), Glue Laminated Timber (GLT), Parallel Strip Lumber (PSL) and Oriented Strand Lumber (OSL) although there are several differences between bamboo and wood for example macroscopic and microscopic characteristics, chemical composition, physical and mechanical properties.**

keywords - **Key Words: Climate change, mechanical properties, building material, alternative use**

Introduction

Naturally bamboo grows in diverse climate. It is a fast growing grass which falls under perennial evergreen poaceae family, grass more commonly in tropical areas that experience seasonal monsoons. In India more than 19,000 km2 of forest cover is occupied by bamboo, which is equal to 2.48% of the recorded total forest area. Bamboo constitutes more than 50% of this area (FSI, 2013). There are more than 100 species from 70 genera found abundance in Asia and South America (Zakikhani et al.2014). It is the 2nd most economically important non-timber forest products in Peninsular Malaysia after Rattan(Mahamed and Appanah 2000). India is the second largest producer of Bamboo in the world, after China. Now a day's bamboo has emerged as eco-friendly substitute of constructing material. Specific compressive strength of bamboo is higher thanwood, brick or concrete and a specific tensile strength that rivals steel. (Roach, Mary (1 June 1996), Rottke, Evelin (27 October 2002).Traditionally bamboo provide pillars, walls, window frames, rafters, room separators, ceilings and roofs for houses. It is used in the making of furniture, handicrafts, musical instruments, basket ware, matting, rayon and paper, and is used as food (bamboo shoots), fodder and fuel wood. Bamboo got an increasing attention as raw material alternative to wood in industrial application since 20th Century. Particleboard (PB), medium density fibreboard (MDF), hard fibreboard (HB), plywood, oriented strand board (OSB), zephyr board, laminated bamboo lumber, parallel strand lumber (PSL) and oriented strand lumber (OSL), inorganic-bonded board (i.e., cement), wood plastic composites (WPC) are some of the examples of wood based composites where bamboo can be used as alternate raw material instead of wood. Its versatile utility covering as domestic items, house building material and raw material for industry it gained attention from all over the world as a alternative of wood. (Dronsfield and Widjaja, 1995).

This review evaluates the benefit of bamboo as alternate of wood obtained from forest trees.

Morphology of Bamboo

The major morphological characteristic of bamboo is divided into the rhizome and the culm system (Zhang et al., 2002; Jiang, 2007).

The underground part of the bamboo stem or culm is the rhizome.These are not roots. Roots grow under the rhizome and culms erect on top of rhizome. Rhizomes have nodes and internodes and new rhizomes can produce from the axillary buds of the rhizomes.These new rhizomes are bamboo shoots which grow into culms. It also serves for the uptake, transport, distribution and storage of water and nutrients, which function of parenchyma and conduction tissue.

The jointed stem of the bamboo is called culm. Generally the culms are hollow but in some species solid culms are also found. Bamboo culm is complemented by branching system, sheath, foliage leaves, flowering, fruits and seedlings.

Harvesting of bamboo used for construction purpose should have culms with their greatest strength and lowest sugar levels at their sap to minimise the pest infestation rate. Bamboo can be harvested at shorter period than tree plantation as it grows fast as compared to forest trees. (Razal, Ramon; Palijon, Armando 2009). Generally life cycle of bamboo culm goes through 5 to 7 years and it is ideal to allow the culm to reach this level of harvesting prior to harvesting. Depending on the species, bamboo is harvested from two to three years through to five to seven years and it is best a few months prior to the start of the wet season. It is found that bamboo yield is 25 times higher than timber hardwoods like oak tree, which takes at least 40 years to mature before harvesting.

