

328: New building components from an ancient material: bamboo

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Abstract

The human beings need to be in relationship with nature, but in the last centuries we are losing this fundamental link. Especially in the building sector, the use of artificial materials and the intensive need of technological equipments to obtain internal comfort have amplified this gap.

Nowadays, the attention to the relationship with nature is growing and in the construction industry it is possible to work in this direction, for example proposing the return to the use of natural materials.

To reduce at minimum the impact of buildings construction on environment, the attention is focalized to natural removable materials and in particular on bamboo, appreciated for its eco-sustainability attitudes and for its good mechanical characteristics.

The paper's aim is to draw the readers' attention on this material, very often considered only as an exotic product, to underline how interesting can be its use in our projects and in everyday life.

Attention is given to the traditional way of using bamboo, the present production of building components and the potential uses of this material taking advantages from new knowledge and technologies.

Keywords: natural renewable material, building component, bamboo, industrial production.

1. The buildings and the environment

In the last centuries, the relationship between human beings and nature has become weaker and weaker.

This distance has grown, for example, in the construction field with the use of processed and artificial materials. Moreover, new comfort needs have entailed the use of more and more sophisticated equipments.

Human activities have become a factor of instability for the nature and only in the last decades the attention has been focused on this vast problem.

The aim to reduce the impact of the building process on the environment can be pursued in different ways.

First of all, attention must be paid to decreasing the need of energy both during the construction process and when the building is used. The new, more efficient organization of the building yard improves the first aspect; a good bioclimatic design and an efficient control of the building envelope reduces the energy consumption during the life of the structure.

Another field of research is focused on the possibility to reuse and to recycle the materials used in the buildings.

2. The natural renewable building materials

Among the different approaches, this research aims to show the importance of choosing renewable materials as first step to avoid to

impact on the environment and to reduce, as much as possible, the use of non renewable fonts.

Attention will be paid on the scale of the building components investigating the different possibilities to realise some of them with renewable materials and, in particular, analysing those deriving from vegetable fonts.

The concept is that the first way to reduce the impact of the building process on the nature is to avoid to deprive it of sources that can't be replaced. A correct management of vegetable fonts can offer a good solution to this problem.

Among the different vegetable materials (wood, hemp, linen, jute, cotton, coco, etc.), the attention has been concentrated on bamboo, which is interesting for its eco-sustainability attitudes and for its mechanical characteristics.

3. Bamboo

Bamboo is a grass, a woody giant herbage. It belongs to the family of *Gramineae* (*Poaceae*), and the different bamboos are grouped in different subfamilies, the *Bambusoideae*.

The main part of a bamboo plant is the culm that grows very quickly and can reach more than 300 centimetres of height and more than 25 centimetres of diameter.

The culms have a main stem with filled joints (nodes) and hollow sections in between (internodes). Many branches grow in the side parts of the culms.

The plant is characterised by a high content of silicic acid that provides its extraordinary physical characteristics like elasticity, hardness and strength. In spite of them the culms can be cut very easily also with manual tools.

The high diffusion of this plant all around the world permits to use it both at the handcraft and industrial scale.



Fig 1. Bamboo culms in North Italy.

The natural distribution of bamboo goes from about 46 degrees northern latitude to around 47 degrees southern latitude [7]. In spite of all, according to the species, bamboo also grows naturally in different areas and can be cultivated as well where it isn't autochthonous.

3.1 Bamboo and environment

One of the most important environmental characteristic of bamboo is that it has a good capacity to recycle considerable carbon dioxide (12 ton/hectare) helping the purification of the air [7].

The extensive clumping of the bamboo's root system prevents soil erosion and helps to strengthen steep slopes.

Four/five years old culms of bamboo are ready to be used, so the regeneration of the plant is very quickly. Moreover, in the cut process only the ripe culms are selected avoiding the clearance of the area and a strong impact on the landscape.

