The Ringve Botanical Garden Viewing Platform

Second Case Study on Digital Timber Fabrication at NTNU Trondheim

Knut Einar Larsen [1], Christoph Schindler [2], Fabian Scheurer [2], Simen Stori [1]
[1] Norwegian University of Science and Technology (NTNU), Faculty of Architecture and Fine Arts, [2] designtoproduction GmbH, Switzerland
www.ntnu.no/1-2-tre, www.designtoproduction.com
[1] knut.e.larsen@ntnu.no, [2] schindler@designtoproduction.com
Abstract. *Since 2006 the Faculty of Architecture of the Norwegian University of Science and Technology (NTNU) has organized the '1-2-TRE' workshops on digital timber fabrication. The annual one-semester courses explore the possibilities and conditions of file-to-factory processes in cooperation with professional carpentries. The 2007 course focused on adding varied simple elements to a complex whole. Within a full semester course, a permanent viewing platform for the Botanical Garden of Trondheim was designed, produced and built by the participating students.*
Keywords: *Teaching project 1:1; Industry cooperation; Digital fabrication; CAD/CAM; Ringve Botanical Garden Viewing Platform.*

Figure 1
The Ringve Botanical Garden viewing platform in Trondheim completed in December 2007 by students of the NTNU '1-2-TRE:7' course. The timber used for the project is heartwood of larch of local origin donated to the project by the municipal forest authority of Trondheim city. Photo: Pasi Aalto.

Introduction

In 2005 the Faculty of Architecture at the Norwegian Institute of Technology established a R&D and teaching program on digital modeling and prefabrication of buildings, called '1-2-TRE:lab'. [1]

The first course in the fall semester of 2006, called 1-2-TRE:6, designed and built a permanent Camera Obscura in the center of Trondheim city (Larsen et al., 2007). For the course in the fall term of 2007, called 1-2-TRE:7, the management of the University's botanical garden at Ringve invited us to build a combined viewing and access platform to a small natural woodland that is part of the botanical garden. Their vision was to have a structure that would become a permanent installation for the benefit of the garden's visitors. The platform should have two purposes. First, it should lead visitors into the woodland, and, second, it should give the visitors an opportunity to look into the tree crowns.

The 1-2-TRE:7 course had three main purposes. These were to give the students knowledge of and experience in (1) the use of wood as a building material, (2), the use of digital technologies for the planning and production of timber structures, and (3) the legal and practical requirements concerning the building of a permanent structure in full scale at a fixed site. Thus, one might say that the digital content is a part of a larger whole. Although this paper focuses on the digital content, it is also necessary for the understanding of the whole that we give some insight into its interfaces with the whole design, planning, production, and building process.

Course structure

The semester consisted of 17 weeks in total, starting in mid-August and ending in early December at a time when the environmental conditions normally are unfavorable for outside construction work with short daylight time and temperatures well below zero.

Design competition and design development (weeks 3 – 9)

During the first part of this phase (weeks 3 – 5) the class of 12 students was divided into four groups, each with three participants. This segment was organized as an architectural competition between the four groups. However, a final concept with potential for realization was not chosen until the end of course week 8. Design exploration was mainly done through sketching, building physical models and simple 3D design tools such as Sketchup.

The students also had access to and had been trained to use the 1-2-TRE:lab's three-axis router (a Datron M8) machine. Although they were encouraged to use the machine for prototyping, it was used to a very limited extent.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Intro.		Design competition			Design development				Detailing & production preparation			Production		Site assembly		

Figure 2
The time table of the 17 week long NTNU course '1-2-TRE:7' showing the duration of the planned activities during the semester.

Introduction (weeks 1-2)

The first two weeks were used for site studies in the botanical garden, for studies on wood qualities, and to make the students aware of the possibilities and limits of the available production machinery, a Hundegger SpeedCut 1 automated joinery machine. We also organized a design kick-off workshop with external instructors that included architects Corinna Menn (Chur, Switzerland), Bernard Delafortrie of Geninasca Delafortrie (Neuchâtel, Switzerland), and Ruth Berktold of yes-architecture (Munich). Christoph Schindler and Fabian Scheurer of designtoproduction (Zürich) also gave presentations, and continued to serve the course throughout the semester as studio instructors. The workshop focused on the architectural content throughout the course. Thus, the digital tools remained as such and did never become the main topic. On the other hand, without the use of digital tools in the planning and fabrication the project could not have been carried through due to its complexity

Figure 3
During the concept development phase the students used mostly analogue tools such as sketching and building of physical models, but also simple 3D modeling tools, such as Sketchup..

Detailing, production preparation, and production (weeks 10 – 14)

In order to complete a full-scale project by the deadline, a huge amount of tasks had to be completed, ranging from getting screws for joining the timber members and preparing the foundations, to modeling of the final timber structure so that it could be efficiently produced on the CNC machine. In fact, only two students worked on the digital model in the CAD/CAM software Cadwork, while the other ten students dealt with the various other necessities for construction, while constantly giving input for the solution of details and building 1:1 scale mockups.

