

Hothousing collaborative research

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Collaborative design research between the School of Architecture & Design at the University of Tasmania and architectural practice Cave Urban, was central to the construction of a bamboo pavilion for a major international arts festival. The structure housed two events of contrasting scale: an intensive 'think tank' for a small team of 24 people working intensively across a tight 72 hour time frame; followed by a large-scale public winter feast as part of a festival celebrating the dark through large-scale public art, food, music, film, light and noise.

The project drew on an existing portfolio of research into traditional and contemporary bamboo structures and construction, which had been developed by the architects' previous collaboration with key international artists and designers. It was run as part of the Advanced Design Research selective in the Master of Architecture programme, and involved cross-disciplinary engagement with the Tasmania College of the Arts (TCotA), practicing artists, event designers, and bamboo-engineering specialists.

The programme was scheduled as a series of three intensive workshops. A research and design phase involved experimentation with full scale prototypes and scale models to explore the material and formal qualities of bamboo, which informed the schematic design that was used for engineering and council approval. The detail design was resolved on site through the construction process, which involved a team of 25 people were involved in the three week period. Design research was extended into the dismantle phase, which involved structural testing to expand knowledge of bamboo construction techniques. This studio provided the opportunity for students to work with expert collaborators, to expand practical and theoretical knowledge through the development of a design for a civic event space. This provided a strong contrast to the usual drawing-led method of design that underpins traditional architectural studios in universities.

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Collaborative design research between the School of Architecture & Design at the University of Tasmania and Sydney-based architectural practice Cave Urban was central to the design and construction of a bamboo pavilion for the Dark Mofo arts festival in Tasmania. The project, which expanded the architects' extensive research into traditional and contemporary bamboo structures, engaged with 10 Masters of Architecture Students as part of an Advanced Design Research selective, and also involved cross-disciplinary engagement with the Tasmania College of the Arts (TCotA), practicing artists, event designers, and bamboo-engineering specialists.

The Hothouse structure was created for two events of contrasting scale: an intensive big-picture 'think tank' for a small team of 24 people working intensively across a tight 72 hour time frame; followed by a high-profile public winter solstice festival involving large-scale public art, food, music, film, light and performance. The Hothouse integrated three components: a 40 metre-long canopy; four independent cocoon-like pods; and a conversation pit with a hearth, which was positioned in the central bay of the canopy. Each element consisted of structural and decorative components with a strong emphasis on re-use. The canopy was embellished with a secondary layer of 'fan vaults', which both reinforced the structure and created a strong visual form. Beneath the canopy were a series of pods, bamboo splits were used to form the cocoon-like dome, and to clad the plywood substructure. Timber pallets were repurposed to form the foundation of the seats in the conversation pit, which were also clad in bamboo splits. The furnaces were constructed from existing boilers that were decorated by an overlay of welded metal, converting the utilitarian structure into a sculptural form.

From the outset the team was aware of the dynamic nature of this project, and the significance of being involved in a major festival. Coordinated collaboration was required to execute this fast-

paced of the project, with the design needing to be developed, signed off by the stakeholders and passed through the building approval process and then constructed in a period of 14 weeks.

Hothouse as Learning-by-Making

The Hothouse project is part of the Learning-by-Making (LBM) stream that has been central to the University of Tasmania's architecture curriculum over the past 20 years. LBM projects integrate building technology and design through a process of experience-based learning.¹ Projects involve various of teaching and supervision models, ranging from groups of students work independently to design and construct projects, with staff acting as facilitators who provide guidance and practical demonstration of construction processes, through to the 'master/apprentice' model, in which the students shadow the 'master' designer-maker, acting as their assist or 'apprentice.' The Hothouse project provided a unique opportunity to follow the master/apprentice model, as the collaboration with the architects and a team of builders on site provided the high level of supervision needed for this model. The project created a unique form of Work Integrated Learning (WIL), which provided 'authentic learning' through the direct engagement of the students with an architecture practice, and as part of the festival events team.² Working with builders, a specialist bamboo construction team, and artists created a platform for interdisciplinary collaborative design research that extends contemporary practices of bamboo construction.