Suitable bamboo species to use as wood:

The bamboo species which have high culm productivity per acre as well as higher biomass production are better to use as wood. In India, *Bambusa nutans*, *Dendrocalamus crandisil*, *Oxytenanthera stocksii*, *Melocanna bambusoides*, *Dendrocalamus strictus*, *Dendrocalamus hamitonii*, *Dendrocalamus giganteus*, *Bambusa bambos*, *Bambusa polymorpha*,

Bambusa balcooa are the available bamboo species which can be used as wood timber. In North Eastern India the most popular species use for construction are *Bambusa balcooa, Bambusa tulda, Bambusa vulgaris, Dendrocalamus giganteus, Dendrocalamus hamiltonii, dendrocalamus strictus.*

Bamboo as wood

Bamboo is used as building material in road reinforcements, as raw material of houses and schools. According to UNESCO, 70 hectares of bamboo produce enough of the material to build 1000 bamboo houses. If timber was used instead, it would require the felling of trees from an already diminishing forest. Today, over one billion people in the world live in bamboo houses. Different types of Beautiful and intricately crafted beds, chairs and tables are made from bamboo.

There are often use of exotic woods like mango in making of Oriental rugs. Bamboo can be used as alternate raw material of tree in making rugs. In wood industry Bamboo is used to prepare Particle Board, Medium Density Fibreboard (MDF), Oriented Strand Board (OSB), Mat Board, Flooring, Molding etc. In Pulp and Paper industry also Newsprint, Bond Paper, Toilet Tissues etc are made from Bamboo. Besides these Bamboo has tremendous use in high-tech industry as raw material of Bioplastics, Greenhouses, Fencing, Fish Traps, Farming Tools, Baskets and Animal Fodder etc.

It is a renewable source and attains maturity within 3 to 4 years. It is found that bamboo wood is dimensionally stable and minimizes weathering effect. Its products are very easy to clean and maintain.

Superiority of bamboo wood over hard wood:

Due to abscence of rays or knots stresses are eventually distributed throughout its length. Due to difference in chemical composition bamboo can far better glued then wood (Jassen 1995). Bamboo possesses a macroscopically graded structure in its diameter, thickness and intermodal length for which bamboo acquires favourable properties to use as wood. (Amanda et al.1997). Bamboo wood density is more then hard wood density. Similarly hardness, modules of rupture and modules of elasticity is high in bamboo wood then hard wood. As bamboo is a fast growing grass need 3 to 4 years to attain maturity thus it can restrict damage of our environment by preventing the destruction of natural forest. Again stable dimension of bamboo wood product minimizes the weathering effect on it. Bamboo wood has the capability to give customize looks and it is very easy to clean and maintain. http:/www calibamboo.com/why reported that tensile strength of bamboo is higher than alloys of steel and also it has higher compressive strength than many concrete mixtures.

Mechanical properties of bamboo which determine the bamboo wood quality:

Mechanical properties of bamboo is varies depending on different genera, families and species. The main properties of bamboo are Tensile and compressive strength, Flexual strength, Shrinkage, Resistibility and Elasticity etc. Compressive strength determines the capacity of a material to resist forces that are trying to crush it. Bamboo has higher compressive strength than wood, brick or concrete. Tensile strength determines the resistance force given by a material against the forces trying to pull it apart. Tensile strength of bamboo is slightly lower than the tensile strength of steel. The bending capacity of a material without breaking is the Flexual strength of the material. Bamboo obtain higher Flexual strength than wood. When bamboo loses water then it shrinks more than wood.It shrinks in the cross sections ca. 10–16%, in the wall thickness, ca. 15–17%.Due to presence of silicate acid bamboo has abnormal state of flame resistibility.Transportation is easy due to relatively low weight as compared to wood (Klaus, 2002)

The internodal cavities of the bamboo give the inherent strength and lightness to the bamboo wood properties by forming very flexible building material. The basic properties affected by moisture content are like weight, dimensions, strength in terms of compressive, bending or tensile etc (Okhio C. B, C.Eng. Waning J. E, Mekonnen Y. T, 2011).Moisture content of bamboo varies from top to bottom of the culm. It is higher in the inner layers than the outer layers of the culm. This can range from 0% - 200% (Okhio C. B, C. Eng., Waning J. E, Mekonnen Y. T, 2011). Like the other fibrous material dimension of the bamboo change on changing of the moisture content.Shrinkage occurs at different level due to anisotropic nature of it.Maximum shrinkage occur at the direction of growth rings (tangentially) and minimum occurs at longitudinally. Sometimes ununiformed shrinkage results deformation of the culms after drying.

