

## A case study in bamboo construction education: The experience of the Sino-Italian “Bamboo Pavilion Contest – A contest for a pavilion in bamboo technology”

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**ABSTRACT:** This manuscript summarizes the experience of the Sino-Italian “Bamboo #Pavillon Contest\_A contest for a Pavilion in Bamboo Technology” held between the Mediterranean University of Reggio Calabria (Italy) and the College of Civil Engineering of Nanjing Tech University (China) in 2018. The contest for the pavilion to be realized with bamboo technology was divided into three phases. The first one was aimed at identifying the best project idea among those presented from students of Mediterranean University of Reggio Calabria. The second phase was comprised of both the technical design and the construction of the bamboo pavilion by the students of Nanjing Tech University. The last phase consisted in the closing ceremony of the contest held at the Zhejiang University - University of Illinois at Urbana Champaign Institute. Particularly, the goal was the design of a temporary exhibition pavilion to be realized with bamboo structures, such as GluBam, an eco-sustainable building material also light and flexible but solid and resistant. The bamboo pavilion was realized and completed during the summer of 2018 and now it is a good example of a temporary structure made of engineered bamboo.

### 1 INTRODUCTION

The contest “Bamboo #Pavillon Contest\_A contest for a Pavilion in Bamboo Technology” was held between the Mediterranean University of Reggio Calabria (Italy) and the College of Civil Engineering of Nanjing Tech University (China) in 2018.

The contest is a part of the joint actions provided by the Memorandum of Understanding (MOU) for Faculty and Student Mobility. It was signed by the two institutions in Nanjing on July 7<sup>th</sup>, 2017 (see Figure 1) for promoting between the two Universities both study and research relationships along with the exchange of students, PhD students and faculties. During the meeting and the signature of the MOU, the two Universities decided to start cooperation for realizing an innovative structure by joining the good knowledge of architecture from the Italian side with the good engineering knowledge of the Chinese side.

On the Italian side, Prof. Marina Tornatora developed a lot of research in order to deeply understand the meaning of Pavilion in architecture (Tornatora, 2017). As a matter of fact, in architecture, a pavilion has several meanings. The theme of the pavilion is proposed as the moment of materialization of a “thinking” idea: its nature is characterized by an ephemeral condition – given its limited life – and this becomes an opportunity for both continuous verification and experimentation of the “Limits” related to the project. This allows – from a design



Figure 1. Signature of the Memorandum of Understanding (MOU) occurred in Nanjing on July 7<sup>th</sup>, 2017. Picture on the left, from left to right: Dr. Zhi Li, Prof. Xiao Yan, Prof. Alberto De Capua, Dr. Cristoforo Demartino and Domenico Rositano. Picture on the right, from left to right: Dr. Zhi Li, Prof. Yan Xiao and Prof. Alberto De Capua.

point of view – the freedom to define special shapes in order to satisfy the functional requirements. Technological aspects have been treated by prof. Alberto De Capua expert on sustainable construction technologies (De Capua, 2015-2017).

On the Chinese side, the research group lead by prof. Yan Xiao is considered a leader in the use of engineered bamboo-based materials for structural applications (e.g., Xiao, 2009, Li et al., 2014, Xiao and Ma, 2014, Xiao et al. 2014, Wang et al., 2018). It uses the GluBam® technology invented by Prof. Xiao, a technology named by Popular Science magazine in its “Best of What’s New in 2008” feature. The milestones in the use of bamboo for modern construction realized by his research group can be considered the demonstration of the California style house – constructed of bamboo material on Hunan University campus in Changsha, China – and the first modern bamboo truck-loaded roadway bridge in 2007 in Leiyang, China.

The structure of this paper is organized following the three phases of the contest. First, the contest for the students of Mediterranean University of Reggio Calabria (Section 2). In particular, the motivation of the contest and the requirements are introduced. The different proposals design and the winning one are presented. Then, the design and construction of the bamboo pavilion – done by the students of Nanjing Tech University – are presented (Section 3). Moreover, some information on the closing ceremony of the contest held at the Zhejiang University - University of Illinois at Urbana Champaign Institute (Section 4) is provided. Finally, some conclusions and perspectives are drawn (Section 5).