The project was conducted in four intensive workshops across the semester: project briefing, design, construction and dismantle. Throughout the process the students were mentored to master a broad range of skills from research to design and construction, and throughout the project they began to take an increasing role in leadership. Students were assessed both individually and as a group, based on contribution and their critical reflection that evaluated the processes of design, construction and process of team work and decision making.

The project involved a high level of experimentation, actively engaging the whole team in design research into bamboo structures. The varied physical properties of the bamboo meant that the design and construction was typified by exploration and testing, creating a process of trial and error. This process of reflection-in-action formed a critical practice that provided a dynamic and reflexive form of praxis.³ The architects exploited this process to allow them to expand the limits of knowledge and to create projects that are as much experimental installations as they are buildings.

Our philosophy as a firm is to use research in order to investigate a different approach to architecture that tests in situ what we can and can't do with a material. At times that means two steps forward and one step back, but we find this process allows for the best result in a design that is utilising non standardised materials. For us design is all about flexibility and being open to the notion of new possibilities, if an opportunity presents itself. For those used to a more conventional way of doing things, this can be at times challenging and frustrating.⁴

Workshop 1: Project briefing

At the start of the project, it was necessary for the students to quickly develop an understanding of the structural properties and formal possibilities of bamboo. An introduction was provided in an initial lecture by Cave Urban, which was followed by a site visit to document the wide colonnade of deciduous trees that would define the spatial parameters of the project. Mapping the location of each tree and the profile of its canopy provided an understanding of the building's scale and allowed for an engagement with the qualitative aspects of the site. Information was collated by the students, and sent to the architects for revision, with the teams connecting via Skype and teleconferences to discuss the preparation of the base site drawings. This process mirrored the traditional supervision that would occur in practice, with the iterative feedback highlighting to the students the need for precision and detail, beyond that of a typical speculative design studio project.

In parallel, research into bamboo structures, both historical and contemporary, was initiated by students reviewing Cave Urban's portfolio of bamboo projects from many cultures across the world, and collating additional examples of other precedents that might inform the qualities of the project. Students were also encouraged to experiment with making bamboo structures, and to gather information on a range of other materials that could be used in the construction process.



Figure 1 : Scale models testing bamboo systems (left) and detail (right). Images: Helen Norrie.

Workshop 2: Design, documentation and presentation

Both the design and the preparation of presentation drawings and models was completed in an intensive four day workshop. This stage of the project served as a basic training session in bamboo construction, with Cave Urban providing practical demonstrations of ideas, which were experimented with by the whole team. The design process involved the testing of spatial and structural ideas through 1:20 scale models, and the construction of a 1:3 scale mock-up of a prototypical structural idea presented by the architects. This allowed the students to develop a hands-on understanding of bamboo construction; a process that represented a significant shift in the students' understanding of design, particularly an appreciation the overlapping of structural and

sculptural qualities. It established an appreciation for the process of trial and error that became central to the on-site construction.



Figure 2: Scale models of structural bay of canopy (left) and pods (right) Images: Helen Norrie.

This workshop cemented the interpersonal relationships within the team. The students began to understand of the dynamics and expertise within Cave Urban's team, as they became part of the process of negotiating the content and format of the drawings and electronic presentation. This process was lead by the architects, with the students producing drawings, renders and montages and participating in the decision-making about graphic content and format, in a manner that replicated an office scenario, particularly during design competitions.

The project contrasted with the university's Learning-by-Making projects traditions, which generally use more conventional materials and construction processes. Research was central to the design and construction process, utilising various modes of design research that can be understood in terms of Christopher Frayling's tripartite model of research *into/for/through* design.⁵ Research *into* design involved a critical investigation of pavilions for performance and public events, both historical and contemporary, while research *for* design examined bamboo precedents, particularly

analysis of structural and construction systems. The development of prototypes across a range of scales allowed for formal testing of the structural and aesthetic ideas, providing an understanding of structural performance and establishing a process of research *through* design.

Workshop 3: Construction



Figure 3: Central bay of canopy (left) and column and beam junction. Images: Helen Norrie.