3.2 Characteristics and uses

The plant of bamboo is divided in the aerial part - formed by the culm and the branches - and the subterranean elements: rhizomes and roots.

Rhizomes grow can follow two different ways.

In temperate climate there are the *monopodial* types which grow in all directions forming a intertwined network. Examples of *monopodial* bamboos are genera *Arundinaria* and *Phyllostachys*.

Sympodial rhizomes grow in tropical zones and can not withstand freezing temperatures. These rhizomes are short and squat and create compact forests with very close culms. *Bambusa*, *Guadua* and *Dendrocalamus* represent the *sympodial* bamboo.

Different elements, like climate and soil quality, influenced the physical and chemical characteristics of the plants of bamboo but in

every case human beings have been able to use them in the best way.

Many cultures throughout the world have used for centuries bamboo in everyday life.

The shoots of bamboo are very popular vegetables in Asian countries and the culms end uses are many and various: musical instruments, furniture, garments, scaffoldings, paper, food, building components.

Bamboo is also used in hydraulic projects. After the removing of the diaphragms the culms can be connect to make water pipes collocated either below or above ground.

Aeronautical, naval, automotive, chemical, civil engineering uses bamboo from the small to the very large scale.

3.3 The bamboo in the building sector

One of the best known use of bamboo is as scaffoldings in building industry in Asia, but it can be used also to make flooring, boards, veneer, walls, partitions, doors, windows, ceilings and roofs.



Fig 2. Bamboo scaffoldings in Mumbai (India).

In building sector bamboo is used in different forms. The whole culms can become the structure of buildings as timber poles. In many countries like Ecuador, Colombia, Mozambique, the bamboo culms are used as structure for external and partition walls.

When the diameter of the stem is not enough for structural purposes, three or four culms are roped to ensure the necessary strength.

Cutting the culm it is possible to obtain strings that can be flatted and used glued to make boards.

A large use of bamboo strings is related with the realization of woven mats that can become external partition or windows in hot-wet climate.

The same mats glued in different layers are used to produce panels and corrugated roofing sheets. The production of bamboo based panels is increasing both in Asia and Latino America and they can be utilised for structural as well as non structural applications.

It is also common to reduce the bamboo culms in fibres and use them as many other organic fibres, like sisal, as reinforcement in the cement mortar. From the bamboo culms it is possible to obtain a pulp used, not only for the paper production, but also to make insulated boards.

3.4 From the tradition to the industry

Bamboo has been a relevant resource in many areas of the world. The easy way to cut and woven it has guaranteed the possibility to use it in different ways.

The huge knowledge around bamboo becomes the first step in the research on new innovative ways to use it, because it can show us potentialities and limits of this natural material.

The contemporary industrial processes represent the organized and faster way to produce the elements created by traditional handcraft.

From the tradition we know how to cut it splitting in the direction of the length of the culm and which is the most convenient way to glue the pieces obtained. From the craftsmen we have learnt the skilful method to woven bamboo strings.

What the industry has created are machines that make these works faster and give the chance to have a high production with lower prices.

As a consequence the market of bamboo components is growing and this material is starting to be used in some aspects of everyday life also in Europe and North America.

3.5 The industrial production

The bamboo industrial production is manly focalized on the use of it in strings and small pieces and has introduced in the market a wide variety of products like laminated planks, fibreboards and chipboards.

The first industrial production of bamboo multilayer boards has been developed glued with casein, or other resinous substances with adhesive properties like blood or soy beans, many woven mats.

Nowadays, the production starts in rural areas where mats are hand-woven. The bamboo strings are first cleaned by the external layers and become 12-16 millimetres wide. The strings are later woven in 250x130 centimetres mats.

Then they are brought in factories where they are immersed in resin, mixed with preservatives to protect them from termites and other insects attacks.

The next step is to dry them with hot steam till they reach the right level of humidity.

