Preservation of Bamboo in Service

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Abstract: Bamboo culms are an excellent material for countless applications. Their wider use for construction is encouraged by the growing scarcity of timber. Since bamboo has a low natural resistance, protection against biological degradation is of vital importance for long term service. Protective measures without chemicals are preferable, but often limited in their effectiveness. When using preservatives, the restricted permeability of culm tissue, choice of preservative and treatment method and environmental effects as well as economical aspects have to be considered.

Keywords: Bamboo, deterioration, permeability, protection, preservation, preservatives, treatment techniques, environment, economics

According to the constitution of the Academy, the phrase "wood science" covers "lignified natural materials" of which bamboo is an important component. The Academy Lecture given at the IUFRO World Congress 1986 in Ljubijana deait with "Research on Bamboo". On this occasion I want to be more specific with the "Protection of Bamboo in Service". There is no other country in the worid, in which bamboo plays such a major role as a multi-purpose commodity as in China, with a total area of about 4. 4 mill. ha bamboo forest, a production of 2. 2 mill. tons shoots, 12 mill. tons of culms, partly converted in about 200 mills into over 1 millon m3 panels of various products. The China bamboo industry contributes about 2. 2 billion USD annually to its economy, and goods for 400 mill. USD are exported. AIso, 5. 6 million people are working with bamboo, of which 4. 5 in the forest and 1. 1 million in factories. Therefore bamboo has to be on the agenda of this conference with at least one paper.

Bamboo in Service

Among the many uses, bamboo is an important construction material, such as scaffolding, bridges, shelters, towers and for simple and modern engineered structures. Bamboo houses provide homes for a billion people, not only in rural areas, where it is considered as a cheap, replaceable material. Its wider use as a substitute for wood is supported by the increasing scarcity and expense of timber in several bamboo producing countries. Its wider acceptances however is often hindered due to problems with biological degradation of the raw material, construction components as well as finished products.

A wide range of protective procedures, including chemical preservation methods are known, but not regularly applied. The reasons afe lack of knowledge about possibilities for bamboo protection, lack of adequate treatment facilities and chemical preservatives, uncertainty about its economics and lack of demand for treated bamboo components. Protection of this versatile material, especially in areas where longer service life is desired, can result in immense social and economical benefits. An increase in bamboo availability would facilitate employment potential, save processing and labour costs, which would otherwise occur due to frequent replacement of degraded bamboo components. In the following only a brief overview about some facts and problems can be presented. Details are given in the "Bamboo Preservation Compendium" by W. Liese and S. Kumar, presently as INBAR Technical Report 22 in print.

Natural durability

For its utilization bamboo has a few serious obstacles, mainly its low durability against biodegradation and its low penetrability for preservatives. Bamboo culms do not produce any toxic substances during their lifetime, unlike the heartwood of many trees. In contrast to timber, a bamboo culm consists of about 40 % parenchyma cells which are filled with nutritious starch, even in older culms. Only in flowering bamboo, the starch is used up for the seed production. Much belief exists that the cutting around the full moon phase may result in an increased resistance. This is also said for timber but detailed investigations have been unable to substantiate these claims. Starch affects the susceptibility against borers and blue-stain fungi, so that harvesting during or after the rainy season, when starch content is lowest, reduces incipient attack during storage.

The common water-storage of fresh culms has a similar effect, since the starch is degraded, mainly by bacteria. The susceptibility against damaging fungi and insects is however hardly reduced.

In ground contact, bamboo structures afe destroyed in less than two years, under cover after 4 -7 years, but may last 10-15 years and much longer under favourable conditions.

Main criteria for the service life are the environmental conditions around the bamboo structures, as well as the physical access of damaging organisms.

Non chemical protection

A long standing tradition exists to protect the bamboo structures by constructional methods which prevent the access of moisture and keep the material dry. Their main advantage is that no toxic chemicals with their unpleasant side-effects have to be applied. Well-known are the base-supports by stones, pre-formed concrete footings or even durable or pressure treated wood blocks. If the environment is unsuitable for beetles and fungi, impressive structures can be built, like in the Cordillera region of Colombia, where in an altitude above 1.500 m termites can not exist. Another common method for protection without chemicals is the plastering of bamboo mats with mud, clay or cement. Plastering is not only applied by villagers, but also for urban houses in many countries, where split bamboo walls are covered on both sides with mortar. The tight seal protects the bamboo against moisture and prevents the entry of beetles. The common bahàreque technique in countries such as Colombia and Costa Rica uses coarsely woven bamboo panels which are plastered on both sides with cement.

