The Cocoon Project

- A cross-cultural case study in development and construction of a bamboo building with arbitrary double curved forms

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Using built constructions as investigating tools for architects

The idea of the project is to investigate architecture from a sustainable low-key point of view in local climatic conditions with local materials and cooperating with local people, but with an experimental approach that involves architects from different places and cultures with their unique individual backgrounds.

Cross cultural cooperation

The development of this experimental building in local materials through a cross cultural engagement was initiated and mainly sponsored by Aarhus School of Architecture, Denmark. The purpose of this was to unify different cultures and backgrounds and through mutual learning develop a new way of thinking about material, form, space, and function under local conditions. Through the design phase, which took place at the Aarhus School of Architecture in Denmark, the professors and students of Studio CONTEXT, assisted by visiting professor Byoung Cho and assistant Sara Kim from South Korea, formed the idea of the project and the design. Through the actual implementation of the design in South India we cooperated with professor Vijaykumar Sengottuvelan, staff and students at the CARE School of Engineering in Tiruchirappalli, for a workshop with architect Neelam Manjunath and staff from the Centre for Green Building Material & Technology in Bangalore. The joint cooperation developed ideas and solutions, which were fit for the local climate and environment.

Inspiration

The inspiration for the project came through the studies by students at Studio CONTEXT, Aarhus School of Architecture of climate responsive architecture in the subtropical and tropical zones, which later were developed into small sketch models and drawings of possible constructions. From that stage the idea of a light bamboo construction evolved, and more intensive studies on bamboo used in buildings started. In this context students were especially interested in professor Auwi Stübbes organic bamboo project for the IMM

furniture exhibition 2006 in Cologne, Germany—the structure was made for indoor use but had an open construction in split bamboo from a central column and outwards in soft and individual rounded curves. This construction had big resemblances to the act of silkworms that spin themselves into cocoons, with arbitrary and round shapes. The production of silk worms is one aspect that is cultivated on the building site at the KVK farm in South India. That is why the project at an early stage got the title: 'The Cocoon'.

The site

The location of the project was decided under guidance by the CARE School of Engineering. The choice fell on the 'Krishi Vigyan Kendra', which is a NGO research and education centre for none educated farmers situated 20km southwest of Tiruchirappalli (Figure 1). The actual location on the site was changed a couple of times but after negotiations it was finally decided to place the building on the left side of the entrance to the farm with a close diagonal connection to the main administrative building, some more functional buildings and palm trees on the south side. The access to the building is from a main path and along the organic bamboo construction to the different plateaus in the middle of the newly designed building (Figure 2).

The function

The function of the building is a new small training centre for education of farmers. The building consists of an educational ecological toilet, a constructed water purifying bed and an open 'plaza' in connection with the natural surroundings shaping the arrival and a place for casual relaxation. Finally, an organically shaped bamboo construction that stands free from the plinth enables ventilation through the centre of the building. Together the elements create a space for alternative learning.

The four building elements

The building consists of four elements (Figure 4). The first element is a layering of three plateaus that grounds the building to the place. The first plateau is rough and made of granite stones for the foundation. The second is of red brick and the last is of a dark refined orthogonal granite slab. The plateaus divide the building into three sections. The middle section is an open part, an entrance, and at the same time a connection between the building and the surrounding nature. Small raised platforms in solid red brick create places for resting and casual social meetings. Two building volumes are embracing this empty entrance space. On the right hand to the east is the eco compost toilet with a planted water purifying system; its designed in red brick and with three black sun chimneys in iron for air ventilation. The toilet, water purifying system and the external sitting arrangement appear unified because of choice of red brick material and orthogonal design. On the left hand to the west is the section for alternative teaching, which is a bamboo

construction of woven of split bamboo, it stands on an organically shaped frame of joined split bamboo strips with coconut thread holding it in place. This frame is lifted from the ground/plateau by a series of black bracket arms made of steel. The bamboo construction has a central woven column of with a hole in the middle so air and light can penetrate through the roof construction. A series of twenty 4-split bamboos run out from the sides of the column and are fastened to the bottom frame. They form the organic shape of the building and at the same time centralise the space in the column. Diagonally on the vertical 4-split bamboo, 8-splits are woven into the column till the second ring of the column, where another 8-split diagonal is woven in the other direction. These 8-splits and 4-splits are woven together in lines that form the whole shape of the bamboo construction like a basket, forming triangular shapes in a system that create static stability. The bamboo splits are tied together with iron thread such as a concrete reinforcement. On top of the bamboo construction are layers of bark from the palm tree 'areca' (also known as betel nut) fastened on slim splits of bamboo and joint on the construction with the same iron thread as mentioned earlier.

The digital design tools

The computer programs used during the design process had a major impact on shaping the building. One could say the building's final appearance during construction is forged through the meeting between between digital tectonics and the will of the bamboo material. When the decision was made to lay out the building through a dualistic play between orthogonal forms with heavy materials and a light organic construction of bamboo on top the choice of which programs for sketching the building could begin. Very soon we chose the program Rhino to be our main design tool, hereby T-SPLINEs became the medium to assist in shaping the curves of the construction. The program Revit was used to calculate quantities of material, make sun analysis etc. (Figure 5). This decision of programs has had a major impact on the final result of the building with its doubled curved forms in natural materials. It exposed a creative potential of the combination of modern digital technology, natural, sustainable materials and handcrafts in a local environment.