When the mats are ready they are covered with glue. Seven to fifteen layers are obtained with the superimposition of the mats and then they are pressed together under heat.

Sometimes the panel is also covered with a veneer paper and again compressed.

When the panels are cold they can be cut.

An interesting use of these panels is the realization of bamboo mat corrugated roof elements. The difference in the production process is only in the use of a press studied to realize the ribbed form of the panels.

Another kind of panels are obtained with the same process but the bamboo strips are sewed parallel, and then the mats are glued alternating mats in the opposite directions.

Plybamboo panels, which are also used with structural aims, are mainly made in China, with culms of *Phyllostachys pubescens*.

In this case the culm is cross-cut in strips, the inner and outer surfaces are scraped and the node's diaphragms are removed.

The pieces are then soaked in hot water and after softened by steaming to permit to spread out, flatten, dry and stabilize them through a heat press.

The next step foresees that the pieces are planed smooth and edged straight on both sides to be ready for the next processes when the two faces of the piece are glued, assembled and hot pressed.

In Europe one of the most common product realized in bamboo is bamboo parquet that shyly is taking its place in the market.

The process to obtain it foresees many steps. First of all, as seen in the previous examples, the culm is split into strips and cleaned of unuseful parts like the node's diaphragms. Then the pieces are flatted and pressed to obtain a thickness of 7 millimetres. Also in this case the pieces of bamboo have to be immersed in hot water with treated solutions against insects attacks.



Fig 3. Bamboo parquet commercialized in Europe.

The bamboo strips need now to dry in a kiln at a low temperature and once they are dry they are rolled again to reach a thickness of 6 millimetres. Finally, the strips are selected and placed side by side vertically or horizontally, covered with glue and hot pressed.

It will be necessary also to finish off the borders to create the joints for the laying.

The final product can be realized in different colours with the carbonization process and it is possible to cover it with varnishes to improve the hardness and the durability of the surface.

Also the residues of bamboo and leftovers can be useful to produce boards. In this case panels are made compressing small particles of bamboo. These slivers are mixed, cut, grinded and dried. The next steps are to glue the particles, to form the panels in the needed size and then to hot pressed them.

Bamboo particle boards can be used in alternative to those produced by wood. The applications are various from the ceilings to the wallboard furniture.

3.6 The market and the prospective

The Bamboo market is growing day after day both for the handcraft products and for the industrial components.

China and India are the first producers in the world but in other areas the interest for bamboo is improving at different scales.

Bamboo is considered a good ecological material so it gives an interesting answer to the desire of nature and sustainability that people express.

As said before, the knowledge about bamboo uses starts from the traditional way to utilise it, but the industrial development helps to increase its use permitting to obtain the same products in a faster way.

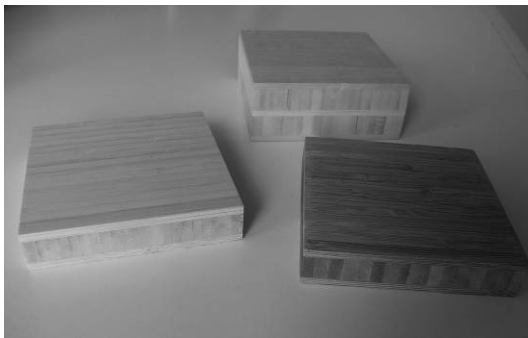


Fig 4. Bamboo boards used to realise furniture.

New processes are giving the chance to make products like lamellar beams.

Interesting solutions are those obtained using bamboo with other materials like steel. Their combination brings to the realization of new types of joints that can be very useful, for example, in structures that need to be assembled two or more times.

A critical aspect in bamboo elements production is the common use of chemical bonding agents as adhesives to glue the parts.

As a consequence an in-depth study on these substances should be carried out in order to find alternatives not injurious to the health.

