

**Design, Build and Preservation: an Innovative Bamboo Treatment for industrial building use**

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Building with bio-sourced material is an emerging industry that can make a high contribution to the reduction of GHG emissions and help to unlock the low-carbon, circular economy. Bamboo is a very interesting bio-sourced material for construction. Since years, bamboo is demonstrating a very nice alternative to mineral materials. By maximising the use of bio-sourced in new built and renovation through optimal hybrid solutions with other materials, the built environment can be transformed into a large-scale carbon sink. However, unlocking the potential of bio-sourced as both a sustainable building material and climate solution (the '*natural-carbon-pump*') requires a stronger focus on the bio-sourced construction chains and the whole innovation ecosystem.

First, we will talk about the building value chain for different products and building systems. Comparison will be made with wood industry using engineered wood products (EWP) for the latest developments of high-rise wooden buildings. Authors will show that building with innovative material such as bamboo and engineered bamboo products (EBP) is only a matter of regulations, engineering capacities and implementation methods.

Second, we will focus on bamboo treatment showing some relevant results coming from the Philippines. We will show case of an innovative bamboo treatment implemented at a country scale in the Philippines that is turning today international, with the Base Bahay Foundation of the Hilti Foundation. The project concerns building with bamboo quality socialized homes. Homes that are comfortable, affordable, disaster resilient, ecologically friendly, and with social impact.

Bamboo is known to be difficult to treat due to its high resistance to impregnation. Soaking – diffusion gives some efficiency for needed bamboo preservation rate, as well as for the intensive productivity rate. Alternative solution to the use of traditional treatment products for bamboo poles treatment was investigated and an innovative methodology was successfully implemented in 5 sites in the Philippines, supplying bamboo for housing projects. We will show how a treatment facility has to be designed for workers safety, for environment safety, for bamboo material efficiency, and for product quality control. The treatment procedure is composed of 15 necessary steps to be followed. BSInnovations is the body responsible of the invention, the installation and the technical validation of the treatment facility.

**Keywords:** Bamboo, treatment, preservation, efficacy, environmentally friendly, worker safety

## Introduction

For building material, companies must guarantee the durability of implemented products. The use of bamboo as a building material must fulfil this requirement. Bamboo is known to be very vulnerable to insects including termites and fungi. Guaranteed durability of bamboo is one of the technical brakes that forbids the use of bamboo as a building material. To overcome that brake BSInnovations team mostly composed of well-known international researchers and experts of the wood industry operated a technology transfer from the wood industry to the bamboo sector.

The aim of the treatment of bamboo poles used in construction is to provide a suitable durability for its uses in the respect of safety and environmental concerns, during the treatment process and when Bamboo is in service. The most popular products like Boric acid and its derivatives are known to be effective against fungi, beetles, and termites, biocides registered as very dangerous for Health in Europe, under replacement by alternatives for their uses. To achieve a that goal for bamboo, the treatment solution must be saturated in boron and warmed up to a temperature above 80 °C. In practice, those conditions are rarely encountered due to the complexity of the operative conditions and the safety protections for the workers, that leads to attacks of poles by those destroying biological agents, as we noticed. Those biocides are not fast acting, that is a drawback for poles in use. Such behavior is necessary to protect bamboo from beetles and termites attacks.

Ideally, treatment product must:

- (1) Penetrate entirely the bamboo walls.
- (2) It has to be toxic (efficient) to act like a killer for insects
- (3) Its repellent effect is a “plus”
- (4) It has to stay in the material, non-leachable.
- (5) In addition, products must be safe for the workers during implementation and for the houses owners
- (6) Finally, the treatment and the treated bamboo has to be safe for the environment

At the start of the project we performed tests at FPRDI laboratory in Los Bagnos, in the Philippines. We tested the Toxicity of different chemicals/products by topical application method. The topical application method is one of the standard methods of insecticide testing that gives the relationship between dosage and the response of test insects.

Measurements were performed on powder post beetles (*D. minutus*), subterranean termites (*M. losbanosensis*) and drywood termites (*C. dudleyi*). 100% of death was recorded after 10 min for some organic insecticides whereas traditional products were recording 10% of death. For building application, such a small rate of efficiency is unacceptable.

From wood industry knowhow we looked for a preservative with will suit to the needs. For instance, the repellent effect of the insecticide is a characteristic that enhances the global efficacy of the perseverative. Traditional treatment products are not repellent. they are very leachable, they are usually salts, fixation is therefore very poor. Salts are leached out during storage and building phases. They can also be leached out when into service, in tropical climate.

All the methodology was guided by European regulation and procedures described in European (EN) or International (ISO) standardization.

## Development of an innovative Bamboo Treatment

A valid alternative for Bamboo Treatment was developed by BSInnovations scientists, in 2015. Different technologies of preservatives and treatment processes were tested. The treatment is implemented by soaking - diffusion methodology. The procedure is composed of 15 necessary steps to be followed.