The bamboo smoking system as applied traditionally in Japan by storing fresh bamboo above a fireplace has been recently developed further in Colombia for commerciaI large-scale operations. A square or cylindrical furnace with a chimney is filled with semi-dry culms and heated by burning organic matters at around 55°C for 15-30 days until the moisture content is reduced to about 12%. The incomplete combustion generates smoke, that should penetrate the culm. During heating a partial pyrolysis of bamboo substances occurs. The expected effect is an increased resistance against fungi and beetle attack. An impressive example was the ZERI pavilion at the EXPO 2000 in Hannover, where about 3,500 culms of 9 m length were smoke-treated in Colombia and transported to Germany. Regrettably, this unique example of modern bamboo architecture by Simon Velez had to be dismantled at the end of the fair, so that long-time exposure and testing were not possible. Our laboratory results with samples and other observations on corresponding structures in Colombia indicate that such bamboo is not immune against biological degradation. Presently, the paraeters for the process are being systematically evaluated in order to improve the promising method. Even then, the culms can be used only for outside application, due to their intensive smell, beside their darkened surface.

For timber, a heat treatment has been developed in recent years with a wider application. The material is submitted to temperatures above 150°C for a better dimensional stability and improved resistance against micro-organisms due to the modification of organic matter. Experiments with split bamboo at temperatures above 200°C bave resulted in an

enhanced durability against fungal attack, but the mechanical properties are severely reduced, as also observed for timber. Consequently, the heat treatment may be applicable only for selected uses.

Protection with chemicals

In most cases, chemical treatment of bamboo is required. A key factor for the protection is the sufficient preservation of the culm. Unlike timber, the bamboo tissue is rather resistant towards penetration of liquids due to its anatomical structure.

Treatability

The uptake of a preservation solution is restricted mainly to the metaxylem vessels, which run through the culm like long "water-pipes". At the nodes, they become partly structurally modified by branching, so that the passage through a node may be hindered. Their total volume amounts to only 6%-8%, so that the remaining tissue of fibres and parenchyma has to be protected by diffusion. Ray cells, like in wood do not exist in the bamboo-grass. The degree of axial penetration is often reduced after the culm is harvested and starts drying. As a typical wound reaction, slime extrudes from the parenchyma cells into the vessels causing a blockage of the lumina. Monopodial bamboos, like Moso, Phyllostachs edulis, also produce tyloses as balloon-like protrusions into the metaxylem vessels.
The uptake at the leaf scars and the cut branches at the nodes is minimal.
The culm is covered on its outer side by a special layer, the cuticula, which hinders any penetration by simple treatments, such as soaking. At the inner culm wall, suberin layers lying on sclerotic parenchyma cells also hinder any penetration, although to a much legger extent than from the outside.
This special anatomical make-up of the bamboo culm as well as its moisture content must be taken into consideration when choosing a suitable preservative and method to be applied.

Preservative treatment

As preservatives, mainly water-home types are in use, especially non-fixing salts. They can penetrate by diffusion and thus protect the entire culm. Boron compounds are most widely used for culms and products under cover, since water or ground contact may induce a leaching of the toxic components. CCA and the CCB-types are also used, mainly in companies which normally treat timber.
Creosote is rarely used anymore due to the unpleasant handling of the culms and the environmental side-effects.
For prophylactic protection of bamboo in storage, mainly insecticides are applied. Fire retardants are hardly used. They can be used only under cover and need a high uptake of preservative.
Natural toxicants afe tried from several plants, such as Aziderata indica (called Neem), Calotropis gigantea (Calotropin) and Stemona tuberosa (Stemonacol). They are applied for protection of bamboo handicrafts. The treatment methods for bamboo depend mainly on the intended use, the type of material and the environmental aspects.
As a non -pressure process, the "butt -end treatment", is common whereby the base of fresh culms is kept immersed in a container. It is a simple process without special skills, but may save much material, like as support for fruit trees. The soaking method is also often applied. The fresh culms are submerged in a boron-based preservative for 7-10 days. To ease the sidewise penetration, bare holes are made on apposite sides in each intemode and/or the solid nodal wall is punctured with a long stick.