Mechanical properties of bamboo are reflected by the density of bamboo.At the nodal position density is higher due to presence of closer vascular bundles. Density of bamboo increases up to 6 years of age and then become stable at 5 to 8 years and gradually decreases slightly after 8 years. Bamboo densities are grouped into basic density, fresh density air dried density and absolute dry density. The higher the density of bamboo is the more the strength it has in the same culms. The variation of bamboo density relates to its geographical distribution in general that is according to the CBRC Utilization of Bamboo Book 1 (2009) page 10. (T. Gutu, 2013).

Chemical Properties:

The main organic components of bamboo culms are similar to those of wood, mainly cellulose (±55%), hemi-cellulose (±20%) and lignin (±25%), which amount to over 90% of the total mass (Tomalang et al., 1980). The minor components, which vary with different parts of bamboo stem and different ages of the same bamboo stem, are resins, tannins, waxes and inorganic salts. Compared with wood, however, bamboo has higher alkaline extractives, ash and silica contents (Chen, Qin, Li, Gong, & Ni, 1985). Bamboo has similar chemical composition to that of wood except its high alkaline extract, ash and silica contents. The carbohydrate content of bamboo plays an important role in its durability and service life. The durability of bamboo against mold, fungal and borers attack is strongly associated with the chemical composition (Liese, 1980).

Environmental impacts

The economic development of a country depends on the development in industrial sector. But progress in industrial sector can cause climate change by polluting air , water, soil, human health and also extinction of species, as these sectors are the largest source of CO_2 .Moreover industrial revolution may be considered as a major cause of diversion of forest land for non – forestry purposes. According to global outlook study on the trends of demand for wood production it is said that demand for

wood product is increasing by 20% in 2010 (FAO 1997). In India the largest energy user industrial sector is the iron and steel sector which act as source of 151 million tone CO_2 emissions. (Nathdie truden et al. 2011).

Use of bamboo as naturally occurring products and alternative construction raw material in place of still and iron can decrease the increase of energy consumption and CO_2 emissions. It also plays an important role in environment by lowering the light intensity and protects ultraviolet rays.Use of bamboo also decreases the deforestation rate of the forest and thus gives positive impact on environment. Bamboo plants reduce up to 35% carbon dioxide in the climate and deliver more oxygen. It can be harvested and replenished without destroying the natural forest. Bamboo can be harvested and replenished without destroying the natural forest. International net work of Bamboo and Rattan (INBAR) reported bamboo as effective carbon sink and also a very good socio- economic service provider. According to INBER increasing popularity of durable bamboo products ensures to consider productive bamboo systems as important carbon sink (INBAR, 2009).

Bamboo reduces the use of timber consumption and its waxy surface does not oblige paint and thus it is free from health hazards brought about by paints.In Earth quake prominent areas it is a very good constructing material due to its enormous elasticity."In 1992, Cost Rica was hit by an earthquake which registered 7.5 in magnitude on the Ritcher scale. The only buildings which survived were homes built of bamboo construction…" (Russel, 2015)

Conclusion

Use of bamboo as alternative of wood timber can reduce the increasing pressure on existing forest resources. The uncontrolled removal of wood from forest make hazard to the ecological imbalance by deforestation and forest degradation. When we compared bamboo with wood bamboo comes out ahead in the green race. It releases 35% more oxygen than the equivalent timber forest. Some bamboo grows up to 3 feet in just one day, making it one of the earth's fastest growing plants which results quick harvest in 3 to 5 years as compared to hardwoods.Again replantation of bamboo is not required as the root system is not damaged during harvesting; it can grow up again once harvested.Thus it can be concluded that due to fast growing nature, having positive impact on restoration and deforestation and create socio-economic benefits in developing countries bamboo is a very good sustainable alternative to wood.

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