Understanding the physical properties of the bamboo was central to the design and construction. Four different species of bamboo were used, and it was necessary to be able to visually identify the different types and understand the different structural characteristics, particularly flexibility and strength. Two container-loads of 2000 bamboo poles needed to be sorted in order to be able to keep track of the amount of different types that were available, as this needed to be factored into the design and construction decision-making. Each stage of the assembly involved a process of testing to see what worked, and adapting both the overall strategy and the execution of each component to suit. This meant that although the project involved a series of essentially repetitive tasks, each step also required an evaluation of techniques and composition. This provided a very clear illustration of the relationship between design and detail, highlighting the nexus between structure and aesthetics.

Unlike conventional building projects, where the design is documented and then implemented through construction, in this project the design continued to develop throughout the 23-day design/build phase. The project was not documented in the traditional sense, with a full set of general arrangement and detail drawings. Instead, the design principles for an overarching spatial and structural strategy were developed through sketch drawings, montages and models. The various stages of site set out, column erection, beam construction, roof cladding, and layering of internal secondary structure involved a high degree of experimentation.



Figure 4: Construction of the pods - dome (left) and interior cladding (right). Images: Helen Norrie.

The initial intention to construct a hybrid of a bamboo forest and a Gothic cathedral was achieved through the addition of the secondary layer of bamboo to create a series of fan vaults, which was both aesthetic and structural. The lighting design was a key element, transforming the scale of the building from day to night. Amber yellow light at the base of each column graded to fire red at the top, reflecting the 'fire' motif of the mid winter festival. The columns provided a surface to receive the light, doubling the height of the building and increasing its scale and sense of theatrical spectacle during the long winter nights.

Although the finished building looked very similar in character to the montages and models, there was a fundamental shift in the structural system used. It was originally intended that the triangular bays would be constructed from a series of arches, as explored in the 1:3 scale mock-up. However, the bamboo was not as flexible as anticipated, and after an exhaustive process of experimentation, a structural system of columns and curved beams was adopted. The construction of the first set of beams in the central bay was very complex; aligning the structure to ensure that beams were evenly spaced in relation to the centre also involved a process of trial and error. Also, as bamboo was added to the structure the additional load caused the columns began to spread out, and the bindings needed to be adjusted and reinforced. This required a coordinated approach, with one team focusing on the construction of the beams and another focusing on the effect that this structure was having on the columns. This created an ongoing process of testing and critical reflection, continually building knowledge about the performance of the structural system.



Figure 5: Roofing complete on central bay (left) and end bay (right). Images: Helen Norrie.

Master apprentice model

During construction, the Cave Urban team expanded from the initial three members to between 5-8 people, and they were joined by a site construction crew of four. The 10 architecture students were

joined by a group of art school students, which varied between 2- 6 volunteers per day. This meant that the ratio of skilled and experienced *masters* (architects and construction crew) and *apprentices* (architecture and art students) was roughly one to one. All the tasks required teamwork, and each team was formed around the guidance and leadership of one of masters. As the students gained construction expertise and an understanding of the structural system they were able to become collaborators in the decision making. Each of the students also became an instructor or *master* as new volunteers – *apprentices* - joined the team throughout the process. This created a high level of peer-to-peer collaboration, which required communication within each team, and with the project leaders.



Figure 6: The conversation pit (left) and pods under canopy (right). Images: Helen Norrie.

Separate teams worked on particular tasks, and everyone rotated between tasks to gain a holistic knowledge of all the construction processes. By end of the second week the whole team had become familiar with all of the different construction methods, and they were able to move between tasks as required. The construction process was characterized by a sense of measured calm, even in the final stages when there was a need to work more quickly to complete within the timeframe. The constant communication between the team was central to the refinement of techniques for jointing

and assembly. The distinction between master and apprentice dissolved, as everyone gained knowledge, skills and confidence.



Figure: The Hothouse in action during the think-tank (left) and feast (right). Images: Helen Norrie.