Another aspect to improve in bamboo use is the treatment of the culms to avoid that they are attacked by termites and insects. Also in this case not sustainable products are often used

eliminating the good environmental characteristics of the original material.

The strict roles of European Union in products imports are pushing the market in the right direction. Research and experimentation are working to find the best solutions to stimulate the market of bamboo elements promoting their ecological characteristics.

Bamboo is now, not only the exotic material that was in the past, but also an interesting product to use in our houses from the kitchen to flooring and furniture.

Moreover, the world is discovering bamboo potentialities thanks to the use of it in important projects realized by famous architects.

A good example is the new terminal at the Madrid Airport where the architect Richard Rogers has covered the ceiling with more than 200.000 square metres of bamboo.

In Italy bamboo has been used, for example, to build an interesting pavilion that has been assembled in Turin during the *XXIII UIA World Congress* (June 29th – July 3rd 2008) and is now located in a public garden in Olivetta San Michele (IM). This bamboo and steel structure, designed and realized by *UtopieRealizzabili*, is made only with local culms and shows that bamboo can be used with good results in many different contexts.



Fig 5. Bamboo pavilion assembled in Turin during the *XXIII UIA World Congress*, July 2008. Designed and realized by *UtopieRealizzabili*.

4. Low cost houses in bamboo

Bamboo is a good answer to different needs, for example, it can be a solution to give a house to the billions of homeless people in the world.

In Ecuador, since many years, the Organization Hogar the Cristo builds and sells bamboo low cost houses to low income families and give them the chance to have a home.

This simple house (24 m²) is made with bamboo, wood and galvanized sheet iron. It is realized in the Organization factory and then gathered by the owners.

Two Italian architects, Gabriele Casu and Giuseppe De Nunzio have designed and built a new prototype of the house which have permitted to improve the comfort standards inside it.

Another important result that has been achieved is the replacement with bamboo culms of the mangrove wood poles used in the standard house produced by Hogar the Cristo. This change was necessary because today mangrove is a protected wood.

The new prototype has concrete foundations connected with iron bars to the bamboo culms that heighten the house from the wet ground level. The flooring is realized with concrete and bamboo panels, which have been planned, made and tested by the two architects. The external and internal walls, as in the standard project, are made with a wood frame and bamboo mats. The ordinary corrugated galvanized iron roof has been improved, from a thermal point of view, with the addition of a bamboo panels false ceiling.

The final result is a more sustainable and durable house. This experience shows an interesting and useful way to use local resources to improve the population's life standards.



Fig 6. Prototype of a house designed and realized by the architects Gabriele Casu and Giuseppe De Nunzio in Guayaquil (Ecuador) for the Organization Hogar the Cristo. (image by Casu and De Nunzio)

5. Conclusion

The use of bamboo at large scale can become a strong input to local work market in areas in which poverty has to be won.

At the same time, the use of bamboo can be a good solution in eco-sustainable building projects, because it combines excellent mechanical characteristics and all the positive aspects of a natural removable material.

We can learn from China, India, Ecuador, Colombia and other countries how to rethink many common building components, like parquet or windows, in a more sustainable way using bamboo.

Moreover, attention must be paid to avoid to destroy the natural habitat where the bamboo grows. It is necessary, like it happens with wood, to take care of the forests both to avoid contamination with chemical agents and to destroy animals' habitat.

The best solutions will come from the connection between the traditional culture developed in the centuries around the use of bamboo and the possibility to resort to new knowledge and technologies.

At the present moment, in many countries like Italy, there isn't any set of laws for the structural use of bamboo in the construction sector. This lack makes it necessary, each time it is used, to organize tests to verify the physical properties of the material. A significant push to the use of bamboo will be given if the laws are updated.



Fig 7. Physical resistance test of a bamboo culm held at the Polytechnic of Turin in 2007.

The interest of people and market is growing around bamboo, our task as architects and engineers is to push the research with the aim to manage to use in the best way all the potentiality of this wonderful material.

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