## 2 THE CONTEST

The Mediterranean University of Reggio Calabria (Italy) and the College of Civil Engineering of Nanjing Tech University (China), announced the “Bamboo #Pavillon Contest\_A contest for a Pavilion in Bamboo Technology” on December 2017. The idea of a pavilion is related to the main features of this typology in the architecture. As a matter of fact, the pavilions are extraordinary for their temporary character (Piatkowska, 2013). The temporariness factor and the cost-effectiveness of pavilions’ constructions are juxtaposed with high expectations due to the pavilion’s prestige and the aesthetic expression. According to the circumstances often there are built objects that become architectural icons or unforgettable symbols and physical proclamation of the present.

The contest consisted on the choice of the best design idea among the presented ones. The participation to the contest is held for the students and Ph.D. students (or obtained within 5 years) who are regularly enrolled at the Mediterranean University of Reggio Calabria. The design project, for the exhibition pavilion, must respect the following requirements:

- Realized mainly with bamboo (raw bamboo, GluBam beams or panels) and designed to enhance the expressiveness of the material;



- The maximum size must be within a cube with side 5.4 m;
- Have a free exhibition space, also flexible and transformable.

The calendar of the contest was as follows: December 18<sup>th</sup>, 2017 – call for proposals; January - 12<sup>th</sup>, 2018 – deadline to send questions; January 30<sup>th</sup>, 2018 – deadline for receipt of project proposals. The award of the contest was the realization of the design idea and the participation to the Bamboo summer school at Nanjing Tech University.

The contest had two main objectives to stimulate students in innovative project activities. The first one consists in promoting the use of bamboo technologies, such as GluBam. The second one is related to the development of a discussion about the theme of the pavilion, that today is a hot topic in architecture. The ephemeral and multiform nature of the pavilion makes it privileged for spatial research and, therefore, a sensitive indicator of the profound changes in architecture and art. This character made the pavilion particularly suitable for a design competition that wants to be an opportunity for research and teaching together. In fact, the theme was proposed as a device of knowledge capable of materializing an idea that is still thought, expression of art and technique.

## 2.1 Proposals

10 groups of students (a total of 50 students) sent their design ideas to the contest. A summary of the design ideas is reported in Figure 2. Left-to-right then top-to-bottom in Figure 2, the proposals are:

1. [RE]frame - [Re]frame is an architectural design experiment referring to two main issues, namely: the notion of Rethinking the concept of the pavilion in the contemporaneity by Reusing and Reinterpreting the historically developed concepts, and the notion of frame as a tool towards the ephemeral character of the pavilion.
2. Blooming pavilion - Each perspective of the pavilion recalls a blooming flower shape, in the plan as well as at the eye-level perception. From the outside, the pavilion is glowing and fluctuating, thanks to the translucent fabric shell. Its petals overlap, in a play of light, shadows and transparencies. From the inside, the flower reveals, instead, the strength of its structure in GluBam technology.
3. BAM pavilion - Beyond Architecture Mutation. Space in a Convergence of Time is focusing to unfold several moments in time, able to emphasize the different qualities of conscious and unconscious experiences.
4. Lotus Amoenus - In China the Lotus flower is more than a natural beauty to be observed: behind its delicate petals, it hides a very deep spiritual meaning. The concept of the pavilion comes from this concept. The figure can be traced within a circle inscribed in a square.

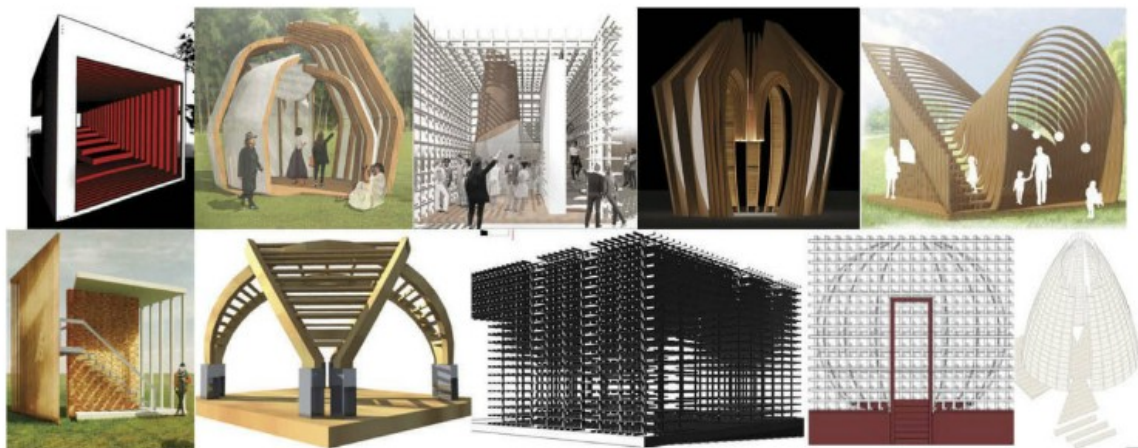


Figure 2. The 10 design proposals of the contest.

