Architecture, Design and Conservation
Danish Portal for Artistic and Scientific Research

Aarhus School of Architecture // Design School Kolding // Royal Danish Academy

‘COCOON’

Høgfeldt Hansen, Leif; Kim, Sara

Publication date:
2016

Document Version:
Peer reviewed version

Link to publication

Citation for pulished version (APA):
Høgfeldt Hansen, L., & Kim, S. (2016). ‘COCOON’: A bamboo building with integration of digital design and low-tech construction. Paper presented at ICSA2016, Guimarães, Portugal.

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal ?

Take down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Download date: 26. Apr. 2024

ARKITEKTSKOLEN AARHUS Designskolen Kolding Det Kongelige Akademi

'COCOON' a bamboo building with integration of digital design and low-tech construction

L. H. Hansen
Architect maa, Denmark; associate professor, Aarhus School of Architecture, Denmark

S. Kim
Architect, South Korea; visiting lecturer, Aarhus School of Architecture, Denmark

ABSTRACT: COCOON I is an architectural case study, with the purpose of investigating the possibilities of merging contemporary digital design technology with local low-tech building handcraft on a sustainable level. The investigation is mainly empirical and performed on a cross-cultural basis to benefit from a mutual learning process.
COCOON I is a climate responsive building in South India for agricultural teaching. It is constructed out of local materials; bamboo, palm bark, burnt bricks and granite. The unique design approach of the building shows that the use of digital design tools enables the investigation of new qualities in the understanding of local materials. In this case the focus is on development of arbitrary double curved shapes of a bamboo construction and the formation of local burned bricks. The building was designed in a collaboration between Danish and South Korean teachers and students and constructed with CARE School of Architecture and local workers in South India.

1 IDEA AND PROCESS

The idea of the project was developed at Studio CONTEXT at the Aarhus School of Architecture in Denmark. Studio CONTEXT deals with research and teaching in the field of cross-cultural architecture with an emphasize on mutual learning and an experimental approach to architectural projects in 1:1 on the basis of a broad contextual understanding of local conditions.

The COCOON I project started after several years of teaching and research in India (Hansen & Hilberth, 2013). The idea was to develop new design strategies across boarders combining South Korean and Danish knowledge in cooperation with a local community in India. A cooperation started in 2014 with professor Byoung Soo Cho and architect Sara Kim from South Korea and the location of the project was decided under guidance by the CARE School of Architecture in South India. The decision of the project site fell on the 'Krishi Vigyan Kendra', which is a NGO research and education centre for agriculture situated 20 km southwest of Tiruchirappalli in South India. The NGO needed a new alternative space for student's education, where both teaching, exhibiting and casual discussions could take place, with a less formal approach to spatial expression than a normal class room.

Studio CONTEXT's pedagogical approach for the architectural students was for them to perform individual work in the beginning of the process to sketch a series of building proposals, and from there through discussions develop one collective design proposal based on climate and habitation studies, which should be realized as a functional building in cooperation with the local community in South India.