The students managed to get sponsoring from more than 16 private companies, who provided goods and services which were necessary to build a 1:1 structure in situ. This work also included application for building permit.

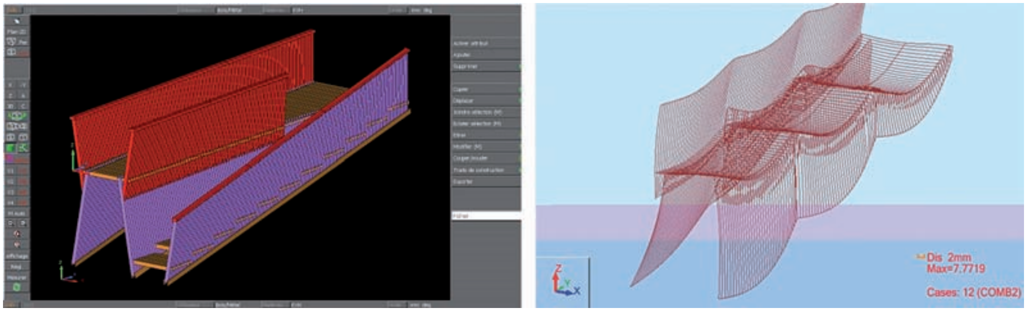

Figure 4
Left, screenshot of the Cadwork 3D model; right, screenshot from Robot Millennium showing deformations calculated from wind- and snowload, and the platform full of people.

Figure 5
The Hundegger SpeedCut SC1 CNC machine used by Kjeldstad Sagbruk & Høvleri AS to produce the nearly 700 timber components for the Ringve Botanical Garden viewing platform. All components were automatically labeled with the machines ink lettering unit. Without this numbering system it would not have been possible to assemble the structure.

One of the sponsors was the engineering company TDA, which also is the Norwegian vendor of Robobat software, including the structural calculation program Robot Millennium.

Fortunately, our cooperating production partner, Kjeldstad Sagbruk og Høvleri AS in Selbu outside Trondheim, had employed an excellent timber engineer from Switzerland, Mr. Christian Schmid, with whom the students responsible for the Cadwork model were in constant dialogue. Due to this close collaboration with the producer, the actual production phase of the project was remarkably smooth. The production of the nearly 700 components, all with different geometries, was completed in 5 hours. We can safely say that without the digital chain from the 3D model to the production software, the project could not have been realized within the given timeframe.

Site assembly (weeks 15 – 17)

This phase was indeed hectic and included activities such as designing and constructing the foundations (concrete and steel beams) and the final assembly. The students preassembled the components into sections, which were then brought to the site and erected. The structure was finished just in time for the official opening.

University of British Columbia in Vancouver (Neumann and Schmidt, 2007; Neumann, 2007).

After having underestimated the joinery machine's constraints in the previous course, we tested our structures from the very beginning in the simulation module of the machine software to ensure their technical feasibiliy.

Figure 6
Left, the delivery of the concrete for the foundations; right, the site assembly of a section.

Project analysis

CAD/CAM chain

Just like in the 2006 project 'Camera Obscura', the combination of the timber software Cadwork and Hundegger's automated joinery machine was the technical backbone of the workshop. For two reasons, we decided to run a second workshop on the same technical basis. First, from the students' perspective, Cadwork turned out to be easily learnable but highly effective and therefore especially suitable for large groups such as semester courses. With comparatively small efforts, students learn how to prepare the machine data for a highly developed industrial CNC-machine. Second, from the timber industry's perspective, the pair Cadwork/Hundegger is of high practical relevance through its wide application in the industry, providing us with ideal conditions for cooperation. The CAD/CAM pair Cadwork/Hundegger was chosen as well by Prof. Oliver Neumann within an academic workshop at the

The periphery around this backbone was rather flexible: In the concept phase, any means of design from manual sketching to 3D-CAD software was implemented. The interface to Cadwork was not crucial, as all the detailing was drawn directly with the timber software as a 3-dimensional model with timber specific attributes such as fiber direction and joints.

The structure was evaluated with the structural software Robot Millenium. The French company Robobat is one of software developers cooperating closely with Cadwork for optimizing the IFC (Industry foundation classes) interface. However, as the structural engineer imported our IFC-model, it turned out that the volumes of our structural members had been split up into their b-rep surface elements and could not be recognized as a structural member. An import via CBS-Pro, another Robobat product, solved the problem for most members.