Recently, a Vertical Soak and Diffusion Process (VDS) has been further developed by the EBF, Bali. Freshly harvested culms are vertically stacked in a basin and all nodal walls are fractured, except the lowest one. The inner part of the culm is then used as reservoir for the treatment solution and filled up for about two weeks after which the lower node is al so ruptured to release the solution into a basin.

Through diffusion of the preservative , especially the inner culm should be protected which is most nutritious and thus mainly affected by beetle damage. However, this inner wall is covered by a special cell layer of suberized cells. Furthermore, there are structural differences between species and possible changes during ageing, so that more knowledge is needed before this apparently convenient method can be generally recommended.

Of special importance is the classical sap-replacement method which allows a complete penetration of the culms by boric salts with a clean surface and a possible re-use of the preservative. Once developed for spruce stems by A. Boucherie the method was modified for bamboo by Dr. Purushotham, Dehra Dun, India (1954). It has been further improved by FUNBAMBU in Costa Rica, by EBF on Bali and is employed in many other countries. If properly used it is a most reliable and environmental friendly preservation method.

The pressure treatment of bamboo provides the best protection, but it is rarely applied, except, for example, for waterfront structures. The technical installations and special handling make it costly and often not financially viable. For culms, the inner void, the lacuna has to be opened to avoid cracks and splitting. Split bamboo obtains a high absorption and penetration and may be useful for special applications. Creosote and CCA - or CCB salt types are the main preservatives. The environmental side-effects could be considerable…

Alongside bamboo culms (either round or split) semi -finished and finished products, such as baskets and furniture, may also require protection. especially against moulds and beetles. This causes special care for selecting a suitable preservative since often these products come into contact with food or human beings.

A chemical pre-processing is rarely applied. like for furniture by the sap-repiacement. For slivers and handicrafts a simple dipping or brushing with boron preservatives or natural toxicants (as in Thailiand) are common.

Painting with industrial lacquers contributes to water-resistance protection.

Quality control

Quality control is an essential component of bamboo preservation, albeit much neglected. It is concerned with the quality of the bamboo to be treated, the choice of preservative and its concentration, the required up-take of preservative solution and its sufficient distribution within the culm tissue. The treating equipment has to be regularly inspected. Treatment records should ensure the consumer about the quality of the product.

Health and environmental concerns

The use of preservatives for bamboo and the handling of treated products pose potential risks to humans, animals and the environment. Required precautions are often neglected. Visits to treatment installations and factories have often shown an alarming negligence of the most basic and urgent precautions.

The same lack of concern exists in regard to the environmental consequences of bamboo preservation. Although regulations may exists at varying degree, they are often hardly known or considered.

Dangers arise from preservatives lost during preparations, during treatment, cleaning of equipment and disposal of residues in form of treatment solutions, cut-offs from treated material, sludge from the treatment plant and the disposal of remaining treatment solution. General dumping sites can only bear a limited amount of poisoned bamboo. Approved waste disposal sites are hardly available or unknown.

Since bamboo is treated mostly in rural areas and outside cities in simple installations and by workers without the required technical skills, the danger of environmental damage is considerable. Strict regulations have to be applied wherever bamboo is chemically treated. Consequently, the chemical preservation of bamboo should only be done at sites where the required skill, experience and control is given.

Marketing

Marketing of treated bamboo is a key factor for continuous demand and essential for the success of treatment installations. Marketing however is rather poorly developed. Most factories treat on demand so that stock -keeping does not exists. This influences the work performance at the factories as well as the generaI awareness about the availability of a quality product. Supply and demand will have considerable impact on the economics of bamboo preservation.

Economics

Economics is a major component by the consumer for the choice of bamboo preservation, since bamboo is still a low cost material compared to timber and other commodities. Preservation cost may considerably exceed the basic costs of bamboo, when long service life is required with high retention by a reliable treatment process. The desirable life of the product has to be compared with the expected life-span if untreated. For short term applications, the exchange of degraded parts is common and may be more economical. Often the initial costs for installing treatment facilities become a dominant factor. Experience with sap-replacement treatment resulted in additional costs of 20% ~ 50% ; for bamboo poles about 20% and about 15% for mats. There is an urgent need for thorough calculations of the various treatment possibilities to increase the demand for value-added bamboo products.

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