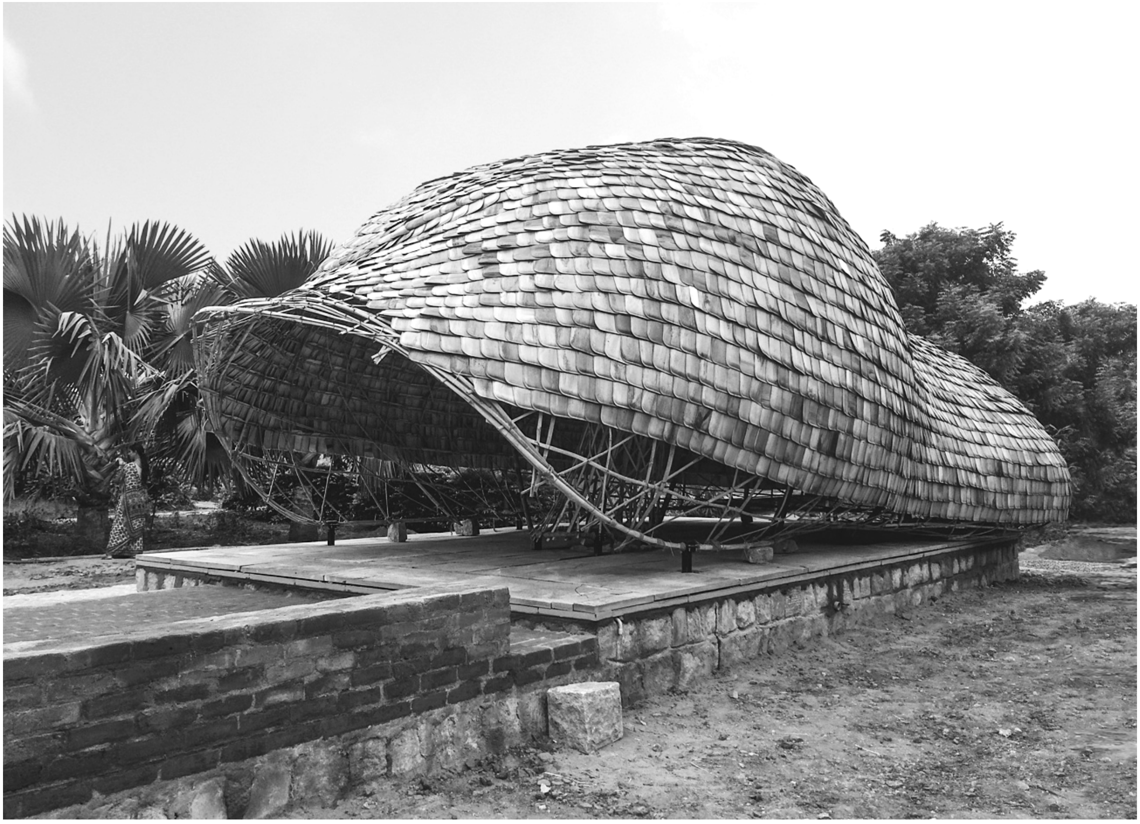

Figure 1. The split bamboo construction of COCOON I seen from North East

2 BUILDING ELEMENTS AND FUNCTIONAL USE

The designed building COCOON I is a new training building to facilitate agricultural education for children and existing local farmers. The area of the building is 9 x 17 m and it is build up by a series of plinths, which form the foundation for a bamboo construction for alternative teaching, a ‘plaza’ for casual meetings and relaxation and an ecological toilet with a water purifying bed - which was basically designed as being part of the education. Together the elements create a floating and dynamic space for alternative learning.

The building consists of a layering of three plinths that grounds the building to the place. The first plinth is of local granite stones. The second is of local burned red mud bricks, and the last under the bamboo construction is of dark orthogonal granite slabs. The plinths separate the construction into three different but continuous zones. The zone in the middle functions as an open ‘plaza’ for casual meetings and relaxation. It is an entrance space, and at the same time it unifies the building and the surrounding nature. Small volumes of red bricks create outdoor sitting spaces for relaxation and casual social meetings. The empty entrance space functions as a void, which is embraced by volumes. To the east is the ‘Ecosan’ compost toilet with a water purifying bed; it is also constructed in red bricks as the ‘plaza’ and has three dominant black sun chimneys in steel for air ventilation. The idea of the red brick material and orthogonal design of the toilet, water purifying bed and the external sitting arrangements is to make a unified appearance. To the west of the ‘plaza’ is the building for alternative teaching It is a light bamboo construction of woven split bamboo. This organic shaped split bamboo construction is 7 x 11 m with a max. height of 3.8 m. It is lifted up from the plinth on an organically shaped frame of joined split bamboo strips by steel bracket arms, which enables ventilation through the centre of the building. The bamboo construction has a central woven column with a hole in the middle, which enables air and light to penetrate through the roof construction.