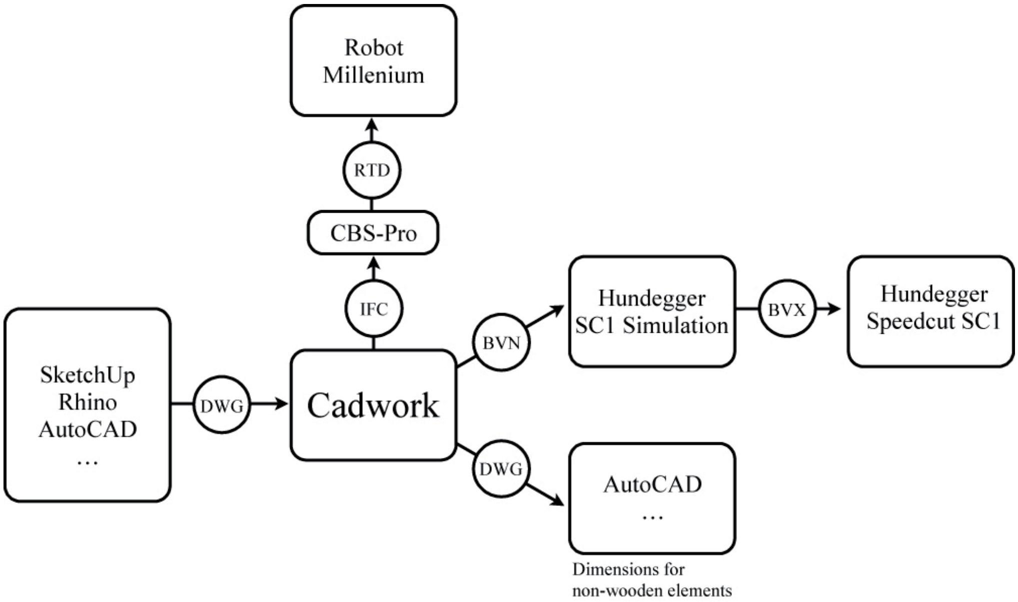

Figure 7
Simple and effective – overview of the digital chain with standard software solutions

Sophistication vs. variation

While technically only a few details had changed, the ways the Camera Obscura project and the Viewing Platform made use of the given technology differ significantly:

The Camera Obscura project focused on the characteristics of the automated joinery machine's CNC tools. Our formal exploitation could be called a 'sophistication of the detail': We designed the building elements as complex as possible, such as the wall planks with their shifted cut and especially the sill and top beams. Those latter elements were very laborious, even for digital fabrication. The fabricator's engineers used two days of work to prepare the fabrication. The fabrication time itself of a single sill beam took long time on the Hundegger K2, without mentioning that we had to finish them manually because we forgot to respect an area for clamping the beam. While the single element was complicated, the total number of different elements was only 8.

The Ringve Botanical Garden Viewing Platform followed a very different approach that might be titled a 'variation of the element'. While a single element was quite simple and optimized to the joinery machine's normal use, we achieved the formal intention by adding lots of elements in which we gradually varied some properties. To be able to identify those elements on the construction site, we labeled them with the Hundegger's implemented ink lettering system.

From the perspective of fabrication, the result was absolutely surprising. Although consisting of approximately 70 components, the digital fabrication of the Camera Obscura had taken several days. In contrast, the approximately 700 components of the Viewing Platform were fabricated within 5 hours. On average, an element was manufactured within 25 seconds.

Conclusions

Evaluation of the teaching approach

This course was a follow-up of an earlier workshop, using largely the same technical backbone. While it could be argued that novelty is obligatory in academic teaching and research, we felt that slow progress on a taken path had some advantages:

First, by building on existing knowledge from an earlier course, a lot of beginner's mistakes could be avoided and we focused on important details. Successful features were kept, hindering details improved.

Second, a series of workshops allows comparing the result on different levels, for instance fabrication-induced design approaches (such as sophistication vs. variation), the efficiency of the process and finally the outcome.

However, when the main aim of a project is to design, produce, and build a permanent structure in 1:1 for a client, and the sponsoring of a large part of the project has to be handled by the students, it is very challenging to keep a focus on the study of the digital chain. During long periods of the course, the focus will inevitably be on the architectural quality of the finished product and the handling of all the necessary practicalities in order to realize the project. These 'external' aspects, particularly the focus on the cultural or architectural aspects are also represented in other similar projects (Neumann, 2007).

Figure 8
The Ringve Botanical Garden Viewing Platform. Photo: Pasi Aalto.

In last year's conclusions we stressed the reflection of fabrication technology in the 'complex shape' of the result, this year we would like to make a more humble statement: We do believe that the knowledge of building should be the core of an architect's education. Today, students are thrilled by digital technologies, both in design and fabrication. By superimposing those digital technologies with the often very dry reality of building, the construction site turns into something contemporary and fascinating.

Acknowledgements

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Notes

The numbers (1, 2) refer to the digital content of the project while the word 'tre' refers to wood, which is the building material that the laboratory has focused on since its inauguration.

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