Golden Flower

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Abstract Traditional constructions are generally realized using metal, adobe, cardboard or concrete structures. In this study, we consider to build a structure by using *phyllostachys edulis*, a Chinese bamboo species also known as "Moso bamboo". Bamboo, as a new trend in the construction market, is a good acoustic and thermal insulator. Compared to traditional construction materials, bamboo is light, easy to handle, and with very good earthquake-resistance performances; in fact, it has been used in certain regions of Ecuador and Colombia by using different anchoring and fastening techniques. In this project, we implement mooring and anchoring techniques, which are traditional construction approaches. The proposed pavilion is an external bamboo installation made of six petals. Based on principles of dynamics, colour, size and proportion, an innovative bamboo structural design was created after the required calculations. The design is inspired by the concept of golden ratio. Golden Flower, an architecture installation by using round bamboo poles and strips, fully showing the material and artistic characteristics of bamboo.

Keywords Eco-friendly material · Aesthetic design · Bamboo installation · Golden ratio

1 Introduction

Bamboo is a plant of great importance for rural areas inhabitants [1]. Bamboo has an immense potential to be an environmentally friendly material, not only due to its

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astonishing mechanical properties, flexibility and great resistance for the elaboration of furniture, musical instruments or tools, but also due to its large diameter which is suitable for processing into structural components of houses and boats [2].

Being a light material, bamboo is easy to transport, store, facilitate, build quick for the construction of temporary or permanent structures in different terrains [2]. Furthermore, this plant can be used after some transformations to make various construction materials, such as mats, strips, handmade or industrialized laminated bamboo products. Bamboo, therefore, has become an important alternative for various construction projects, due to its multiple uses and its rapid growth [2].

The material required by the Organising Committee of IBCC 2019 is moso bamboo (*Phyllostachys edulis*), which is often harvested in China during the winter [3]. The height of the plant varies between 12 and 15 m and its diameter is between 6 and 13 cm. We will use this bamboo species to design our pavilion. The proposed pavilion is an external bamboo installation made of six petals. The design is inspired by the concept of golden ratio.

2 Design Process

2.1 Concept Design

The concept of the Golden Flower was born from the idea of the golden ratio. In mathematics, two quantities are in the golden ratio if their ratio is the same as the ratio of their sum to the larger of the two quantities. In geometry, a golden spiral is a logarithmic spiral whose growth factor is the golden ratio. That is, a golden spiral gets wider (or further from its origin) by a factor equal to the golden ratio for every quarter turn it makes. An approximation of a golden spiral is a Fibonacci spiral, which is constructed slightly differently. A Fibonacci spiral starts with a rectangle partitioned into 2 squares. In each step, a square the length of the rectangle's longest side is added to the rectangle. Let us take the Fibonacci spiral as a module of our design. A set of six spirals are rotated on the plane present seen in Fig. 1. Thus, the design shape of the Golden Flower comes to life in a configuration provided by the central circle of the 6 spirals, repeating in synchronization of its axis and becoming an inscribed hexagon. Around the central hexagon, six petals are also abstracted as the final shape of the design.

2.2 Design Development

During the design development, the whole structure is divided into two parts: one is the upper hexagon structure surrounded by 6 petals, which was inspired from the concept of the golden ratio; the other is a central supporting structure, consisting of

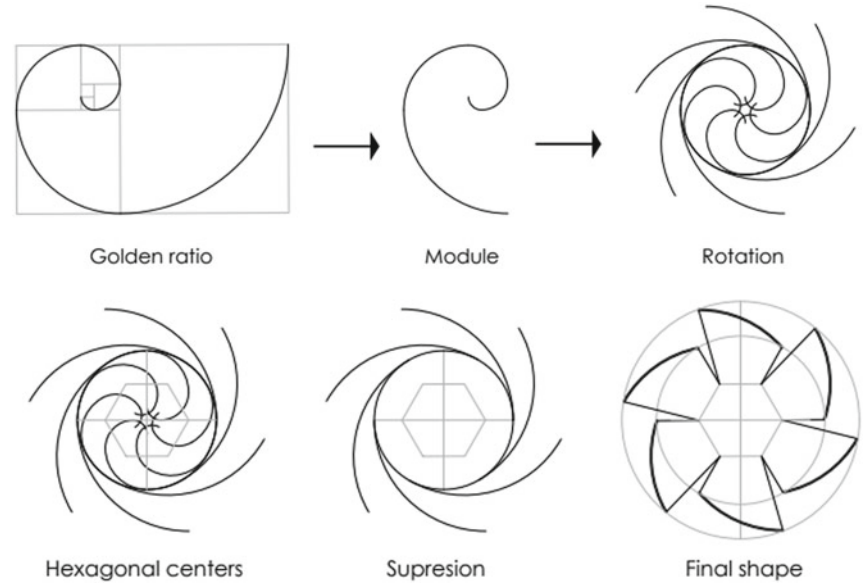

Fig. 1 Golden Flower's shape process

6 round bamboo culms. Figure 2 illustrates the top, elevation and section view of Golden Flower.