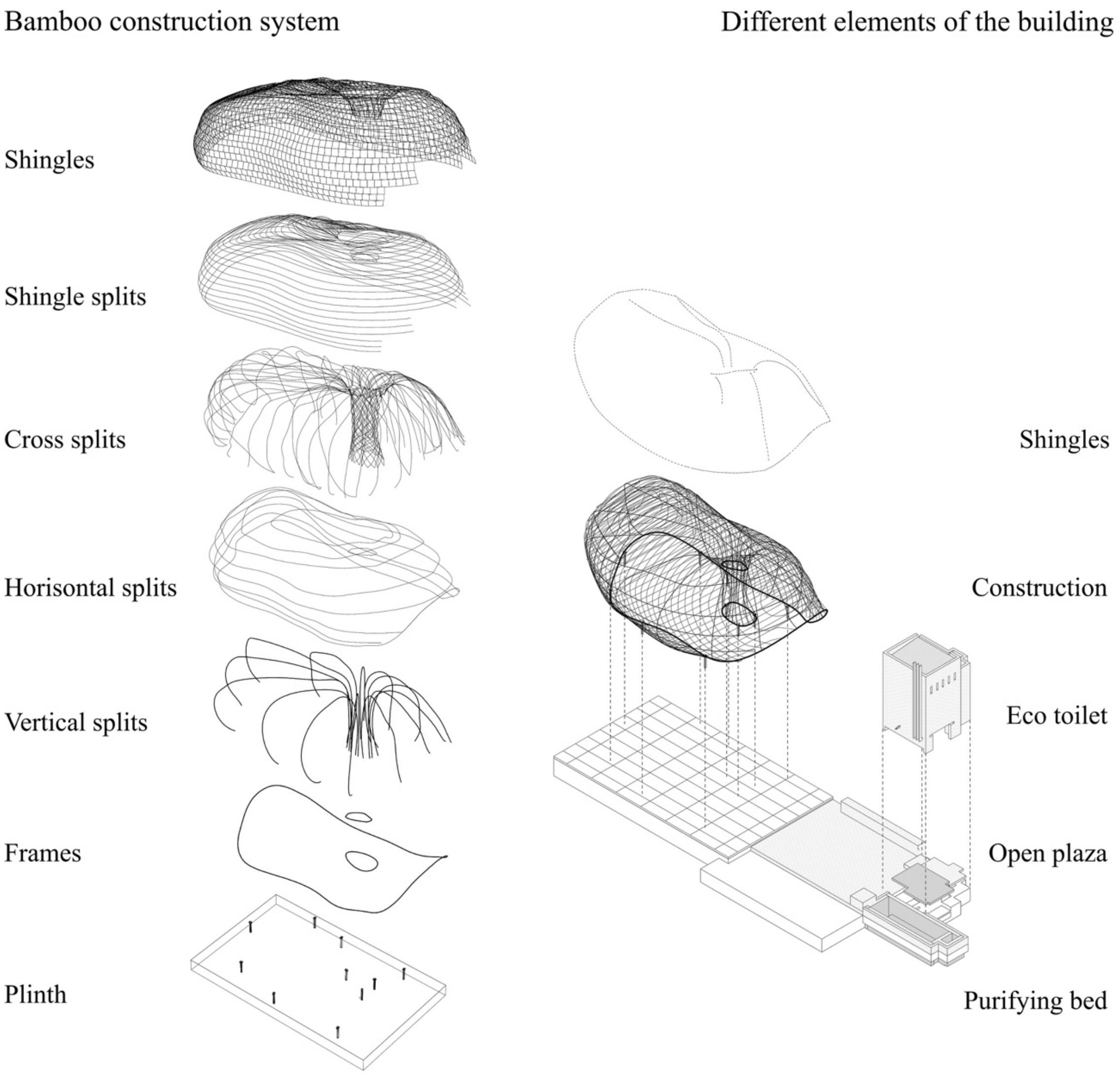

Figure 2. Axonometric drawings

A series of twenty 4-split bamboos run out from the the column and are fastened to the bottom frame of bundled split bamboo. They form the basis of the organic shape of the construction and at the same time define the centre of the building in the column. Diagonally on the vertical 4-split bamboo are 8-splits woven into the column till the second ring of the column, where other 8-splits are woven diagonal 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 stability. The bamboo splits are fastened together with iron used for concrete reinforcement. As a roof on top of the bamboo construction are fastened layers of bark from the palm tree ‘areca’.

3 DIGITAL GENERATED DESIGN AND LOW TECH CONSTRUCTION

The design process of the project was highly supported by the use of computer programs as a tool to control the curved forms and the elements of the construction. As a supplement to the computer tools a series of small physical scale models were constructed to test the spatial composition and the basic principles of the construction. The use of computer programs developed a freedom to generate double curved forms along with more conventional shapes. For this purpose, the program Rhino was used in combination with the plug-in T-spline, which enabled us to change the shape