For this work, our core values are:

- (1) safety for workers and users,
- (2) security for the environment,
- (3) efficiency of the treatment.

The efficiency come in third position of importance, for us safety and security are not to be of any discussion.

### Safety and environment risk

Challenge was to protect workers and environment. Workers must be protected from direct contact with solution, for that workers were trained for safety, during treatment implementation they wear security equipment, and in case of accidental splashes, there are emergency devices to wash out product. Also, a complete shower on site near the treatment tank was implemented, as European regulations requires.

Previously, treatment solution when using traditional chemicals. The treatment solution was disposed after two weeks of use, in the environment nearby the tank. This is because of supplier advice, and also, because of the strong smell caused by butyric fermentation. It is unacceptable to dispose such high amount of treatment solution in the back yard of a facility. This environment pollution was completely eliminated by the new process. Chemical analysis was carried out and an equilibrium for the solution was found, so the solution was kept and used until the last drop.

The industrial facility has a life span, it needs maintenance, and accident can occur. Sensitive parts of the installation are reinforced. For instance, treatment tank is doubled with a second retention tank to overcome leaks or complete lesion of treatment tank. Moreover, under the foundation a tight membrane is implemented.

As a result, the treatment is designed to have no risk for workers, during implementation, and no risk for owners, during lifetime of the construction. Preferably bamboo can be coated with a stain finish, this can even extend its durability against fungi. Concerning end of life of the treated bamboo bars, the chosen treatment product and its concentration is not considered as a dangerous material. It can be recycled easily.

### Treatment process flow of 15 stages and treatment efficiency

Bamboo is cut, and it enters immediately the treatment procedure. Each culm has to pass through the product specification quality control. Bamboo is processed as soon as possible after harvesting. Then it is cleaned, hemicellulose are washed out, it is dried, soaked for a certain time depending on the needed level of durability, then the product is dripped while stored vertically, then dried, then stored, then ready to be sent to the building site.

We applied the European regulation for the choice of active ingredients and their concentration in solutions. The selected active ingredients are authorized in Europe according to the biocide regulation: directive of accepted active ingredient authorization. The active mater is on a positive list of efficiency health and environmental acceptability for their declared uses.

This is very important for class 2 usage as defined on EN 335, "Durability of wood and wood-based products - Use classes: definitions, application to solid wood and wood-based products"

To control effectiveness, tests were performed to identify chemical impregnation and efficiency. Chemical penetration was tested in a recognized and accredited German laboratory. We tested the penetration of active mater in the middle of treated culms of 5 m. Tests were performed on the whole thickness of the wall and also in different depths of the thickness.

Results could able us to authorize the use with a confident durability conferred by the treatment. Moreover, the treatment in full volume of bamboo wall thickness permit cutting and drilling of bamboo culm without altering the protection conferred by the treatment process.

## Synoptic view of the treatment method

### Strong points of the “BSInnovations Bamboo Treatment” method

- Simple to implement
- No heavy machine or big energy supply
- No need for a big investment
- No disposal of chemicals (no fermentation, no smell)
- Control treatment and soaking time
- Easy for quality control
- Efficient and reliable, no infestation incident after 6 years
- Procedures for treatment is clear for trained workers

### Treatment Facility requirement

- Needs of abundant water to wash bamboo
- Monophasic electricity for water pump
- Featuring of water
- Drying area
- Reinforced security zone for the soaking area, Double tank for environment safety

### Treatment facility installation:

- Step 1: the site is identified according to BSInnovations specifications. Visits /Audits are organized in order for BSInnovations experts to validate the site. Special attention is given to location and to the risk for environment.
- Step 2: Drawings for the treatment facility, equipment’s, technologies and key features are transferred to the local team.
- Step 3: Construction of the treatment facility, warehouse, storage, safety area, machines and tools.
- Step 4: Audits by BSInnovations experts for launching the site and for training the local team.
- Step 5: running of the sites, efficiency testing of treated products. Implementation and running of quality control procedure.
- Step 6: Annual Quality control and products efficiency testing audit.

### Material and documentation transferred

- Treatment procedure
- Security and safety procedure
- Drawing for step-by-step treatment procedure
- Quality control procedure with specific points to be controlled
- Quality label for treated bamboo, “BSInnovations bamboo treatment”. Marking

## Conclusion

Three years work was necessary to set the process of bamboo treatment with the right preservative. The process is fully innovative for bamboo treatment and is recognized now by the market to be efficient and safe for the human and its environment. This treatment process is ready to be transferred to other interested builders. The transfer method relies on a partnership with BSInnovations that will help for design, help to implement, train the workers, run the treatment facility, test the treated product, then endorse the efficiency and the quality treatment.

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