5. Bamboo wave - The designer team decided to adopt 27 pieces of streamline 20-meter long wooden bamboo forming a fluctuating body. The pavilion is made of advanced fiber by hot gluing technology; it has the characteristics of high strength and high toughness.
6. Bamboo in the ephemeral space - recognizing in the theme of pavilion the intrinsic value of the ephemeral and the need not to consider it as an inhabited building, but a temple/laboratory. The idea of this project is configured as an open object in all its parts, playing with the transparency of the form and with the lack of distinction between the inside-outside of the exhibition space.
7. RIB Resisant Innovative Bamboo - The expositive pavilion Rib has been designed to valorize the structural technology of bamboo. The main elements are the arches (the “ribs”), two lamellar beams in bamboo with a rectangular section that are connected at the top and partially supported by a sequence of straight culms.
8. Bamboo#Pavilion - The project is proposed as a multisensory device that simultaneously involves sight, hearing, smell and touch. From a conceptual point of view, the scheme consists of three elements: the BASE, the YIN module (white) and the YANG module (black) which are characterized by four sub-modules of light (bamboo Ivory) and dark (carbonized bamboo) coloring.
9. The Cube and the Sphere - The project consists of a design for an expositional pavilion realized with bamboo technology. The basic idea is to combine the pure, symmetric volumes of the Cube and the Sphere into a single architectural object.
10. Comfortably Numb Pavilion - The name is from the well-known Pink Floyd’s composition. The pavilion stems from a retelling of the peculiar relationship between the “irrationality” of the bamboo’s growth process and the will of making the organic essence of this material rational, since it has the capacity of behaving as a structure generating spaces “domesticated” by the architectural gesture.

## 2.2 The winning idea: the [RE]FRAME bamboo pavilion

The work of the Committee<sup>1</sup> was not simple for the high-quality of all the design projects. The three winner design projects were in order: 1. [RE]frame; 8. Bamboo#Pavilion; 4. Lotus Amoenus. The groups were awarded during a ceremony held in Italy (Figure 3).

[Re]frame was designed by Blagoja Bajkovski, Cosimo Metastasio, Matteo Milano, Antonia Vadalà, Stefano Vitale. The intention of [Re] frame is the materialization of a flexible and adaptable pavilion to different contexts and places without imposing itself on the landscape, but at the same time capable of insinuating its roots in ever different terrains, with the



Figure 3. The award ceremony at the *Mediterranea* University of Reggio Calabria. From left to right: Prof. Gianfranco Neri, Prof. Francesco Carlo Morabito, Prof. Marina Tornatora, Prof. Alberto De Capua, Prof. Yan Xiao.

1. Prof. Gianfranco Neri, Prof. Yan Xiao, Prof. Alberto De Capua, Prof.ssa Marina Tornatora, Dott. Zhi Li, Dott. Cristoforo Demartino.



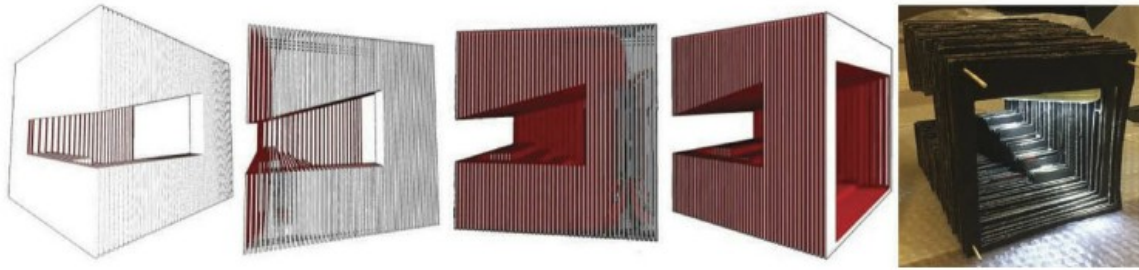


Figure 4. Mutable perception of the pavilion. Preliminary studies on a simplified model (right).

maximum integration (see Figure 4). Reuse and re-adaptation are the strongest features of the pavilion, which lends itself to different needs and can perform different functions in different time periods. The project uses the frames in GluBam as a complex and multiple systems that are neither hierarchical nor central. This multiplicity and seriality that conforms to a system with repeatable characteristics, makes possible different spatial combinations of the pavilion assembly.