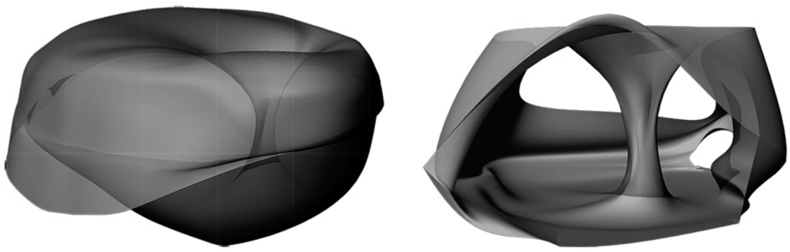

Figure 3. Early Rhino computer sketch drawings on basis of the 'doghnut' shape

of the surfaces quite rapidly to make fast decisions with the right flow in the working process. Parallel to the process of combining double curved forms and orthogonal compositions, the studio made a research into the use of appropriate materials for the building (Brodo, 2014, Conrad & Otto, 1965, Greenberg & Henrikson, 2006, Minke, 2012, Roland, 1965). The starting point for this investigation was to use materials for the building, which could be found and manufactured within the neighborhood of the construction site in the outskirts of Trichy, South India. Quite fast it was decided to test some basic materials, which our local collaborators from the Care School of Architecture informed us were available in the area. The first selection of materials was: bamboo (splits), laminated bamboo, straw, granite, local burned red mud bricks, compressed stabilized earth blocks and iron fittings.

Slowly the choice of materials was starting to take form along with the design process. Bamboo was chosen as one of the main materials, which could be formed into a more organic light weight construction. A later field study of the design possibilities of this material took place at Auroville Bamboo Centre. Local granite was finally chosen for the foundation level of the whole construction.

Investigations for the use of materials for the open 'plaza, the sitting arrangements, the compost toilet, and the purifying water bed were made, and focused on compressed stabilized earth blocks and local burned red mud bricks. The first choice fell on the compressed stabilized earth block with the standard size of 290 x 140 x 90 mm or alternatively the blocks in ¾ size 290x 140 x 90 mm (both with 5% stabilizing cement) as a local sustainable solution. This material was later studied in India at Auroville Earth Institute. To enable the control of design, quantity and cost of the construction, the design was then put into the program of Revit to give a first estimate of the consequences of the design decisions. The visualizations in the program showed that the dimensions of the earth blocks didn't fit properly into the idea of the design, because the walls looked too bombastic compared with the relative small volumes of the building masses. This changed the choice of material to the local burned red mud bricks with the standard Indian dimensions of 228 × 107 × 69 mm. To make diagonals in the brick material, a tetra bond organized the structure of the stones on the floor of the small 'plaza' of the building, which would unconsciously lead people in the direction of the opening of the bamboo construction for alternative learning.

Revit was also used to calculate the dimensions of the bamboo construction, which was originally digitally built up in Rhino on a donut shape strategy, that was cut up and deformed into the preferred spatial composition. The construction of the split bamboo building with an aesthetic constructive cross weaving for stabilization found its inspiration through scale model tests in the design studio and from studies of constructions designed by Auwi Stübbe (Minke, 2012) and Frei Otto (Otto, 1972). Through Revit it was calculated that the total length of the split bamboo construction would be of approx. 6300 m. The weight of different roof solutions was calculated, and later in the process palm bark shingles were selected because of the light weight in favour of a thatched roof solution or a laminated bamboo shingle solution.

Later during the process in India, while constructing the bamboo building, no sections or elevations were drawn, but 3D spatial points in a coordinate grid were the decisive factors in defining the positions of the bamboo splits. This was practically done by transforming the plateau into a coordinate system from which the height of the woven construction could be measured. If the point of the split construction was too low, then a pole would lift it up, or if it was to high, then a stone at the end of a string would pull it down. These spatial adjustments were constantly done,