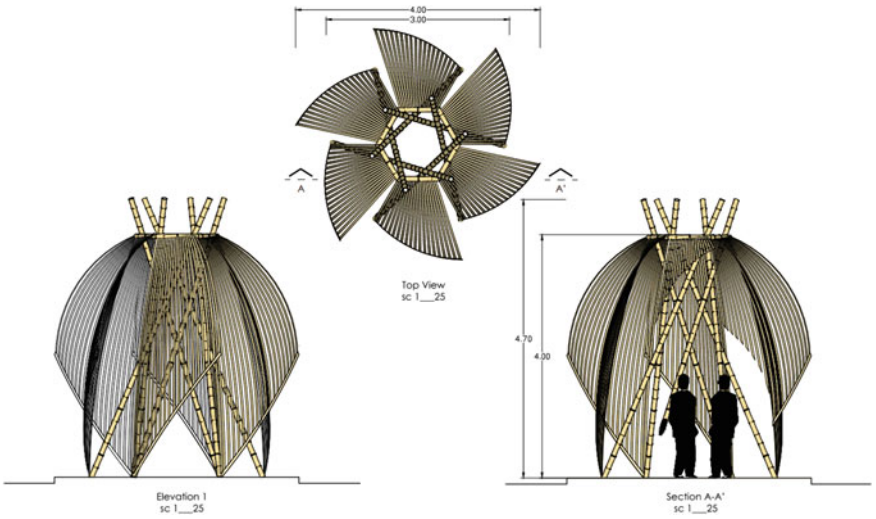

Fig. 2 Top, elevation and section view of the Golden Flower

There are three steps to construct the structure: (1) make a hexagonal frame; (2) form the central supporting structure and connect it with the hexagonal frame; (3) make petals and attach them onto the hexagonal frame.

Firstly, bevel cut joints (Fig. 3b) are used to form a hexagonal frame by using rope and bolt fastenings. The hexagonal frame needs to bear the weight of falling petals.

Secondly, frame the central supporting structure. Six bamboo culms with a diameter of 80 mm are fixed to the hexagonal frame at its upper end by ropes (see Fig. 3c, d). Then, each bamboo culm is arranged diagonally, and its bottom end is fixed on the ground through steel bars and bolts. According to the requirement of IBCC 2019, the ground floor needs to be kept within the area of 3 m by 3 m.

20 pieces of 3 mm of thick bamboo strips of different lengths are used to obtain the required shape, see Fig. 4. In addition, when these bamboo strips are connected to the top and bottom of the structure, their buckling will produce the required curve and form a one-meter cantilever at the shortest part of the petal (the projected area does not exceed 4 m by 4 m). All bamboo strips are fixed with bolts at the bottom end. The purpose of designing these petals is to produce light and shadow effects

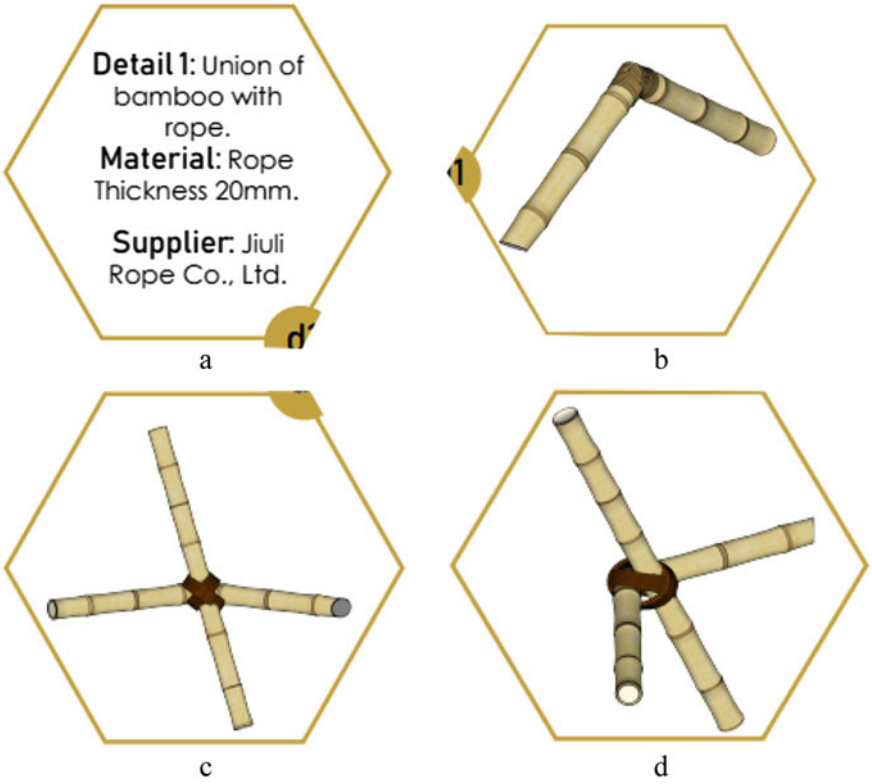

Fig. 3 Joint types

Fig. 4 Making petals

in the process of their interleaving, as shown in Fig. 2. After the main structure is formed, all the petals can be placed on it (Fig. 4).

The spaces are created by petals making users to access freely. At the same time, the installation also has permanent ventilation and cooling effect, which helps to realize the main goal of this design.

3 Discussion

The proposed project (Golden Flower) aims to expose and publicize the current uses of bamboo as a building material in contemporary and modern architecture and to replace traditional high-energy consumption construction materials, like concrete and steel.

In this design, we followed the appropriate use of bamboo. We use round bamboo poles as columns, which are supported by a concrete base on the ground. Thus, the end of the bamboo will never be in contact with the ground directly, avoiding bamboo corrosion, even when it is outdoors.

4 Renderings

Several renderings of Golden Flower are provided in Fig. 5. The renderings are showing the pavilion with some visitors in the structure and providing a schematic

Fig. 5 Renderings of Golden Flower

of the ventilation of the exposition space. Humans are added to the renderings to facilitate the visualization of the scale of the photos.

References

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