### 3 THE DESIGN AND CONSTRUCTION OF THE PAVILLON

The design and construction of the pavilion were made by the students of Nanjing Tech University together with some students of the Italian winner team, that went to China in order to assist to the Bamboo Summer School. This team modified the original design idea to simplify the construction. In particular, the size of the pavilion has been reduced to a cube of 2.5 m and most of the elements has been re-designed to reduce the complexity in manufacturing. The original idea was carefully respected in terms of proportions and shape. The final structure was made only of GluBam panels and steel elements for the connection. Each frame was made by two layers of GluBam panel joined by screws. The final structure was obtained by connecting the different frames (a total of 10) using filleted steel bars, bolts and washers. The result is shown in Figure 5. The floor was realized by using two horizontal panels of GluBam. The final structure was easy to be assembled, very strong and can simply be used for exhibition. Moreover, seen the good performances of GluBam, it can also be installed outside.



Figure 5. Final version of the bamboo pavilion at Zhejiang University - University of Illinois at Urbana Champaign Institute, Haining, China: Sketch (left) and photo (center, right).

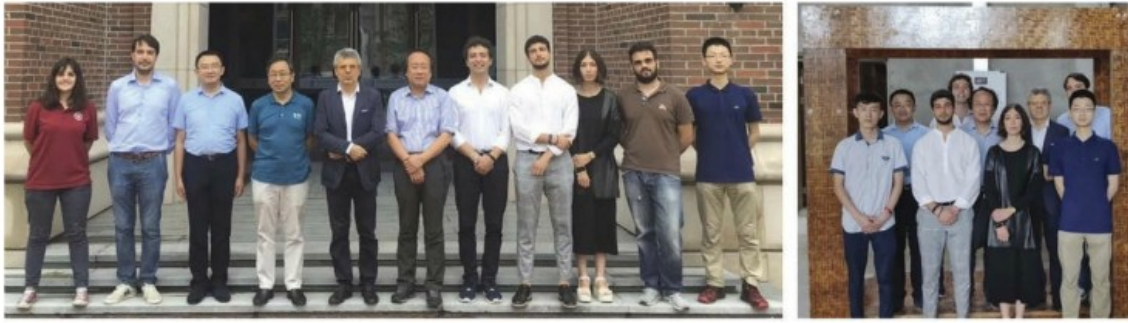


Figure 6. The closing ceremony at Zhejiang University - University of Illinois at Urbana Champaign Institute, Haining, China. Figure on the left, from left to right: student of ZJU, Dr. Cristoforo Demartino, Dr. Zhi Li, Prof. Erping Li, Prof. Roberto Pagani, Prof. Yan Xiao, Mr. Gabriele Candela, Mr. Stefano Vitale, Ms. Claudia Giorno, student of ZJU and Mr. Ma Ke.

#### 4 THE CLOSING CEREMONY

The Closing ceremony was held on June 30<sup>th</sup>, 2018 at the Zhejiang University - University of Illinois at Urbana Champaign Institute (see Figure 6). The closing ceremony was chaired by Prof. Xiao Yan, with the important presence of Prof. Roberto Pagani – Science and Technology Counsellor of the Consulate General of Italy in Shanghai – and Prof. Erping Li (dean of The Zhejiang University - University of Illinois at Urbana Champaign Institute). During the discussion, the future of bamboo structure and the best practice to join architecture and engineering were the main topics.

#### 5 CONCLUSIONS AND PERSPECTIVES

This paper summarized the experience of the Sino-Italian “Bamboo #Pavillon Contest\_A contest for a Pavilion in Bamboo Technology”. The final outcomes of the contest are: i) the creation of an international network between architects and engineers, ii) a great international experience for students characterized by high multidisciplinary, iii) the promotion of bamboo as a construction material and iv) the realization of a prototype of an expositive pavilion realized with bamboo technology. This experience was appreciated by everybody, especially from the student side. In the future, it’s important to continue with this experience by enlarging the number of partners involving a large number of Universities and government agencies to better promote the use of bamboo.

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