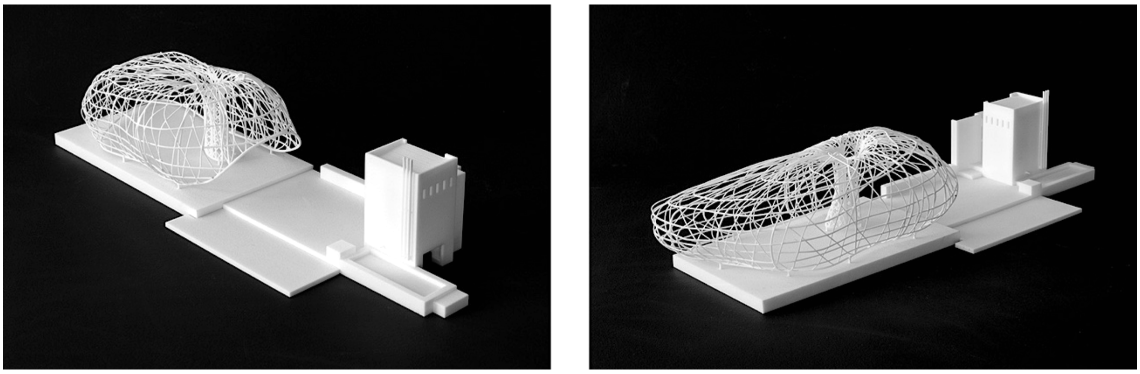

Figure 4. 3D print 1:100 of the final building design

so the actual multi curved building would challenge the qualities of the material formed and controlled by the computerized coordinate system of the design. On top of this some 'on site' decisions were taken for changes to optimize the quality of the spatial 1:1 experience of the construction.

The relation to architectural drawings was more traditional in the design of the open 'plaza, the sitting arrangements, the compost toilet, and the purifying water bed. The program Revit was used and representations of the design were drawn in plan, section and elevation, which also enabled the design team during the design process on site to have control of quantity of materials, costs etc.

Finally, after the construction of the building in India the design tools were used to print a 3D scale model 1:100 of COCOON I for display purposes.

The decision of which kind of computer programs should be utilized during the process has had a major impact on the final result of the design of COCOON I with its combination of multi curved and orthogonal forms built in natural materials. It exposes a creative potential of the combination of modern digital technology, natural, materials and handcrafts in a local environment.

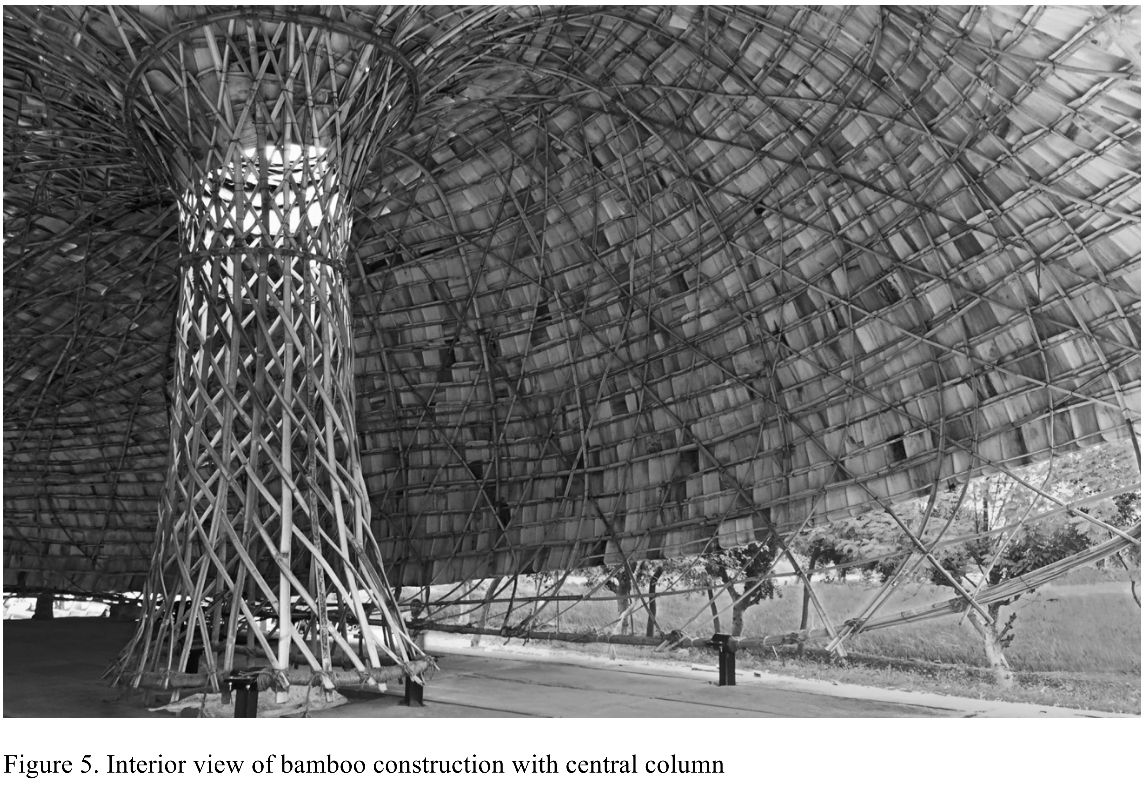

Figure 5. Interior view of bamboo construction with central column

4 CONSTRUCT OF A BUILDING IN A COMPLEX CROSS-CULTURAL CONTEXT

The actual construction of the building in South India had some major challenge. These challenges were basically founded in the different cultural backgrounds and language groups represented on the site. The four major languages for communication were English, Tamil, Hindi and Danish/ Norwegian.