Construction as a process of design research

Understanding the relationship between each component and the overall structure was central to the process, and this facilitated a constant testing and evaluation at micro and macro scales, and ongoing discussions between the team. For example, there was an understanding of the importance of the strength of the bindings to the overall integrity of the structure, reinforcing the need to share of knowledge and techniques, and to continually test the effect of details on the overall structure. A similar evaluation of detail in relation to overall form was played out in other aspects of the project.

Workshop 4: Dismantle

Design research continued through the dismantle phase, which included structural testing of components. Stress testing of the central bay, which was overseen by a rigger and an engineer, allowed the team to measure deflection, and observe the performance of individual components, providing new knowledge into bamboo systems. The majority of the materials were recycled,

including the bamboo poles and splits, ropes, cable ties, *Duralock* channels for the roofing system, and the plastic roofing itself. By this stage the team had developed very clear processes of collaboration; the teams that had been formed in the construction process continued to work together, constantly gauging what others were doing and joining in to assist where possible. Everyone took leadership over a particular task, including the sorting and recycling of materials. The structure was dismantled in three and a half days, including clearing the site of all debris and packing the materials in a container for reuse.

Conclusion

The brief to create a structure that could serve both an intimate think-tank discussion and a large-scale festival event, that was warm and dry in the middle of winter and made from bamboo, was wildly optimistic. The shared learning that was central to the initial design workshop allowed the whole team to develop an inherent understanding of the founding strategy of the project, which was developed through invention and experimentation. This resulted in new research into bamboo structures, building the whole team's knowledge and expertise, and adding to Cave Urban's research portfolio.

The architects' experience in working with a large team of volunteers was invaluable, and they shepherded the students' transition from apprentice to master collaborator. For the students, the speed of decision-making contrasted with the design process of traditional student design studios and this presented a significant learning experience. The students commented on how this process highlighted the need for confident and quick decision making, and the importance of communication within the team and the need to work strategically in order to meet the time frames of the project. This created a steep learning curve, but by the end of the second week the students had begun to understand the dynamic both between architects and with the construction crew, and were able to negotiate their position within the team.

The building process was supervised by a site manager, whose experience on fast, temporary constructions for festivals was essential to the dynamic project with a team of 20-30 people. Adjusting the construction process to comply with Workplace Health and Safety (WHS) requirements was a constant challenge. The mismatch between the rectilinear scaffold and scissor lifts, and the curvilinear structure needed to be continually negotiated, with the site manager keeping a close eye on the team, who in turn were instructed to continually observe the practices of others. This provided the students with significant insights into the relationship between construction techniques and building form, as ways around these challenges were negotiated.⁶

Working directly with Cave Urban and the construction crew provided a unique form of Work Integrated Learning, where the roles and responsibility of the various parties were demonstrated, and the students were privy to the complex, and sometime fraught, negotiations between design and construction. The ratio of *masters* to *apprentices* presented a unique learning opportunity, which allow students to become central agents in collaborative design research.

A sense of camaraderie was built between the students, particularly as they debriefed with each other and the end of each day. By the end of the project they were able to clearly articulate the different relationships and hierarchies on site, and understand the different lines of leadership in a seemingly unstructured process. The students recognised the need to embrace the experimental nature of the project, and this and allowed them to understand the value that of trial and error as a design process, which contrasts strongly with the process of design through drawing. Throughout the project the students' confidence with this new process develop, allowing them to become key members of the collaborative design research into bamboo structures.

¹ Wallis, Louise. *Learning-by-Making: Design-build studios at the School of Architecture at the University of Tasmania* (Masters thesis, University of Tasmania, 2005).

² Carol-joy Patrick, Deborah Peach & Catherine Pocknee, Fleur Webb, Marty Fletcher & Gabriella Pretto . The WIL [Work Integrated Learning] Report: A national scoping study, (Queensland University of Technology, Brisbane, 2008).

³ Fraser, Murray. (2013) *Design Research in Architecture: an overview*. (Farnham, England; Burlington, USA: Ashgate, 2013).

⁴ Personal discussion with Cave Urban.

⁵ Frayling, Christopher. 'Research in Art and Design' Royal College of Art Research Papers series 1(1) (1993).