Local materials and local workers

To obtain a sustainable approach to the project as possible, it was decided to primarily use materials that were available locally and craftsmen from the nearby community. This meant the decision of materials fell on granite, low-burnt red bricks, bamboo and bark from the palm tree 'areca'. The workers were self-educated in the surrounding community and the nearest blacksmith fabricated all ironwork by hand.

Preparation of construction

The construction process started with a workshop where different aspects of the main bamboo construction were investigated in a scale model of 1:10 and mock-ups in scale 1:1 (Figure 6). Simultaneously with the

investigation process the preparation of the bamboo splits began and the foundation of the building was made. The investigation for the mock-ups were centred around the construction of the openly woven bamboo column in the centre and the relation between it and the bottom frame made by the many woven bamboo splits, this would finally form the building. Progress was made through three mock-ups, establishing the concept on how to form the final building from inside to outside. At the same time a perception of the form of the bottom frame was developed. Unfortunately, time was short, so any detailed study of load bearing capacity, strength of different joint methods and special cantilevered areas of the construction were not executed, which later proved to be a lacking point in the preparations. Parallel to this process the preparation of the bamboo started with water treatment for days in open vessels with holes drilled into them for tar treatment. After that the bamboos were split into 4- and 8-splits and treatment with local knives and sandpapering of more than 5km bamboo splits started. Mock-ups of the shingle roof were created and decisions on how the layers of bark from the palm tree 'areca' should be mounted on the construction were taken.

Construction

The construction of the building was divided into two sections. One section with students and local craftsmen took care of constructing and building the ecological toilet, water purifying system and the external sitting arrangement with the appearance in red brick, while the other division of students and local craftsmen were engaged with building the lightweight construction in bamboo. As the purpose of this paper is to deal with bamboo, I will mainly focus on building the bamboo construction. After putting the scaffolding around the building site the first objective for the bamboo construction was the foundation of the bracket arms, which hold the outer bamboo frame and the oval ring for the inner woven column. When the bracket arms were fixed in the foundation, it was possible to start the construction of the bamboo frame with 4-spilt bamboo pieces joint into a continuous and unified line of six bamboo pieces (Figure 7). After that it was possible to establish the oval of split bamboo on three brackets in the middle of the building and start weaving from the inner 'bamboo tree' formed of three oval bamboo split rings and outwards (Figure 8). To adjust the form made by the woven splits to the designed digital model strings were drawn up to the scaffolding when a lift was needed and for downwards pressure stones were hanging from the splits (Figure 9). When completing the weaving of the 5km of 4- and 8-split bamboos the crossing bamboo sticks were joined together by metal thread to create a stable structure that would spread the forces out over the whole construction (Figure 10). After the making of the construction the shingles of coated bark from palm tree were mounted on long narrow bamboo splits that were fastened to the construction as a new layer with a darker brown colour on the outside surface and a lighter tone on the inside (Figure 11, 12). Some smaller construction and surface details were added at the end of construction.

The final building

The result of the investigation can be found in the design of the final building. Surprisingly it turned out that the meeting between a digitally designed and hand manufactured building was better than expected. The inner will of the flexible material bamboo seems to have added an extra layer of dynamics to the digital design, that has given the building an expressive exterior character and a light and crispy interior feeling (Figure 13, 14, 15). The building is small but acts as a series of materialized plateaus leading into the light and three-dimensional bamboo construction where new learning processes can proceed (Figure 16, 17).

Conclusion about the bamboo construction

During construction the team found that there were several mistakes in the overall process, partially caused by lack of understanding of the character of the bamboo material and also due to miscommunications during the construction phase. There should have been more bracket arms placed closer to each other, the bottom ring should have been thicker, and the bamboo weaving should have been denser. Finally, the joints between the bamboo splits should have been done from the column and outwards, so the load would have been spread more harmonious on the whole construction system during built up. On the other hand the project showed that with the right treatment it is possible to construct a bamboo building with arbitrary double curved forms from thin split bamboos, that through the material use points back to the local history and though its form and space points to a contemporary understanding of architecture.

Final conclusion about the project

The final building proved a fruitful mutual learning experience among the participating people from different cultures in the project. Despite some misunderstandings the result shows a unique approach to bamboo construction where it's possible to merge new digital techniques with a craftsman's understanding materials. The project shows it is possible to investigate the potentials of arbitrary double curved forms in climate responsive bamboo constructions in the future for new sustainable architectural solutions.

Illustrations

Figure 01: Project location in Tiruchirappalli, India
Figure 02: Site plan at the KVK farm
Figure 03: Section diagram showing wind flow and exterior shade
Figure 04: Axonometric drawing showing the different elements of the project
Figure 05: Digital elevations of the building
Figure 06: Mock-up in scale 1:1 of inner woven bamboo column
Figure 07: The start of construction with inner column and bottom frame

Figure 08: Constructing the woven bamboo column
Figure 09: Adjusting the heights of the bamboo splits with stone
Figure 10: Tightening the form with iron thread
Figure 11: Mounting bark shingles from outside
Figure 12: Mounting bark shingles from inside
Figure 13: Bamboo building seen from southwest
Figure 14: Bamboo building seen from northwest
Figure 15: Bamboo building seen from northeast
Figure 16: Interior of wall
Figure 17: Interior of central column

Literature

Visionary Bamboo Design for Ecological Living/ Shyam Paudel, David Greenberg, Robert Henrikson, Hymos Advertising Co. LTD Beijing, P.R. China 2006
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