The work on the site started with a short common bamboo workshop for students and local labors, where different aspects of the main bamboo construction were investigated in a scale model 1:10 and mock-ups in scale 1:1. During this process the water and borax bamboo treatment for a better durability and the tar treatment for termite protection of the bamboo material for the building were taking place, and the foundation of the building was established.

The construction of the building was divided into two teams. The first team consisted of students and local craftsmen, and they took care of constructing and building the ecological 'Ecosan' toilet, water purifying bed and the external sitting arrangements with the appearance in burned red mud brick, while the other team of students and local craftsmen were engaged with the building of the lightweight construction in bamboo.

The bamboo sticks for the bamboo construction were split into 4- and 8-splits and treated with knives and sandpaper to smoothen the surface of more than 6000 m bamboo splits. The first objective of the bamboo construction was the foundation of the steel bracket arms, which hold the bottom frame of bundled split bamboo and the oval ring of the inner woven column. 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. First with vertical 4-splits and later cross-weaved for aesthetic and constructive reasons with 8-splits in a controlled manner guided by the previous mentioned 3D spatial points in a coordinate grid by computers and finally adjusted by the human eye for spatial quality 1:1.

5 CONCLUSION

The result of the investigation can be found in the design of the final building, which can be characterized as a meeting between digital design and hand-manufactured craft.

The material character of the flexible bamboo seems to have added an extra layer of dynamics to the digital design, and has given the building an expressive exterior character and a light and crispy interior feeling.

The project shows it is possible to construct a bamboo building with arbitrary double curved forms from thin split bamboos, which through the material use points back to the local history, and though its form and space created with digital tools points to a contemporary understanding of architecture.

Figure 5. Cross-cultural building process of eco toilet and bamboo construction

The final building proved to be a fruitful mutual learning experience among the participating people from different cultures in the project.

The result shows a unique approach to construction with bamboo and local materials, where it is possible to merge new digital techniques with a craftsman's understanding of materials. The project shows it is possible to investigate the potentials of local materials and arbitrary double curved forms in climate responsive bamboo constructions in the future for new sustainable architectural solutions.

REFERENCES

Brodo, Eduard 2014. Bamboo, architecture and design. Links Books. Barcelona, Spain

Conrad, R. & Otto, F., 1965. Spannweiten. Ideen und Versuche zum Leichtbau. Ein Werkstattbericht/ Ullstein, Berlin.

Dunkelberg, K. 1996. Bambus – Bauen mit panzlichen Stäben.

Hansen, L.H., Hilberth, T. 2013. Made in India. Studio CONTEXT. Arkitektskolens Forlag, Aarhus, Denmark

Minke, G. 2012. Building with Bamboo/ Birkhauser Otto/ Krämer, Stuttgart, ISBN 3-7828-2031-2.

Otto, F. 1988. Gestaltwerdung. Zur Formentstehung in Natur, Technik und Baukunst/ Müller, Köln

Paudel, S., & Greenberg, D., & Henrikson, R. 2006. Visionary Bamboo Design for Ecological Living/ Hymos Advertising Co. LTD Beijing, P.R.

ACKNOWLEDGEMENTS

Idea, Design and Construction

Studio CONTEXT, Aarhus School of Architecture

Leif Høgfeldt Hansen, associate professor, architect - initiator

Thomas Hilberth, associate professor, PhD, architect

Sara Kim, assistant professor, architect, South Korea

VELUX Guest Professor Byoung Soo Cho, architect, BCHO Architects, South Korea

Studio CONTEXT students

Construction and realisation

CARE School of Architecture, India

Vijaykumar Sengottuvelan, dean, professor, architect

Er. Rajendran, engineer, structural consultant

Workshop: Architect Neelam Manjunath and staff from Center for Green building Material & Technology CARE assistant staff: Judith Belinda Laura, Jothi Mani, Christian Stephen, Raj Aarunachalam

CARE students and local workers

Sponsors: VELUX foundation, Statens Kunstfond, Aarhus School of Architecture